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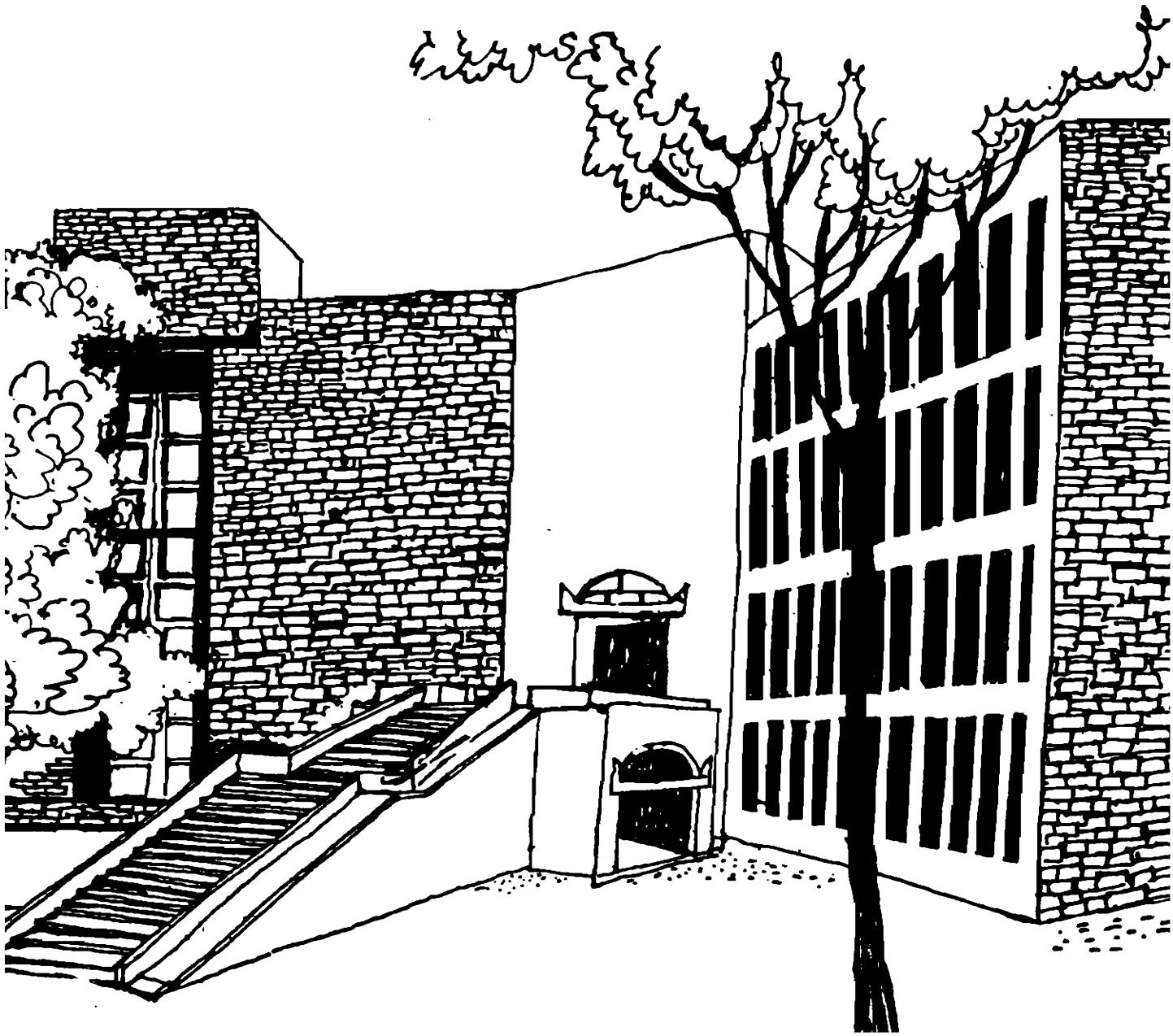

COTTON IN INDIA: ANALYSIS OF DIFFERING PERFORMANCE

By

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Abstract

This paper attempts to investigate the performance of Indian cotton sector and impact of economic and biological factors on acreage and yield of cotton in the major cotton growing states of the country using time series secondary data. The results indicate that the cotton production in the country increased significantly (2.37% per annum) between 1951-52 and 1995-96, largely as a result of improved productivity. This increase in productivity can be largely attributed to the technologies embodied in improved cotton varieties, efficient irrigation and cultivation, fertilisers and novel pest management. This growth has been accompanied by an increase in variability of production and the increase in yield variability was important source of generating instability in cotton production. Central region comprising Gujarat, Madhya Pradesh and Maharashtra was the major cotton producing zone accounting for about 51 per cent of the total production in 1971-75. However, major changes are occurring in the distribution of cotton growing and the main expansion in acreage and production is in North while the traditional cotton producing region (central zone) is tending to cutback on cotton planting. Research findings also indicate that the use of cotton textiles in the country has been steadily rising but the per capita availability and share of cotton use in total fibre use has been declining moderately. Results of cotton share equations revealed that cotton consumption in the country was not much responsive to the prices but the lagged consumption of cotton captured the strong trend in consumption which indicated that decline in share of cotton was not price related but due to technological improvements in the manufactured fibres industry. Per capita GDP was found to have a significant and positive impact on the per capita total fibre and cotton use and the income elasticity was 0.22 for total fibre use and 0.48 for cotton.

Results from the acreage response models reveal that the relative prices of cotton vis-a vis competing crops play a much greater role in determining the growers' acreage allocations. Favourable weather and irrigation also influenced the cotton acreage. The expected role of fertiliser and irrigation in the cotton yield equations was found in most of the states, indicating a crucial role of these factors in determining the yield. Therefore, if cotton production is to be promoted on sustainable basis, the farmers will have to be assured of not only remunerative and stable prices but also of stable yields.

COTTON IN INDIA: ANALYSIS OF DIFFERING PERFORMANCE

In many countries particularly developing countries, cotton is an important agricultural commodity, providing a significant contribution to farm income and export earnings. In India, over 60 million people derive income from the cotton/textile sector (Bell and Gillham, 1989) and Indian textile industry accounts for 20 per cent of industrial output and contributes nearly one-third of the total exports. No crop competes with cotton's potential for value added in processing (Hitchings, 1984).

Despite having largest area (85,000 ha) under cultivation, India ranks fifth in cotton production, which has been erratic over the years. The yield per hectare is only 290 kg against 550 kg in Pakistan, 1500 kg in Israel and a world average of 603 kg (Damani, 1996). The domestic consumption in India has been high as India has the second largest spinning capacity of 31 million spindles (China topping with 40 million spindles).

Cotton, one of the most important commercial crops in India is grown all over the country but its production is concentrated mainly in nine states, namely, Punjab, Haryana, Rajasthan, Gujarat, Madhya Pradesh, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu- theses states together account for about 99 per cent of the total area under cotton. India is the only country in the world that grows all the four cultivated cotton species, viz., *G. hirsutum*, *G. arboreum*, *G. herbaceum* and *G. barbadense*. On the basis of agro-climatic conditions the country is divided into three major cotton growing zones, the *Northern* comprising the states of Punjab, Haryana and Rajasthan, accounting for about 1.7 million ha, the *Central* consisting of Gujarat Madhya Pradesh and Maharashtra, the major cotton producing region, accounting for 4.3 million ha and the *Southern* comprising of Andhra Pradesh, Karnataka and Tamil Nadu, accounting for about 1.6 million ha.

The governments of most cotton producing countries are heavily involved in cotton production and marketing because of its multi-sectoral role in the economy and its socio-economic and strategic importance. This involves some form of price intervention or stabilisation to prevent wide fluctuations in production due to price volatility. Government interventions influence domestic production, domestic textile industry and the international cotton, yarn and textile markets. In India, *Cotton Corporation of India (CCI)* primarily canalise the imports and exports of cotton and acts as an agent of Government of India to maintain stability in the cotton market through its market operations including support price operations. Besides CCI at the national level having its operation in almost all states except Maharashtra, *State Co-operative Cotton Federations* also are associated with the marketing of cotton in their respective states. In Maharashtra, a scheme of monopoly procurement of cotton is in operation under which the farmers have only one choice with regard to sale of their produce, i.e., to the *Maharashtra State Co-operative Cotton Growers' Marketing Federation*.

Production of cotton depends on a number of factors like farmers' decision to allocate land, the expected price for the produce, availability of improved seed and irrigation, rainfall, prices of fertilisers and pesticides, relative profitability of cotton vis-à-vis

competing crops. There have been considerable year to year fluctuations in acreage production and prices of cotton and these fluctuations have far reaching effects on farm income levels. Fluctuations in cotton acreage are caused by variations in the prices of cotton vis-à-vis competing crops, weather conditions, availability of irrigation, marketing of produce and the risks arising from the price and yield variations. There is, therefore, obvious need to examine the impact of these factors on cotton acreage.

The present paper attempts to analyse the growth and instability behaviour of cotton acreage , production and yield and impact of different factors on the acreage, yield and consumption of cotton in India. The specific objectives of the study are (i) to study the growth and instability pattern in area, production and yield of cotton; (ii) to analyse the cotton demand, supply, trade and consumption situation in the country, (iii) to examine the acreage response of various factors influencing the decisions regarding allocation of land to cotton and impact of theses factors on crop yields, and (iv) to suggest policy measures to increase the cotton production in the country.

