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Impact of Bt cotton on India's cotton sector: A statistical analysis of production, prices, and costs

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Abstract

Cotton is a vital fiber and cash crop in India, playing a significant role in both the agricultural and industrial economy. This study analyzes the compound annual growth rate (CAGR) to assess the changes in area, production, productivity, farm harvest prices, and cost of production (A2+FL) of cotton across nine major cotton-growing states in India before and after the introduction of Bt cotton. The analysis considers two periods: the pre-Bt cotton era (1996-97 to 2001-02) and the post-Bt cotton era (2002-03 to 2019-20). The findings indicate a significant increase in the area, production, and productivity of cotton in India after the introduction of Bt cotton (2002-03) compared to the earlier period. Additionally, the cost of production decreased in Gujarat, Haryana, Karnataka, and Madhya Pradesh, whereas Andhra Pradesh, Punjab, Rajasthan, and Tamil Nadu experienced increased production costs. Farm harvest prices of cotton rose in almost all major cotton-growing states post-Bt cotton introduction, with Madhya Pradesh recording the lowest and Haryana the highest farm harvest prices.

Keywords: Bt cotton, cost of production, farm harvest prices, growth rates and trend analysis

Introduction

India is the world's largest producer of cotton, followed by China, the USA, Brazil, Pakistan, Uzbekistan, Egypt, Argentina, Australia, Greece, and Turkey. The country holds the top position globally in both cotton area and production, covering 12.76 million hectares and yielding 354.91 lakh bales (1 bale = 170 kg). While cotton is cultivated across India, nine major states dominate production: Gujarat, Maharashtra, Telangana, Haryana, Rajasthan, Punjab, Andhra Pradesh, Karnataka, and Tamil Nadu.

During the kharif season of 2020-21, Telangana ranked second in cotton acreage, covering 60.22 lakh acres, and third in production, following Gujarat and Maharashtra. Key cotton-producing districts in Telangana include Nalgonda, Nagarkurnool, Adilabad, Sangareddy, and Asifabad. In recent years, both the cost of production and farm harvest prices of cotton has been rising.

Given the significance of cotton in the Indian economy and its major producing states, this study aims to analyze the growth in area, production, productivity, farm harvest prices, and cost of production (A2+FL) using the compound annual growth function. The findings of this research will aid in shaping policy decisions for short- and long-term planning while also guiding future research toward sustainable agricultural development.

Review of Literature

Growth models play a crucial role in understanding the relationship between time and growth, determining the rate of growth at different points in time, identifying turning

points, and serving as reliable indicators of overall growth. Rao and Reddy (2005) ^[4] analyzed the growth rates of area, production, and productivity of groundnut in Andhra Pradesh across two periods: Period I (1988-89 to 2002-03) and Period II (1953-56 to 2002-03). Their study covered three geographical regions of Andhra Pradesh as well as the state as a whole. The findings indicated that the compound growth rate of area was significant only in Rayalaseema, while production showed significant growth across all three regions and the state overall. Productivity exhibited significant growth in coastal Andhra and Andhra Pradesh as a whole. Mathur (2005) ^[2] estimated the compound growth rates of area, production, and productivity of rice in India during the high-yielding variety period (1966-67 to 2000-01) using the least squares method to fit an exponential function ($y = a bt$). Similarly, Aparna *et al.* (2008) ^[1] analyzed growth trends in major vegetable crops in the Visakhapatnam district by calculating compound growth rates. Pandey (2004) ^[3] studied the area, production, productivity, and exports of vegetables in India during the 1990s and projected vegetable demand up to 2021. Sharma and Amod Kalita (2008) ^[7] examined trends in the area, production, and productivity of major fruit crops in Jammu and Kashmir using secondary data from 1974-75 to 1999-2000. Their study revealed a positive and statistically significant growth in all three aspects during the analyzed period.

Materials and Methods

Nature and sources of data

The secondary data was collected from the official website

of the Central Institute for Cotton Research (CICR) (<https://cicr.org.in>), www.Indiastat.com, and the Directorate of Economics and Statistics, India (<https://desagri.gov.in>).

Analytical tools

To evaluate the objectives of the study, appropriate analytical tools have been selected based on the nature and availability of data. The analysis of area, production, yield, farm harvest prices, and cost of production of cotton in India will be conducted using standard statistical methods, including compound growth rates and graphical representations. These tools will help identify trends in the area, production, and productivity of cotton in India, leading to meaningful results and conclusions.

Compound annual growth rate analysis

To study the annual growth rate of area, production,

productivity and cost of production, the compound growth rate was computed using semi-log or exponential model.

$$\ln Y_t = \alpha + \beta t + u_t$$

Where,

Y_t = Quantity (tonnes) of coir products exported in year t .

t = Time element which takes the value 1, 2

n for various years. α = Intercept

$$\text{Compound Annual Growth Rate (CAGR)} = [(\text{Antilog } \beta_t) - 1] \times 100$$

Results and Discussion

The findings of the present study as well as appropriate discussion have been summarized as follows:

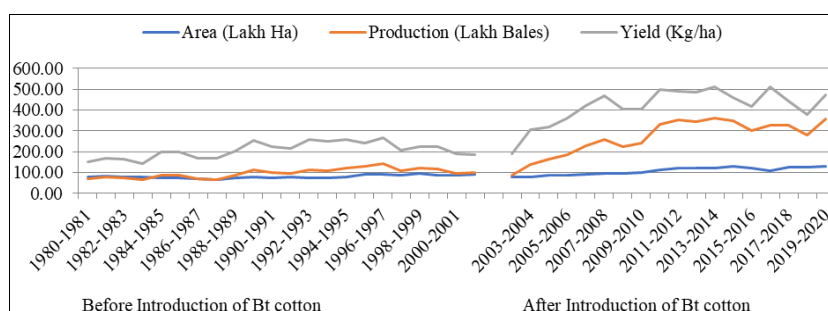


Fig 1: Trends in area, production and productivity of cotton in India i.e., before and after introduction of Bt cotton

In India, the major cotton-growing states include Gujarat, Maharashtra, Telangana, Rajasthan, Haryana, and Punjab. Before the introduction of Bt cotton, the area under cotton cultivation, production, and productivity showed a gradual increase from 78.23 lakh hectares to 91.32 lakh hectares, production from 70.10 to 99.97 lakh bales, and productivity reaching 152 kg/ha between 1980-81 and 2001-02 (Table 1).

However, after the introduction of Bt cotton, a significant surge was observed, with the area expanding from 76.70 to 127.67 lakh hectares, production rising from 86.24 to 354.91 lakh bales, and productivity increasing from 191 to 473 kg per hectare. A sharp spike in cotton area, production, and productivity was particularly evident during 2010-11.

Table 1: CAGR of area, production and productivity of cotton before and after introduction of Bt cotton in India

Period	Area (Lakh Ha)	Production (Lakh Bales of 170 kg each)	Yield (Kg/ha)
Before Introduction of Bt cotton	1.00	2.70	1.70
After Introduction of Bt cotton	3.10	6.20	2.90

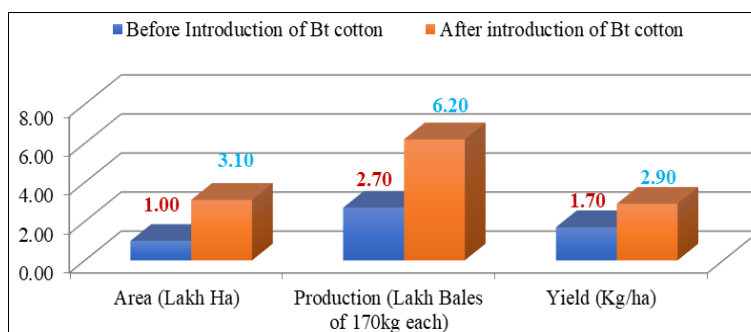


Fig 2: CAGR of area, production and productivity of cotton before and after introduction of Bt cotton in India

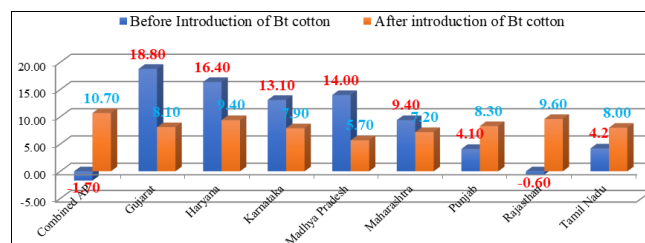
The compound annual growth rate (CAGR) for area, production, and yield of cotton before the introduction of Bt cotton (Table 2) was 1%, 2.70%, and 1.70% per year, respectively. After the introduction of Bt cotton, these rates

increased to 3.10%, 6.20%, and 2.90% per year, respectively. Both sets of growth rates were found to be statistically significant at the 1% level.

Table 2: State wise cost of production of cotton (Cost A2 + FL) (in Rs. /qtl)