The paper is organised into five sections. Section I describes the coverage of data and the nature of analysis. The growth and instability of cotton sector is summarised in Section II. In section III, a discussion of theoretical issues and analytical results of the cotton demand, supply, trade and consumption are presented. In section IV acreage and yield response functions and elasticity estimates are reported and discussed. Finally in Section V, a summary and conclusions of the study are provided, along with some policy measures to enhance cotton production.

I. COVERAGE OF DATA AND NATURE OF ANALYSIS

The study is based on secondary data covering the period 1950-51 to 1995-96 in case of all India and 1970-71 to 1994-95 for the states. The study period was divided into two sub-periods, namely Period I from 1971-72 to 1980-81 and Period II from 1980-81 to 1994-95. The study includes nine major cotton growing states which altogether account for about 99 per cent of India's cotton acreage and production. In order to organise the discussion of the state level results and also to trace the regional patterns, the states are classified in 3 major regional groups. The organisation of these regions is as follows:

North : *Punjab, Haryana and Rajasthan*
Central : *Gujarat, Madhya Pradesh and Maharashtra*
South : *Andhra Pradesh, Karnataka and Tamil Nadu*

The data on area, production, yield, irrigated area, farm harvest prices, rainfall, cotton imports, exports, mill consumption, etc., were compiled from various issues of *"Estimates of Area and Production of Principal Crops in India"*, *"Statistical Abstract of India"*, *Indian Agriculture in Brief"*, *"Economic Survey"*(Government of India), *"Fertiliser Statistics"* (FAI), *"Handbook of Statistics on Cotton Textile Industry"* (ICMF), *"India's Agricultural Sector: A Compendium of Statistics"* (CMIE, 1996).

In order to assess the growth performance of cotton in the country and its various sub-regions, the annual compound growth rates have been calculated by fitting the trend equation (i) to the time series of three-year averages of area, production and yield per ha.

$$Y = AB^t \qquad (i)$$

Where, Y's are the triennial averages of area, production and yield per ha, t is the time variable.

The use of three year moving average series of area, production and yield, instead of the original series is expected to reduce considerably the influence of extreme variations in climatic factors on the estimates of growth rates.

Additionally, for verification of existence of statistically significant acceleration or deceleration in growth rates of area, production and yield, 't' statistic used for estimating the significance of difference between the means of two independent samples was computed.

In order to analyse the components of change in the average production of cotton, a decomposition procedure is used (Hazel, 1982, 1984, 1985). Let P denote production, A the area sown and Y yields. Also, letting subscript i denotes states, the total production is:

$$P = \sum_{i=1}^{n} (A_i Y_i)$$

Average production is:

$$E(P_i) = \sum_{i=1}^{n} E(A_i Y_i) \qquad (ii)$$

$$= \sum_{i=1}^{n} [\bar{A}\,\bar{Y} + Cov\,(A\,Y)] \qquad (iii)$$

where $\bar{A}$ and $\bar{Y}$ denote mean values of area and yield. The decomposition analysis partitions the changes in E(P) between Period I and Period II into constituent parts. This involves decomposing the changes in equation (ii) with the help of equation (iii) and then summing up the changes in different components.

Using equation (iii) and ignoring the state subscripts, average production in the second period is :

$$E(P_2) = \bar{A}_2\,\bar{Y}_2 + Cov\,(A_2 Y_2) \qquad (iv)$$

Each variable in the second period can be expressed as its counterpart in the first plus the changes in variable between the two. Equation (iv) therefore can be written as :

$$E(P_2) = (\bar{A}_1 + \Delta A)\,(\bar{Y}_1 + \Delta Y) + Cov\,(A_1 Y_1) + \Delta Cov\,(A\,Y)$$

The change in average production is then obtained from :

$$\Delta E(P) = E(P_1) - E(P_2)$$
$$= \overline{A}_1 \Delta Y + \overline{Y}_1 \Delta A + \Delta A \Delta Y + \Delta Cov (A Y)$$

There are four sources of change in $\Delta E(P)$. Two parts, $A_1 \Delta Y$ and $Y_1 \Delta A$ arise from changes in the mean yield and the mean area. These pure effects arise even in the absence of other sources of change. The term $\Delta A \Delta Y$ is an interaction effect and $\Delta Cov (A Y)$ arises from changes in the covariability of area and yields.

Several studies attempted to estimate the demand for cotton and a wide range of approaches have been used. Donald et. al. (1963), Dudley (1974), Magleby and Missaien (1977) and Thigpen (1978) estimated the demand for cotton as a function of real income, lagged prices and per capita income. Many researchers have used adaptive expectations models to estimate the equations. Studies that have used this approach include Monke (1981), Adams and Behrman (1976), Ecevit (1978), Mues and Simmons(1986), Coleman and Thigpen (1990).

In this paper, the share of cotton in total fibre use is estimated initially as a function of the prices of cotton and the price of non-cotton cloth. This model was not successful with the variables insignificant or the low value of R^2. This may be due to multicollinearity between cotton and non-cotton cloth prices. Therefore, the equation explaining the cotton share of total fibre use was estimated as a function ratio of price of cotton and non-cotton cloth and cotton share in the lagged period. The cotton share equation was of the form:

$$Ln\ COTSHARE = a_0 + a_1\ Ln\ P_{cot}/ P_{noncot} + a_2\ Ln\ COTSHARE(-1)$$

Where,

COTSHARE	=	Cotton share of total fibre use
COTSHARE(-1)	=	Cotton share of total fibre use in the lagged year
P_{cot}	=	Price of cotton cloth (Rs/Mt.)
P_{noncot}	=	Price of non-cotton cloth (Rs/Mt.)
Ln	=	Indicates variable transformed into logarithms.

a_0 is the intercept and a_1 and a_2 are the parameter estimates to be estimated.

Per capita total fibre and cotton use were also estimated as the function of per capita gross domestic product (GDP). The functional form is:

$$PCTFU = a_0 + a_1\ Ln\ PCGDP + a2\ TIME$$

$$PCCOTU = a_0 + a_1\ Ln\ PCGDP + a2\ TIME$$

where, PCTFU = Per capita total fibre use (kg)
PCCOTU = Per capita cotton use (kg)
PCGDP = Per capita Gross Domestic Product (Rs)
TIME = Time Variable

Finally the price and income elasticity of total fibre and cotton use were computed.

The acreage response functions in the present paper have been estimated using *Nerlovian adjustment lag model* as the basic framework of the analysis (Nerlove, 1958). The general form of the model is as follows:

(i) Linear:
$$A_t^* = \alpha_0 + \alpha_1 P_e + \sum_{i=2}^{n} \alpha_{i-1} X_{i-1} + U_t \qquad (i)$$

$$A_t - A_{t-1} = \kappa (A^*_t - A_{t-1}) \qquad 0 < \kappa < 1 \qquad (ii)$$

(ii) Log-linear :
$$A_t^* = \alpha_0 P_e^{\alpha 1} \prod_{i=2}^{n} X_{i-1}^{\alpha i-1} U_t$$

$$\frac{A_t}{A_{t-1}} = \left(\frac{A_t^*}{A_{t-1}} \right)^{\kappa}$$

Where κ is the coefficient of adjustment representing the proportion of adjustment towards equilibrium which occurs in one time period, A_t is the desired acreage under cotton in period t; P_e is the expected price of cotton and X represents the shifter variable.

Now by substituting the values of in equation (ii), the reduced form can be shown as:

$$At = \beta_0 + \beta_1 P_{t-1} + \beta_2 A_{t-1} + Ut \qquad (iii)$$

Where $\beta_0 = \alpha_0 \kappa$; $\beta_1 = \alpha_1 \kappa$; $\beta_2 = (1-\kappa)$

Equation (iii) is the computational equation, the parameters of which are estimated by Ordinary Least Square (OLS) method under the usual assumptions in linear as well as log-linear forms. Of the two functional forms, log-linear model was selected for the interpretation of results considering the values of R^2 and significance of estimates.

Using the adjustment lag model as the basic frame of analysis, the area response equations in the study were estimated with the help of following model:

$$Ln\ At = \beta_0 + \beta_1\ Ln\ RP_{t-1} + \beta_2\ Ln\ A_{t-1} + \beta_3\ Ln\ RY_{t-1} + \beta_4\ Ln\ NIA_t + \beta_5\ Ln\ PSOR + \beta_6\ Ln\ CV\ FHP_{cot} + \beta_7\ Ln\ CV\ Y_{cot} + V_t \qquad (iv)$$

where; A_t = Actual area planted under cotton (percentage to net sown area)

A_{t-1} = One year lagged acreage under cotton

RP_{t-1} = Relative price of cotton with respect the price of competing crop

RY_{t-1} = Relative Yield of cotton with respect to yield of competing crop

NIA = Net irrigated area (percentage to net sown area)

PSOR = Rainfall during pre-sowing season of cotton in mm

CV FHP_{COT}= Coefficient variation of preceding three years' price of cotton

CV Y_{COT} = Coefficient of variation of preceding three years' yield of cotton.

The acreage response equations were estimated for a major cotton growing states using the time series data for the years 1972-73 to 1992-93. In the case of double log function regression coefficients of independent variables itself represent the short run elasticities. The long-run elasticity of acreage with respect to different price and non-price variables has been calculated by dividing the short-run elasticity with the coefficient of area adjustment (κ).

The two major estimation problems associated with the use of time series data are multicollinearity and autocorrelation. The former one was tested by zero order correlation matrix and variables causing multicollinearity were dropped through step-wise regression analysis. The lagged model also suffers from serial dependence. This violates the basic tenets of OLS independence of error residuals and results into the biased estimates of regression coefficients. Since Durbin-Watson 'd' statistic is inappropriate in a model which includes the lagged values of dependent variable among the explanatory variables in supply function, the Durbin 'h' statistic appropriate for testing autocorrelation in the lagged models was computed as follows (Johnston, 1988):

$$h = r\sqrt{\frac{n}{1 - n\ var(\beta_2)}}$$

where $r = (1-d/2)$

d = computed Durbin-Watson 'd' statistic
n = sample size
$var(\beta_2)$ = estimated sampling variance of the coefficient A_{t-1} in the OLS regression equation .

The test breaks down if it should happen that $n.var(\beta_2) \geq 1$. For such cases, the d-statistic was employed to check the incidence of serial correlation.

The constraints limiting the cotton yield are fertiliser, irrigation, rainfall, good quality seed, insect-pest and disease control measures. In order to ascertain the impact of important variables on the growth of crop yields, multiple regression equation of the following form has been fitted to state level data relating to the period 1970-71 to 1992-93:

$$Y_t = \gamma_0\ FERT^{\gamma 1}\ IRRI^{\gamma 2}\ RAIN^{\gamma 3}$$

Where Yt is cotton yield (kg/ha); FERT is the fertiliser consumption (N+P+K) in kg/ha; IRRI is the irrigated area under cotton (per cent); RAIN is the rainfall received during the crop growth period in mm and γ's are the parameters to be estimated. OLS method was used to estimate the equations.

II. PERFORMANCE OF COTTON SUBSECTOR

India ranks top in cotton acreage and constitute nearly 23 per cent of the world cotton area but the average yields are about half of the world average. Cotton production in India increased from 659 thousand tonnes during the period 1951-55 to about 1938 thousand tonnes in 1991-95. The area under cotton increased from 7107 thousand ha to about 7913 thousand ha for the same two periods, respectively. The rapid and considerable rise in cotton production since the early 1950s has resulted mainly from increased yields which rose from 92 kg/ha in 1951-55 to 245 kg/ha in 1991-95, an increase of about 266 per cent (Table 1). Despite this increase, average yields in the country are only 50 per cent of the world average. The yield of irrigated cotton is 1992-93 was 570 kg/ha compared to 130 kg/ha for rain-fed cotton (Gillham, *et. al.*, 1995).

Fig. 1: Trends in Area and Production of Cotton in India

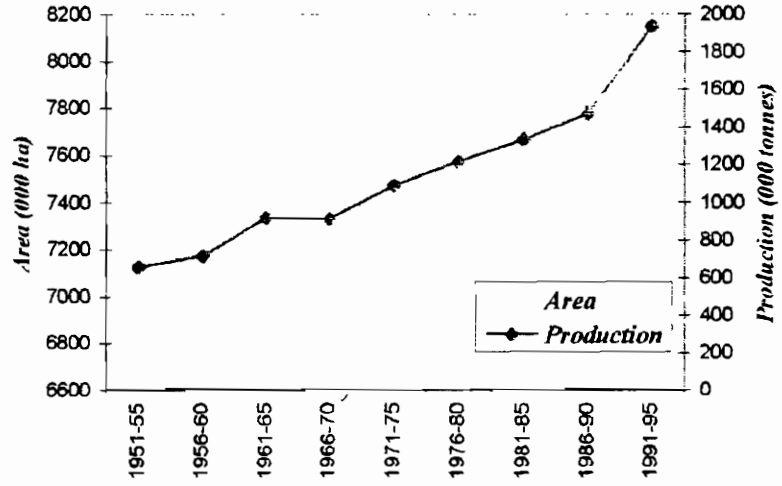
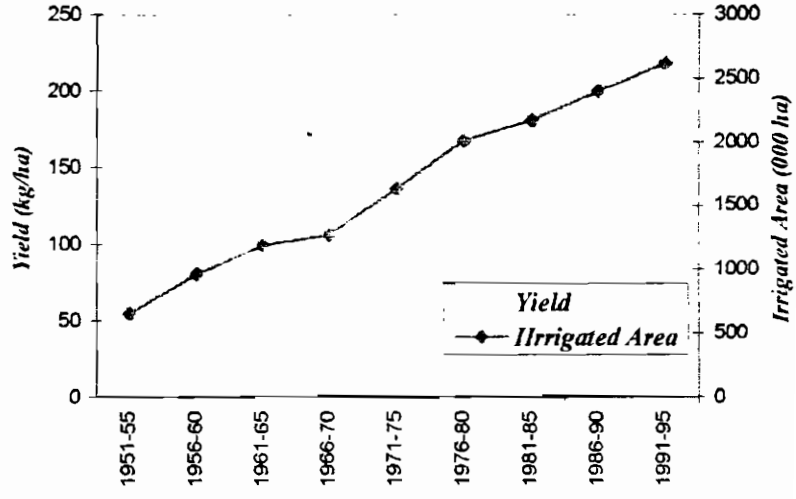


Fig. 2: Trends in Yield and Irrigated Area under Cotton



In these five decades the cotton crop also faced a number of vagaries of weather, insects pests and diseases but the overall performance improved due to well established research system with a number of new varieties, availability of good quality inputs, appropriate plant protection measures, government support price policy. The increase in cotton acreage arose from improvement in irrigation facilities while the yield increases were mainly from improved crop varieties, crop protection and higher fertiliser use. The area under irrigation for cotton increased from 657 thousand ha in 1951-56 to 2671 thousand ha in 1991-95, an increase of about 398 per cent. Further expansion in cotton production will continue to depend primarily on yield increases rather than acreage expansion in the country.

Areas of Production

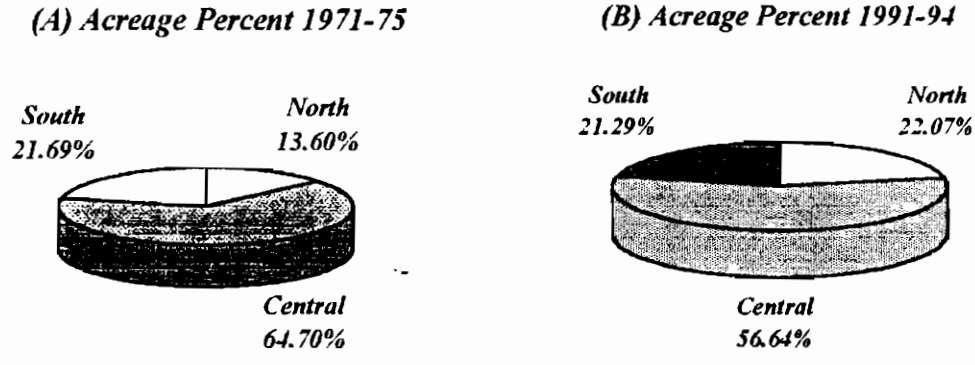
Although cotton, one of the most important commercial crops in India is grown all over the country, there are nine major cotton growing states which contribute more than 99 per cent of total area and production of cotton in country.

Table 1: Production, Acreage, Yield and Irrigated Area of Cotton in India - Five Year Averages from 1951 to 1995

Year	*Production ('000 Tonnes)*	*Area ('000 Ha)*	*Yield (Kg/Ha)*	*Irrigated Area ('000 Ha)*
1951-55	659	7107	92	657
1956-60	716	7780	105	964
1961-65	918	8051	113	1189
1966-70	912	7753	117	1268
1971-75	1091	7592	144	1628
1976-80	1214	7764	156	2006
1981-85	1334	7754	173	2170
1986-90	1471	7176	203	2392
1991-95	1938	7913	245	2617

In 1971-75, the share of acreage in north zone was 13.47 per cent, which increased to 21.94 per cent in 1991-94. However, in central region, the share of cotton acreage declined from 64.06 per cent in 1971-75 to 56.32 in 1991-94 (Fig. 3).

Fig. 3: Indian Cotton Acreage by States as Percent of the Total Five Year Averages from 1971 to 1994.



In 1971-75, Central zone produced about 51 per cent of the total Indian cotton production (Table 3). The share of crop grown in north and south zone was 29.58 and 18.68 per cent, respectively. Small amounts accounting for only one per cent of the crop, were grown in other states. However, in 1991-94, the share of north zone in

total production increased to about 40 per cent, while that of central region declined to 35.87 per cent.

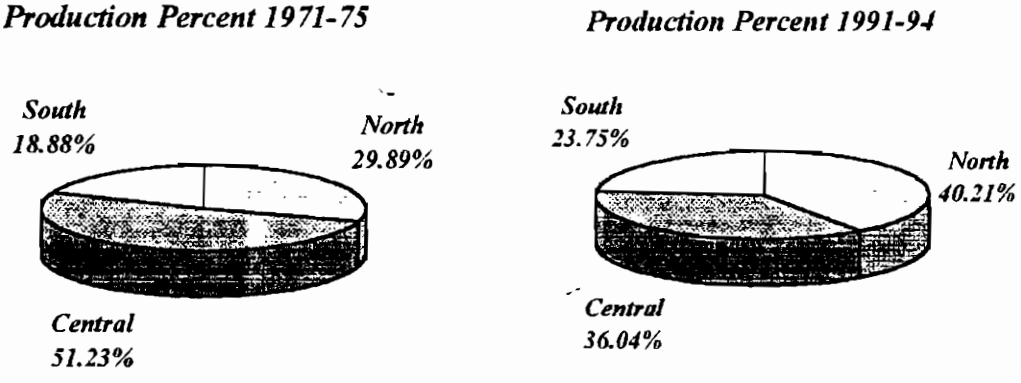
The above results clearly indicate that the share of north zone in total acreage is only 21.94 per cent, but it produced about 40 per cent of the total output of cotton. In this zone the crop is fully irrigated and farmers have adopted new techniques of cotton production. The increase in production has been due to tremendous intensification effort in which research has played a very important role.

Table 2: Five Year Average Acreage of Cotton as Percentage of the Indian Total Acreage

State	*1971-75*	*1976-80*	*1981-85*	*1986-90*	*1991-94*
Punjab	6.45	7.83	8.16	8.92	8.75
Haryana	3.13	3.57	4.49	5.67	6.89
Rajasthan	3.90	4.53	4.83	4.97	6.30
Central Region	**64.06**	**62.19**	**60.52**	**60.31**	**56.32**
Gujarat	22.94	22.70	18.97	15.82	14.70
Madhya Pradesh	8.64	8.36	7.38	7.56	7.00
Maharashtra	32.48	31.13	34.17	36.93	34.62
Southern Region	**21.48**	**21.12**	**21.23**	**19.48**	**21.17**
Andhra Pradesh	4.46	4.73	6.08	7.99	9.68
Karnataka	13.16	12.75	12.30	8.19	8.02
Tamil Nadu	3.86	3.64	2.85	3.31	3.46

By contrast, in central and southern regions cotton is mainly dependent on rainfall with varying amounts of supplementary irrigation. About 13 per cent of the area in the central region and 18 per cent in southern region receives supplementary irrigation.

Fig. 4: Indian Cotton Production by States as Percent of the Total Five Year Averages during 1971-75 and 1991-1994



Growth Rates

Growth rates are estimated by using exponential function on the time series data on production, area and yield of cotton in different regions in India as well as the country as a whole. The results are presented in Table 4 in respect of production, area and yield at national level.

Table 3: Five Year Average Production of Cotton as Percentage of the Indian Total Production

State	*1971-75*	*1976-80*	*1981-85*	*1986-90*	*1991-94*
Northern Region	**29.58**	**31.44**	**30.40**	**39.80**	**40.03**
Punjab	17.33	17.58	15.03	22.35	19.53
Haryana	7.11	7.54	8.94	10.37	11.97
Rajasthan	5.14	6.33	6.43	7.08	8.53
Central Region	**50.69**	**47.49**	**45.60**	**37.76**	**35.87**
Gujarat	28.50	25.95	23.46	15.60	15.12
Madhya Pradesh	5.06	4.16	3.73	3.77	3.26
Maharashtra	17.13	17.38	18.41	18.39	17.49
Southern Region	**18.68**	**20.35**	**23.27**	**21.81**	**23.64**
Andhra Pradesh	3.68	4.87	10.12	8.48	11.53
Karnataka	9.26	9.56	8.64	8.08	7.86
Tamil Nadu	5.74	5.92	4.50	5.25	4.25

The cotton production at national level increased at an annual compound growth rate of 2.45 per cent (significant at 1 per cent level) over 45 years from 1951-52 to 1995-96. The comparison of growth rates during different sub-periods shows that cotton production was stagnant during the sixties and the same has grown at the rate of 2.93 per cent per annum during seventies, 2.23 per cent in the eighties and 4.07 per cent in the period 1991-92 to 1995-96.

Acreage of cotton grew at the rate of 3.31 per cent per annum during the 50s and 3.76 per cent in 90s. While the acreage under cotton remained stagnant during the 60s and 70s and declined significantly (1.44%) during the eighties as a result of these the overall rate of growth in area is found to be stagnant during 1951-52 to 1995-96.

The yield of cotton during 1951-52 to 1995-96 increased at a compound growth rate of 2.34 per cent per annum. However the cotton yield remained stagnant during 1960s. Analysis of data in sub-periods gave some interesting results. The results show that moderately high growth rates of area, production and yield of cotton took place in 1950s. It was also noted that the sharp rise in cotton production during the fifties was associated with greater increase in area. In 1970s the area, production and yield of cotton remained stagnant. The trend analysis for the period 1971-72 to 1980-81 revealed that the acceleration in cotton production was mainly due to significant

increase in crop yield. During 1980's, though the growth rate of area was negative, the positive growth rate of yield had offset the negative impact of area.

Table 4: Compound Growth Rates of Production, Area and Yield of cotton in India; 1951- 52 to 1995-96

	Annual Compound Growth Rates (% /annum)					
	1951-52 to 1960-61	***1961-62 to 1970-71***	***1971-72 to 1980-81***	***1981-82 to 1990-91***	***1991-92 to 1995-96***	***1951-52 to 1995-96***
Production	5.29*	0.76	2.93*	2.23*	4.07*	2.45*
Area	3.31*	-0.10	0.30	-1.44*	1.39*	0.13
Yield	1.87*	0.92	2.66*	3.63*	2.56*	2.34*

**: Significant at one per cent level of significance*

As mentioned earlier analysis of growth in production at regional/state level is carried out for two sub-periods (Period I: 1970-71 to 1980-81, Period II: 1980-81 to 1994-95) and for overall period (1970-71 to 1994-95). The estimates of growth rates in respect of production, area and yield are presented in Tables 5, 6 and 7, respectively.

Table 5: State-wise Compound Growth Rates Cotton Production in India; 1971-72 to 1994-95

	Compound Growth Rates (%/annum)			*Significance of difference between*
States	***1971-72 to 1980-81***	***1980-81 to 1994-95***	***1971-72 to 1994-95***	***1971-80 and 1980-94***
Northern Region	***4.07****	***5.95****	***4.33****	***A (2.5655)****
Punjab	3.19*	5.75*	3.57*	A (3.2687)*
Haryana	3.98*	6.19*	5.39*	A (2.7056)*
Rajasthan	6.82*	6.02*	4.97*	D (0.6733)
Central Region	***1.47****	***0.75***	***0.70****	***A (0.6960)***
Gujarat	0.36	-1.41	-1.10*	-
Madhya Pradesh	-1.80*	2.27*	0.53*	A (5.5906)*
Maharashtra	4.31*	2.73*	2.97*	D (0.9974)
Southern Region	***5.46****	***3.87****	***3.91****	***D (1.4064)******
Andhra Pradesh	13.13*	5.36*	9.46*	D (2.1322)**
Karnataka	4.60*	2.67*	1.82*	D (1.3050)
Tamil Nadu	2.42	2.92*	1.27*	A (0.2328)
All India	***2.93****	***3.26****	***2.62****	***A (0.4804)***

*A : Acceleration; D : Deceleration; Figures in parentheses are 't' values; *, ** and *** : significant at 1, 5 and 10 per cent level, respectively*

Between the three main cotton producing regions of the country, the central region shows relatively poor rate of growth (0.70 per cent). The growth rates of cotton production accelerated for Punjab, Haryana, Madhya Pradesh, and Tamil Nadu from period I to period II. Gujarat recorded a zero growth rate during period II. However, Madhya Pradesh which witnessed a negative growth rate of (1.80%) in production in period I switched to a positive and significant growth rate of 2.27% in period II. On the whole, the growth rate in cotton production at the national level accelerated from 2.93 per cent per annum in period I to 3.26 per cent in period II, with an overall growth rate of 2.62 per cent in 25 years period from 1971-72 to 1994-95. The growth rate in production was negative (-1.10%) for Gujarat only.

Table 6: State-wise Compound Growth Rates Cotton Acreage in India

	Compound Growth Rates (%/annum)			*Significance of difference between*
States	***1971-72 to 1980-81***	***1980-81 to 1994-95***	***1971-72 to 1994-95***	***1971-80 and 1980-94***
Northern Region	***3.83****	***1.84****	***2.30****	***D (3.4990)****
Punjab	4.29*	0.35	1.43*	D (6.1336)*
Haryana	3.25*	4.19*	4.07*	D (1.5909)***
Rajasthan	3.52*	1.81*	1.98*	D (1.6245)***
Central Region	***-0.42***	***1.22****	***-0.77****	***D (4.7298)****
Gujarat	-0.05	-3.34*	-2.69*	D (5.6188)*
Madhya Pradesh	-0.77**	-1.17*	-1.26*	D (0.7765)
Maharashtra	0.58	-0.15	0.43*	-
Southern Region	***0.30***	***-0.63***	***-0.38***	-
Andhra Pradesh	2.13*	4.72*	4.15*	A (3.1218)*
Karnataka	1.01	-4.76	-2.96*	-
Tamil Nadu	-0.83	0.85	-0.83*	-
All India	***0.30***	***-0.52****	***-0.17***	***D (0.4954)***

*A : Acceleration; D : Deceleration; Figures in parentheses are 't' values: * , ** and *** : significant at 1, 5 and 10 per cent level, respectively.*

The growth rates of area under cotton accelerated for Haryana and Andhra Pradesh in period II as compared to period I. The growth rates of area under cotton decelerated for Rajasthan. The negative growth rate of area got sharpened for Madhya Pradesh and changed from zero to negative for Gujarat. The area under cotton remained stagnant during both the periods for Maharashtra, Karnataka and Tamil Nadu. On the whole, it can be observed that the area under cotton increased significantly in all the states of northern region, Maharashtra in central and Andhra Pradesh in southern zone.

The growth rates of yield which were significantly positive only for Haryana, Rajasthan, Maharashtra, Andhra Pradesh and Karnataka during period I turned significantly positive for all the states in period II. The yield growth rate was negative during period I for Punjab and zero for Madhya Pradesh. Highest and positively

significant growth rate was observed in yield in Andhra Pradesh which was 10.15 per cent followed by Maharashtra (4.73%) and Karnataka (4.56%) during period 1971-72 to 1980-81. During period II, highest and significantly positive growth rate in yield was observed for Karnataka (7.81%), followed by Punjab (5.89%) and Madhya Pradesh (4.57%).

Table 7. Compound Growth Rates of Cotton Yield in India; 1971-72 to 1994-95

	Compound Growth Rates (%/annum)			*Significance of difference between*
States	***1971-72 to 1980-81***	***1980-81 to 1994-95***	***1971-72 to 1994-95***	***1971-80 and 1980-94***
Northern Region	***0.54****	***3.76****	***2.00****	***A (7.1151)****
Punjab	-1.05*	5.89*	2.19*	A (7.7662)*
Haryana	5.89***	1.58*	1.10*	A (1.4864)***
Rajasthan	3.27*	4.18*	2.94**	A (1.1630)
Central Region	***1.07****	***2.81****	***1.95****	***A (2.0447)****
Gujarat	0.49	1.91***	1.54*	A (1.005)
Madhya Pradesh	-0.95	4.57*	2.25*	A (4.9279)*
Maharashtra	4.73*	2.92*	2.54*	D (1.2030)
Southern Region	***4.27****	***2.98****	***3.51****	***D (1.5031)****
Andhra Pradesh	10.15*	1.66*	5.28*	D (2.7828)*
Karnataka	4.56*	7.81*	4.97*	D (2.1881)**
Tamilnadu	1.61	1.41*	1.71*	D (0.1825)
All India	***2.66****	***3.80****	***2.80****	***A (2.6362)****

*A : Acceleration; D : Deceleration; Figures in parentheses are 't' values; *, ** and *** : significant at 1, 5 and 10 per cent level, respectively*

From the above results it can be observed that the growth rate of cotton production in India has accelerated and the increase in growth rate is mainly due to increase in yield. However, in northern region increase in area also contributed to the increased production.

Trends in the Mean and Instability in Production, Area and Yield

The instability in area, production and yield was examined by working out coefficient of variation (CV) for the detrended data separately for two periods. The area and yield data were detrended using the formula.

$$Z_t = a + bt + e_t$$

where, Z_t denotes dependent variable (area/yield), t is the time, e_t is random residual with zero mean and variance σ^2, a is intercept and b is the parameter to be estimated. After detrending the residuals (e_t) are centred on mean value of area and yield (Z) for each period, resulting in detrended time series data of the form:

$$Z = e_t + Z$$

Time series data on detrended production is then calculated as the product of detrended area and yield.

Average quantities of cotton production and coefficient of variations are estimated for different regions/states for the period I and period II. Further percentage changes in the mean values and coefficient of variation (CV) between Period I and Period II for cotton production, area and yield are also computed.

It may be observed that all the states witnessed an acceleration in the cotton production in period II except Gujarat which recorded a decline in production (Table 8). The increase in cotton production was as high as 192.18 per cent for Andhra Pradesh, followed by Haryana (90.14%) and Rajasthan (70.45%).

Table 8: Changes in Mean and Variability of Cotton Production in India; 1971-72 to 1980-81 (Period I) and 1980-81 to 1994-95 (Period II)

States	*Production ('000 tons)*			*Coefficient of variation (%)*		
	Period I	*Period II*	*% Change*	*Period I*	*Period II*	*% Change*
Northern Region	**345.2**	**553.3**	**60.86**	**11.47**	**15.09**	**31.56**
Punjab	195.5	283.5	45.01	11.45	21.87	91.00
Haryana	84.2	160.1	90.14	11.93	14.92	25.01
Rajasthan	65.6	111.8	70.43	20.30	24.01	18.28
Central Region	**544.9**	**600.8**	**10.26**	**12.53**	**27.07**	**116.04**
Gujarat	302.2	270.4	-10.52	15.25	31.57	107.01
Madhya Pradesh	49.8	53.9	8.23	22.37	41.25	84.40
Maharashtra	192.8	276.6	43.46	25.37	25.77	1.58
Southern Region	**22.5**	**349.4**	**57.74**	**22.51**	**18.73**	**-16.79**
Andhra Pradesh	53.7	156.9	192.18	33.76	23.53	-30.30
Karnataka	104.2	122.3	17.37	23.20	20.00	-13.79
Tamil Nadu	63.6	70.2	10.38	28.22	20.55	-27.18
All India	*1121.4*	*2524.5*	*35.05*	*12.31*	*16.61*	*34.93*

The results also show that coefficient of variation of production is higher in period II at national level. Similarly, coefficient of variation are noted to be higher in all the states of northern and central zones in Period II compared to Period I. The range of inter-state differences in the magnitude of instability for the second period varied from 14.92 per cent in Haryana to 41.25 per cent in Madhya Pradesh. As a matter of fact central region showed higher magnitude of instability in cotton production compared to southern and northern regions in the second period and between north and south zone, the instability is of higher magnitude in the latter region. The percentage change computed between two periods clearly brings out that instability has considerably increased in Period II over Period I. The percentage increase in average cotton

production was around 35 per cent at national level and ranged between 10.38 and 192.18 per cent in different states.

From the above results it appears the relatively large average production increase of cotton was accompanied by higher instability in its production in northern and central regions. Further in general, low irrigated and low rainfall states like Gujarat, Madhya Pradesh and Maharashtra registered relatively higher magnitude of instability than other states having good irrigation facilities like Punjab, Haryana and Rajasthan.

Coefficient of variation was also computed in respect of acreage under cotton from detrended series of area for period I and period II. The results are presented in Table 9. Table shows that the area under cotton declined by 1.94 per cent or by 148.8 thousand ha. between two periods at national level. The area under cotton witnessed a deceleration in most of states of central and southern region excepting Maharashtra, while the cotton area increased modestly in all the states of northern region between the two periods. The coefficient of variation increased from 4.25 per cent to 5.45 per cent between two periods at national level. Acreage variability increased for Punjab, Gujarat, Madhya Pradesh and Karnataka. The coefficient of variation varied from 3.32 per cent in Maharashtra to as high as 20.18 per cent in Karnataka in period II.

Table 9: Changes in Average Area under Cotton and Coefficient of Variation in India; 1971-72 to 1980-81 (Period I) and 1980-81 to 1994-95 (Period II)

States	*Average area ('000 ha)*			*Coefficient of variation (%)*		
	Period I	*Period II*	*% Change*	*Period I*	*Period II*	*% Change*
Northern Region	**1175.3**	**1477.2**	**25.69**	**10.59**	**8.51**	**-19.64**
Punjab	570.5	643.1	12.72	10.60	11.96	12.83
Haryana	268.3	429.1	59.93	10.40	8.03	-22.79
Rajasthan	336.5	404.6	20.24	15.89	11.78	-25.86
Central Region	**4805.3**	**4446.1**	**-7.47**	**3.53**	**5.15**	**45.89**
Gujarat	1747.6	1245.8	-28.71	5.96	14.23	138.76
Madhya Pradesh	641.3	546.9	-14.72	6.68	6.94	3.89
Maharashtra	2416.4	2653.4	9.81	7.84	3.32	-57.65
Southern Region	**1632.1**	**1556.5**	**-4.63**	**9.55**	**12.40**	**29.84**
Andhra Pradesh	361.3	598.7	65.71	13.67	9.21	-32.62
Karnataka	992.2	716.6	-27.78	9.70	20.18	108.04
Tamil Nadu	278.6	241.2	-13.42	16.56	9.73	-41.24
All India	***7678.2***	***7529.4***	***-1.94***	***4.25***	***5.45***	***28.23***

Table 10 shows the changes in the mean and variability of cotton yield between the periods 1971-72 to 1980-81 and 1980-81 to 1994-95 by regions/states. Between these two periods, the average yield of cotton in the country as a whole increased from 150 kg/ha to 201 kg/ha, thereby showing and increase of around 34 per cent. The increase in cotton yield was highest (75.86%) in case of Andhra Pradesh, followed by Karnataka (66.97%) and Madhya Pradesh (41.25%). However, the average yield of

cotton was highest in Punjab in both the periods. The results clearly indicate that there is a sizeable increase in the levels of cotton yield between the two periods.

The variability of yield, as measured by coefficient of variation, is noticeably higher in period II at the national level as well as in case of northern and central regions. Between the regions the central region shows higher magnitude of yield variability particularly in second period. Whereas in southern region, the coefficient of variation has decreased in the second period. It may be recalled that production instability was also found to be higher in case of central region.

Table 10: Changes in the Mean and Variability of Cotton Yield in India by States; 1971-1980 to 1980-1994

States	*Yield (kg/ha)*			*Coefficient of variation (%)*		
	Period I	*Period II*	*% Change*	*Period I*	*Period II*	*% Change*
Northern Region	***292***	***359***	***22.94***	***4.32***	***10.18***	***135.64***
Punjab	353	445	26.06	8.25	19.89	141.09
Haryana	321	362	12.77	6.05	13.87	129.26
Rajasthan	202	271	34.16	11.25	22.10	96.44
Central Region	***112***	***144***	***28.57***	***11.64***	***24.11***	***107.13***
Gujarat	174	215	23.56	12.46	26.07	109.23
Madhya Pradesh	80	113	41.25	21.68	41.27	90.36
Maharashtra	84	105	25.00	24.33	26.24	7.85
Southern Region	***163***	***244***	***49.69***	***8.39***	***6.17***	***-26.46***
Andhra Pradesh	145	255	75.86	27.03	22.17	-17.98
Karnataka	109	182	66.97	18.23	10.38	-43.06
Tamil Nadu	236	295	25.00	15.25	12.38	-18.82
All India	***150***	***201***	***34.00***	***8.37***	***14.28***	***70.61***

Components of Change in Cotton Production

Table 11 shows the results from decomposing the changes in average cotton production for the states/regions. The results show that the yield improvements were more important in expanding the production of cotton at the national and regional level. At national level, increases in mean cotton yields accounted for about 106 per cent of the increase in total cotton production and the contribution of area was negative.

The components of change in mean production of cotton, by states show that in northern region both the components (area and yield) were important in accounting for growth in cotton production. The increase in average yield was the most important source of increase in production in Punjab and Rajasthan whereas increase in area was the predominant source of increase in production for Haryana state. In case of central and southern zones (except Andhra Pradesh), increase in per hectare yield was the only source of increased production, whereas the contribution of area was negative. The

increase in average yield was more than adequate to compensate the loss in area under the crop, average production therefore increased.

Table 11: Components of Change in the Average Production of Cotton in India, 1971-80 to 1980-84

States	*Change in per cent*			
	Mean yield	*Mean areas*	*Area yield covariance*	*Interaction term*
Northern Region	***35.98***	***50.06***	***2.95***	***10.58***
Punjab	48.68	40.54	1.94	8.83
Haryana	14.64	73.51	2.94	8.91
Rajasthan	50.76	34.41	2.95	11.88
Central Region	***166.42***	***-50.14***	***-4.43***	***-11.84***
Gujarat	168.11	-220.40	-3.10	-44.61
Madhya Pradesh	369.62	-198.11	-18.54	-52.96
Maharashtra	97.73	1.87	-0.11	0.51
Southern Region	***115.40***	***-9.80***	***-0.91***	***-4.69***
Andhra Pradesh	42.04	29.64	1.95	26.37
Karnataka	432.52	-163.45	-63.19	-105.88
Tamil Nadu	592.54	-386.19	-15.30	-91.05
India	***105.95***	***-3.88***	***-0.76***	***-1.31***

Irrigation Extent and Dependence

Irrigation is of major importance in cotton production in the country. Irrigation can increase cotton production either by expanding the area under cotton in arid and semi-arid regions or by increasing supplementary irrigations under rainfed conditions. India irrigates most of the cotton (97.35%) grown in northern zone whereas 13 per cent of the crop in central region and about 20 per cent in the southern region receives supplementary irrigation. Irrigation can be characterised not only by its extent, which is the percentage of area of cotton irrigated, but also by the dependence on irrigation, which is the degree to which rainfall supplements irrigation. The extent and dependence of irrigation in cotton is different states/regions is shown in Table 12.

At the national level average irrigated area under cotton increased by around 29 per cent in period II over the period I. By and large similar picture is found in all the states except Gujarat and Tamilnadu which recorded a decline in irrigated area under cotton. In the northern region, almost all the area under cotton is irrigation. The irrigation water was meeting the most of the crop water requirements but rainfall also makes an important contribution. On the other hand in the central and southern regions rainfall is the major source of meeting crop water requirement and some supplementary irrigation is available to some crops. The extent of irrigated area under cotton varies from 3.02 per cent in Maharashtra to 99.20 per cent in Punjab in second period. On the whole average irrigated area under cotton recorded impressive increase in all the states except Gujarat and Tamil Nadu, as well as at national level. Not unexpectedly

the higher the proportion of crop irrigated in a country the higher is the yield. On the national level the mean yields of rainfed and irrigated cotton are 130 and 570 kg/ha, respectively. This is also reflected in the yields at the state level. However the higher yield associated with irrigation cannot be attributed to irrigation alone. Irrigated crops usually receive higher technological inputs like fertilisers and pesticides because under irrigated conditions, inputs, particularly fertilisers are more efficient in raising yields than under rainfed conditions.

Table 12: Extent and Dependence of Irrigation in different States of India

States	*Dependence**	*Average area irrigated (000 ha)*		*% change between*
		1971-80	*1981-92*	*1971-80 & 1981-92*
Northern Region	***I+R***	***1090.7 (92.61)***	***1428.9 (97.35)***	***31.01***
Punjab	I+R	561.1 *(98.32)*	652.3 *(99.20)*	16.25
Haryana	I+R	263.3 *(98.13)*	411.3 *(98.59)*	56.21
Rajasthan	I+R	266.4 *(78.63)*	365.4 *(78.63)*	37.16
Central Region	***R+I***	***573.6 (11.93)***	***587.9 (13.21)***	***2.49***
Gujarat	R+I	663.2 *(26.54)*	414.7 *(34.21)*	-10.47
Madhya Pradesh	R+I	30.5 *(4.80)*	92.6 *(16.79)*	203.61
Maharashtra	R+I	80.0 *(3.27)*	80.6 *(3.02)*	0.75
Southern Region	***R+I***	***213.2 (12.08)***	***305.7 (12.90)***	***43.39***
Andhra Pradesh	R+I	27.3 *(7.47)*	71.6 *(20.39)*	162.27
Karnataka	R+I	70.3 *(7.10)*	136.8 *(41.16)*	94.59
Tamil Nadu	R+I	115.6 *(41.21)*	97.4 *(20.05)*	-15.74
India	***R+I***	***1817.4 (23.60)***	***2337.0 (31.28)***	***28.59***

Figures in parentheses show the percentage of cotton area under irrigation.

** : **I+R** : Irrigation supplies most of crop water requirements but rainfall makes a significant contribution; **R+I** : rainfall supplies most of crop water requirements but some crop receives supplementary irrigation.*

III. COTTON DEMAND, SUPPLY, TRADE AND CONSUMPTION IN INDIA

This section examines past trends of total fibre use, cotton textile use, cotton mill consumption, production and trade in India and the results are presented in Table 13.

Domestic Market

Cotton textile use in the country has been steadily rising. Total cotton use reached 1655 thousand tonnes in 1986-90 from 1217 thousand tonnes in 1971-75. Per capita availability of cotton dropped from 2.11 kg in 1971-75 to 1.90 kg in 1981-85, and is likely to stabilise at this level.

Competition from Manmade Fibres

Cotton's proportion of fibres consumed in the country has been declining moderately after mid-seventies, but still account for around 88 per cent in 1991-95. The primary reliance will continue to be placed on cotton but the share taken by man-made fibres will gradually rise in the country.

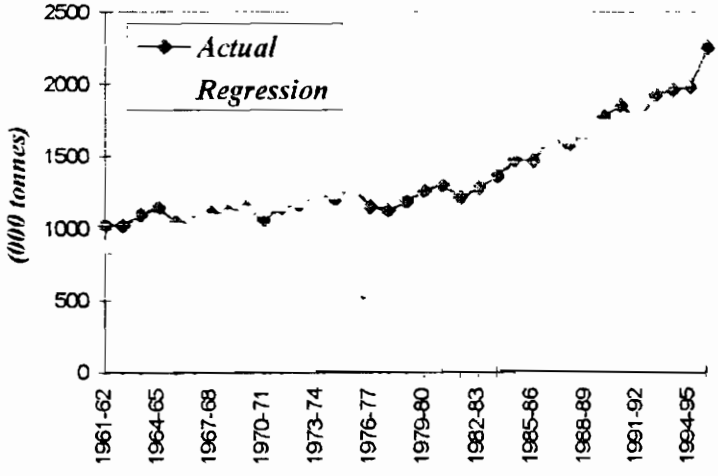
Trade in Textiles

India is one of the major exporters of cotton textiles in the world, but these exports are only a small percentage of total output because of a huge domestic demand. The country was net importer of cotton but shifted to net exporter in 1976-80. In the mid-seventies India was net exporting around 7 thousand tonnes of raw cotton but the net exports could expand significantly to around 121 thousand tonnes in 1986-90 and again declined to 50.8 thousand tonnes in 1991-95 period.

Mill Consumption

Mill consumption of raw cotton significantly increased from 1067 thousand tonnes in 1961-65 to 1970 thousand tonnes in 1991-95 period. The number of cotton spinning spindles has also been gradually rising. With the rising domestic demands and increasing net exports of cotton goods the raw cotton mill consumption is expected to increase in the coming years.

Fig. 5: Mill Consumption of Raw Cotton in India



Supply of Raw Cotton

India has by for the largest area under cotton of any country in the world, but the yields are among the lowest. Cotton area has declined slightly from 8051 thousand ha in 1961-65 to 7913 thousand ha in 1991-95. However, yields are trending upward as a result of increased irrigation, fertiliser, better varieties, insect-pest and disease control measures. Production of raw cotton rose from some 993 thousand tonnes in 1961-65 to 2191 thousand tonnes in 1991-95. As the yields already average among the lowest in the world, a big gain in cotton production can be expected in the coming years.

Cotton Demand

In order to examine the demand system of cotton, cotton share and per capita total fibre and cotton use equations were estimated.

Cotton Share Equation

In cotton share equation the cotton share of total fibre use was estimated as a function of the ratio of price of cotton and non-cotton textiles. The equation is estimated from 1971 to 1989. These periods were chosen on the basis of data availability.

Table 13: Cotton Supply, Consumption and Trade in India

	1961-65	*1966-70*	*1971-75*	*1976-80*	*1981-85*	*1986-90*	*1991-95*
***Area** (000 ha)*	8051	7753	7592	7764	7754	7176	7913
***Yield** (kg/ha)*	113	117	144	156	173	203	245
***Production**[#] (000 tons)*	993	1005	1162	1240	1536	1835	2191
***Imports** (000 tons)*	135.7	135.3	58.7	43.0	4.2	18.1	43.0
***Exports** (000 tons)*	48.6	38.2	44.9	50.2	69.4	138.9	93.8
***Mill Consumption** (000 tons)*	1067	1095	1208	1205	1362	1696	1970
***Total Cotton use** (000 tons)*	*na*	*na*	1217	1227	1370	1655	*na*
***Per Capita Cotton availability** (kg)*	*na*	*na*	2.11	1.90	1.90	2.10	*na*
***Total Fibre use** (000 tons)*	*na*	*na*	1297	1401	1557	1881	*na*
***Cotton share** (%)*	*na*	*na*	93.9	87.5	87.9	88.0	*na*

***na** : data not available, [#] : These estimates are traded estimates derived by the Cotton Advisory Board and differ from the official estimates of production reported by the Directorate of Economics and Statistics, Department of Agriculture and Co-operation, Ministry of Agriculture.*

The estimated cotton share equation along with selected diagnostics (i.e., t-values, R-squared) is presented below:

$$Ln\ COTSHARE = -0.0036 - 0.0636\ Ln\ P_{cot}/P_{noncot} + 0.9815\ Ln\ COTSHARE\ (-1)$$
$$(1.56) \qquad (4.94)$$
$$R^2 = 0.76$$

Figures in parentheses are t-values. R^2 = Coefficient of multiple determination

The equation explaining the cotton share of total fibre use fitted the data better with variables converted into logarithms. The ratio of cotton and non-cotton prices gave an elasticity estimate of 0.0636 but was non significant. It indicates that consumption of cotton in the country is not responsive to price changes. The lagged consumption of cotton captured the strong trend in consumption which appeared in the equation with a coefficient of 0.9815 (significant at 1 per cent level). The fit of the equation was also satisfactory. The cotton share lagged one year variable was included in the model because there has been a steady decline in the share of cotton in total fibre

consumption during the regression period, which was not price related but this trend was due to technological improvements in the manufactured fibres industry.

Per capita Total Fibre and Cotton Use Equations

Per capita total fibre/cotton use was estimated as a function of per capita gross domestic product (GDP). Trend variable was also included to provide more reliable estimates of the elasticity of total fibre/cotton use with respect to income and the inclusion of this variable improved the statistical fit of the equation. The semi-log functional form gave the best fit. The estimates of total fibre and cotton use equations are presented in the following equations:

$$PCTFU = -2.4431 + 0.4906\ Ln\ PCGDP - 0.0841\ Time \qquad R^2 = 0.69$$
$$(2.38) \qquad (1.86)$$

Figures in parentheses are t-values

The estimated coefficient of gross domestic product gave an income elasticity of 0.22 when calculated at the mean of total fibre use. These estimates are comparable with the elasticity obtained from previous study of Coleman and Thigpen (1990).

The estimated equation for per capita cotton consumption is:

$$PCCU = -4.7147 + 0.8275\ Ln\ PCGDP - 0.0841\ Time \qquad R^2 = 0.66$$
$$(2.37) \qquad (2.37)$$

The equation explaining per capita cotton use contained the logarithm of per capita gross domestic product and the time variable. The coefficient of the income variable was significant and resulted in income elasticity estimate of 0.42 which is comparable with the elasticity estimate obtained by Thigpen (1978) for the developing countries.

IV. ACREAGE AND YIELD RESPONSE FUNCTIONS

In this section an attempt has been made to study the acreage and yield response functions for cotton in major cotton growing states.

Acreage Response Functions

Acreage response functions provide us with useful information on the extent of farmers' response to price and other factors. The estimated area response functions are presented in Table 13. The log linear form of the function was found to be consistently superior to the linear form both in terms of proper sign and significance of the coefficients and overall explanatory power. The short and long-run elasticities of acreage with respect to important supply variables were also calculated. In case of log-linear function regression coefficients itself represent the short run elasticity. Long-run elasticity is obtained by dividing short-run elasticity with the coefficient of adjustment. The impact of different factors on cotton acreage is discussed below:

Lagged Acreage

The elasticity estimates of lagged cotton acreage were found to be consistently positive and significant in all the states except Rajasthan, Gujarat and Maharashtra. The value of coefficients of this variable varied from 0.0984 in Tamil Nadu indicating a higher rate of adjustment to 0.8610 in Haryana, indicating a comparatively low rate of adjustment.

Lagged Relative Price

The results of the analysis show that relative price of cotton with respect to competing crops has shown significant positive impact on acreage under cotton in all the states except Madhya Pradesh where it was non-significant. The short-run elasticity of cotton with respect to relative price variable was ranging from 0.0872 in case of Punjab to 0.5501 in Andhra Pradesh. This shows that an increase in area under cotton was observed due to an increase in the relative price of cotton with respect to its competing crops.

Lagged Relative Yield

The relative yield of cotton vis-à-vis competing crops has shown positive but insignificant relationship with area under cotton in majority of the states excepting Punjab, Haryana and Rajasthan, where the coefficients were negative but non-significant. Comparing the yield and price variables, it appears that farmers seem to be influenced less by the past yields but more by the prices.

Irrigation

Increase in net irrigated area in majority of the states has resulted in significant increase in area under cotton. The regression coefficients of irrigation variable have emerged positive and significant in case of Punjab, Rajasthan, Gujarat and Andhra Pradesh. The significant negative effect of irrigation has been witnessed only in case of Madhya Pradesh. The regression coefficient of irrigation was negative but non-significant in Maharashtra, Karnataka and Tamil Nadu.

Rainfall

Rainfall during the pre-sowing months has shown a significant and positive impact on cotton acreage only in case of Gujarat and Madhya Pradesh, because most of the area under cotton in these states is rainfed. While in other states the effect of rainfall was either positive or negative but insignificant, indicating that rainfall during pre-sowing months had no significant influence in acreage allocation. Almost all the area under cotton is irrigated in Punjab and Haryana.

Table 14 : Estimated Acreage Response Equations for Cotton, 1971-1992

	Regression coefficients of									
States	***Constant***	A_{t-1}	***NIA***	***PSOR***	RP_{t-1}	RY_{t-1}	$CV\ FHP_{cot}$	$CV\ Y_{cot}$	R^2	***D-W h-statistics***
Punjab	-3.8021	0.1109 (0.1865)	1.5663*** (0.4279)	-0.1409 (0.1481)	0.0872** (0.0413)	-0.0163 (0.0831)	0.0678 (0.0616)	-0.0699* (0.0355)	0.82	-1.0926 (NSC)
Haryana	-1.4260	0.8610*** (0.2866)	0.3314** (0.1949)	0.0585 (0.1765)	0.3474** (0.1896)	-0.0670 (0.3650)	-0.1091 (0.0779)	-0.0985 (0.1119)	0.84	-1.0582 (NSC)
Rajasthan	-0.1802	0.1937 (0.2076)	0.5571* (0.3000)	-0.2909 (0.1925)	0.0947** (0.0463)	-0.0662 (0.0446)	-0.0365 (0.0339)	0.1341 (0.0893)	0.66	0.7024 (NSC)
Gujarat	3.0128	0.3669 (0.2705)	0.5276** (0.2431)	0.0521*** (0.0245)	0.0962*** (0.0178)	0.0360 (0.1209)	-0.0035 (0.0352)	-0.0356** (0.0132)	0.82	-2.0735[d] (NSC)
Madhya Pradesh	2.0381	0.4954** (0.2341)	-0.1689* (0.0931)	0.1408** (0.0527)	0.0929 (0.0982)	0.1055* (0.0574)	-0.0082 (0.0511)	-0.0293 (0.0393)	0.78	1.7974[d] (NSC)
Maharashtra	3.0255	0.2060 (0.2208)	-0.0042 (0.1459)	0.1410 (0.1449)	0.1796*** (0.0570)	0.0195 (0.0568)	-0.0304** (0.0134)	-0.0133 (0.0244)	0.76	2.0127[d] (NSC)
Andhra Pradesh	-2.1132	0.4685** (0.2472)	1.0937*** (0.6223)	-0.2007 (0.2138)	0.05561** (0.2234)	0.0231 (0.1294)	-0.0843* (0.0425)	-0.0499 (0.0936)	0.84	1.9661[d] (NSC)
Karnataka	-2.1152	0.6588*** (0.2083)	-0.4367 (0.4343)	0.3897*** (0.2051)	0.5086*** (0.1702)	0.0198 (0.1902)	0.0392 (0.0686)	0.2295 (0.2264)	0.87	-1.0220 (NSC)
Tamil Nadu	1.4402	0.0984*** (0.0199)	-0.1289 (0.6126)	-0.0053 (0.1128)	0.4374*** (0.1546)	0.0531 (0.1593)	0.0355 (0.0333)	-0.0264 (0.0586)	0.59	-1.2033 (NSC)

Figures within parentheses are standard errors of regression coefficients; [d] : Durbin d-statistic
****, ** and * : Significant at 1 per cent, 5 per cent and 10 per cent level, respectively*

Risk Factors

Agricultural production is generally subjected to two major sources of risk- one arising from variability in prices and other in yields. The relative incidence of these variables may differ among regions. In majority of the states considered in the analysis, risk arising due to variations in relative farm harvest prices and relative yield of cotton showed a insignificant negative impact on the area under cotton. The regression coefficient with respect to variability in relative farm harvest prices was significant in Maharashtra and Andhra Pradesh only. The risk arising due to yield in cotton has shown significant negative impact on cotton acreage in Gujarat State.

The above results clearly indicated that of all the variables relative farm harvest prices emerged as the strongest factor in determining the cotton acreage in most of the cotton growing states in the country. Comparing the yield and price factors it seems that farmers are influenced more by the prices than the past yields.

Acreage Adjustment Coefficients and Elasticities

The estimated coefficient of adjustment and long run elasticities of acreage with respect to price and non-price factors are presented in Table 14.

The coefficient of adjustment for Tamil Nadu was found highest (0.9016), which implies that the desired adjustment in acreage were most rapidly made and that price inducement operated rather quickly. The lowest rate of acreage adjustment coefficient was observed in case of Haryana indicating that acreage was influenced more by technological and institutional rigidities.

Table 15: Coefficient of Adjustment and Long-run Elasticities of Cotton Acreage with respect to Price and Non-Price Factors

		Long-run elasticities with respect to			
States	***Coefficient of adjustment***	***Relative Price***	***Relative Yield***	***Irrigation***	***Rainfall***
Punjab	0.8891	0.0981	-0.0183 ^{ns}	1.7616	-0.1585 ^{ns}
Haryana	0.1390	2.4992^{ns}	-0.4820 ^{ns}	2.3841	0.1137 ^{ns}
Rajasthan	0.8063	0.1174	-0.0821 ^{ns}	0.6909	-0.3607 ^{ns}
Gujarat	0.6331	01519	0.0569	0.8333	0.0823
Madhya Pradesh	0.5046	0.1841^{ns}	0.2091	-0.3347	0.2790
Maharashtra	0.7940	0.2262	0.0245 ^{ns}	-0.0053 ^{ns}	0.1776 ^{ns}
Andhra Pradesh	0.5315	1.0462	0.0435 ^{ns}	2.0577	-0.3776 ^{ns}
Karnataka	0.3412	1.4906	0.0580 ^{ns}	1.2799 ^{ns}	1.1421
Tamil Nadu	0.9016	0.4851	0.0589 ^{ns}	-0.1430 ^{ns}	-0.0059 ^{ns}

^{ns} *: Non-significant*

The elasticities of acreage with respect to farm harvest price in the long run showed wide variations among the states. The magnitude of long run elasticities was found to be positive in all the states. High values of elasticities in case of Andhra Pradesh and Karnataka indicate the higher sensitivity of cotton acreage to price change in long run. The acreage elasticity with respect to relative yield was significant in case of Gujarat and Madhya Pradesh. The elasticity with respect to irrigation varied from -0.3347 in Madhya Pradesh to 2.3841 in case of Haryana.

Yield Response Functions

Cotton production fluctuates due to multitude of factors including environmental conditions in the major cotton producing states. Seasonal variations in the yield are largely the result of environmental factors on time of planting, seasonal distribution, and harvest conditions and non-environmental factors like fertiliser and pesticide consumption, irrigation and availability of good quality seed. The regression equations for cotton yield were estimated using OLS method for the period 1970-71 and 1992-93 and are presented in Table 16.

Table 16: Estimated Yield Response Functions for Cotton : 1970-71 to 1992-93

		Regression coefficients of			
States	***Intercept***	***Fertiliser***	***Irrigation***	***Rainfall***	R^2
Punjab	5.6772	0.1810* (0.1068)	0.0108 (0.0258)	-0.0873 (0.1764)	0.52
Haryana	-13.7829	0.0631 (0.0503)	4.2479* (2.3368)	-0.0193 (0.0963)	0.59
Rajasthan	3.2511	0.4221** (0.1748)	-0.2329 (0.8603)	0.3708* (0.2026)	0.46
Gujarat	6.8817	0.4750*** (0.1780)	-1.1391 (0.7644)	0.0772 (0.2905)	0.67
Madhya Pradesh	5.3575	0.2332 (0.1954)	-0.0556 (0.2332)	-0.2014 (0.2723)	0.78
Maharashtra	5.3514	0.4342*** (0.1260)	0.0937 (0.1566)	0.3610* (0.2066)	0.69
Andhra Pradesh	3.8150	0.5117*** (0.1864)	0.2128* (0.1268)	-0.1766 (0.4103)	0.51
Karnataka	2.9723	0.0610 (0.2277)	0.4977** (0.1939)	0.0677 (0.2807)	0.79
Tamil Nadu	2.5589	0.2677*** (0.0706)	0.2005* (0.1083)	0.1989* (0.1093)	0.78
India	5.2513	0.3786*** (0.1387)	0.1296 (0.0739)	0.1563 (0.1676)	0.73

Figures in parentheses are standard errors of regression coefficients
****, ** and * : Significant at 1, 5 and 10 per cent level, respectively.*

In order to examine the problem of multicollinearity, zero order correlation matrices were worked out. From these matrices it was observed that there is no problem of multicollinearity in all the cases. Of all the variables, fertiliser consumption emerged as the most important factor in determining the yield variation. The coefficient of fertiliser was found to be significantly positive in majority of the states, indicating that an increase in fertiliser consumption would increase the cotton yield. The variable irrigated area was found to be positive and statistically significant in case of Haryana, Andhra Pradesh, Karnataka and Tamil Nadu. The coefficient of variable rainfall during the crop growth period was found to be positive and significant for Rajasthan, Maharashtra and Tamil Nadu. These results clearly indicated that fertiliser and irrigation favourably influenced the cotton yield.

V. CONCLUSIONS AND POLICY IMPLICATIONS

The cotton production in India grew at an average annual growth rate of 2.37 per cent between 1951-52 and 1995-96, largely as a result of improved yields. This growth has been accompanied by an increase in variability of production. The coefficient of variation of cotton production was 10.31 per cent in 1971-72 to 1980-81 and increased to 12.61 per cent during 1981-82 and 1994-95.

The inter-state comparisons also revealed significant differentials in growth rates. Growth rates of cotton production accelerated for Punjab, Haryana, Madhya Pradesh, Tamil Nadu and at national level. The break-up of increase in cotton production into its components revealed that yield was the major factor for increase in cotton production in all the states except Haryana where area was the predominant source of increased production during 1971-72 to 1994-95. This reflects the impact of rapid growth of irrigation facilities, availability of good quality inputs, appropriate plant protection measures and suitable varieties with desired characteristics. The analysis also revealed that the variability in production and yield of cotton increased for the north and central zones and the increase in yield variability was important source of generating instability in cotton production.

The main cotton producing areas of India can be grouped into three regions, North, Central and South. In 1971-75, the share of crop grown in each of these regions was 50.69, 29.58 and 18.68 per cent, respectively. Only small amounts, accounting for less than one per cent of crop was grown in other states. However major changes are occurring in the distribution of cotton growing states in the country. The main expansion in acreage and production of cotton is in north while the traditional cotton producing region, i.e., central is tending to cut back on cotton planting.

The use of total cotton textiles in the country has been steadily rising but the per capita availability of cotton and share of cotton in total fibre use has been declining moderately after the mid-seventies. the country was net importer of cotton but shifted to net exporter in mid seventies. The domestic consumption in the country has been high as India has the second largest spinning capacity of 31 million spindles.

The results of cotton share equations indicated that consumption of cotton in the country was not much responsive to the prices but the lagged consumption of cotton

captured the strong trend in consumption which indicated that decline in share of cotton was not price related but was due to technological improvements in the manufactured fibres industry. Per capita total fibre and cotton use equations revealed that per capita gross domestic product has a positive and significant impact on the per capita total fibre and cotton use. The income elasticity estimate was 0.22 for total fibre use and 0.48 for cotton use.

The acreage response functions indicated that on the whole price and non-price factors, viz., irrigation, rainfall, relative yield have strategic role in acreage allocation decisions. Rainfall has significant influence on the acreage in rainfed areas. Comparing all the price and non-price factors it seems that farmers appear to be influenced less by non-price factors but more by the relative farm harvest prices.

Yield behaviour of cotton was found to be sensitive to various factors viz., fertiliser, irrigation and rainfall during crop growth period. Fertiliser exerted the strongest influence on the cotton yield in majority of the states. The expected role of irrigation was found in most of the states, indicating a crucial role of irrigation in determining cotton yield.

Stability in cotton production is essential for continued and steady progress of cotton economy of the country. If cotton cultivation is to be promoted on a sustainable basis, the farmers will have to be assured of not only remunerative and stable prices but also of stable crop yields. Appropriate policies, therefore, need to focus on (I) favourable pricing policy by taking into account the prices of competing crops, (ii) creating efficient input supply system and introducing crop insurance scheme to counter the influence of vagaries of nature, (iii) developing better irrigation facilities especially in central and southern regions, and (iv) developing suitable insect pest and disease resistant varieties to fit in different eco-systems.

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