Year	Combined Andhra Pradesh	Gujarat	Haryana	Karnataka	Madhya Pradesh	Maharashtra	Punjab	Rajasthan	Tamil Nadu
1996-97	1215.74	1001.35	922.58	946.6	1234	1143.22	1105.15	713.61	1364.79
1997-98	1288.41	950.87	1433.06	1115.91	1102.77	1284	2122.31	1026.27	1516
1998-99	1257	993.06	1354.24	1326.55	1367	1354	2367.9	1005	1669.2
1999-2000	1226.56	1420.07	899.56	1771.88	1631.53	1425.19	1713.17	985.17	1517.74
2000-01	1130.78	2214.35	1042.72	1955.7	2010.34	1754.74	1347.12	628.22	1847.75
2001-02	1171.55	1873.35	4192.35	1513.38	2078.27	1761.92	2047.36	919.38	1645.84
CAGR	-1.7	18.8	16.4	13.1	14	9.4	4.1	-0.6	4.2
2002-03	946.24	1462.93	1267.42	1355.65	2255.01	1793.22	1766.92	1622.95	1909.1
2003-04	975.55	1094.61	1285.92	1303.21	1892	1562.9	1501.11	1061.9	1742.41
2004-05	1185.78	1137.33	960.31	1065.8	2040.98	1624.41	1104.55	859.44	1663.91
2005-06	1521.6	1177.48	1452.23	1508.14	1226.74	1657.04	961.98	878.65	1938.35
2006-07	1074.19	1267.42	1311.42	1332.74	1557.01	1596.78	997.65	861.22	1436.5
2007-08	1146.78	1236.46	1239.56	1032.12	1309.69	1547.12	1092.66	975.79	1745.74
2008-09	1635.6	1564.99	1465.74	1629.65	1019.91	1828.07	1150.11	1304.83	1623.52
2009-10	1525.21	1561.47	1590.9	1658.76	1217.46	2006.02	1343.92	1200.99	1959.15
2010-11	1933.57	1567.57	1771.76	1843.92	1259.04	2637.07	1559.2	1161.79	2137.09
2011-12	2299.82	2365.19	2038.65	1963.08	1361.55	2924.21	2346.97	1628.18	3319.66
2012-13	2966.3	3324.57	2527.78	2442.06	1613.5	3137.55	2384.41	1910.96	3450.86
2013-14	2901.85	2424.74	2738.67	2520.97	1959.79	3052.13	2622.76	2970.89	4174.49
2014-15	3379.81	2859.81	3978.48	2993.99	4376.33	3522.35	2714.62	2951.52	2950.65
2015-16	3677.88	3010.65	4964.75	3592.41	4383.59	3508.59	6032.17	3065.29	3149.8
2016-17	2953.76	2947.99	2916.36	2673.15	4072.51	3173.22	2513.75	3460.65	4860.9
2017-18	4074.26	2926.67	3096.89	3246.87	3027.87	4327.70	2701.41	2985.30	5186.53
CAGR	10.70	8.10	9.40	7.90	5.70	7.20	8.30	9.60	8.00

From Table No. 2, it can be concluded that after the introduction of Bt cotton in India, the cost of production decreased in the states of Gujarat, Haryana, Karnataka, and Madhya Pradesh, while it increased in Andhra Pradesh, Punjab, Rajasthan, and Tamil Nadu. Before the introduction of Bt cotton, Gujarat had the highest cost of production, whereas Rajasthan had the lowest. After the introduction of Bt cotton, the highest cost of production was observed in Andhra Pradesh, and the lowest was recorded in Madhya Pradesh.

**Fig 3:** State wise CAGR of cost of production before and after introduction of Bt cotton in India**Table 3:** State wise Farm Harvest Prices of cotton before and after introduction of Bt cotton

Year	Combined Andhra Pradesh	Gujarat	Haryana	Karnataka	Madhya Pradesh	Punjab	Rajasthan	Tamil Nadu
1997-98	1973	1754	1839	1887	2123	1569	1817	1772
1998-99	1987	1585	1936	1808	2052	1775	1935	1732
1999-2000	1902	1792	1741	1789	1878	1440	1758	1711
2000-01	2141	1689	1881	2448	2066	1563	1561	1726
2001-02	1737	1533	1525	1643	1685	1824	1816	1550
CAGR	-1.80	-2.00	-4.00	0.30	-4.50	1.80	-2.10	-2.70
2002-03	1903	1754	1751	2055	1998	1854	1829	1757
2003-04	2356	1879	1750	1714	2489	1911	2080	1923
2004-05	1697	1927	1688	1885	1852	1825	1978	1496
2005-06	1925	1684	1885	1432	2036	1868	1718	1574
2006-07	1936	1850	2399	2102	2159	2070	1890	1524
2007-08	2063	2700	2533	2587	2399	2298	2133	2157
2008-09	2763	2056	2631	2515	2714	2266	3152	2848
2009-10	2965	2964	2934	2501	3041	4333	3058	2933
2010-11	4176	2717	4513	4573	4216	3792	4125	3081
2011-12	3682	2445	5516	3835	3876	4273	4503	3142
2012-13	3560	4094	4130	4203	3943	3372	4342	3912
2013-14	4974	4170	5129	4245	4460	4681	4823	4546
2014-15	3737	4068	4963	4127	3912	3688	4407	3801
2015-16	4035	4078	5021	4415	4286	4240	4565	4326
2016-17	4498	4822	5190	5244	4106	4500	4955	4988
CAGR	7.60	8.00	10.10	8.90	6.80	7.90	9.00	9.20

Before the introduction of Bt cotton in India, farm harvest prices exhibited a negative growth rate in the states of Andhra Pradesh, Gujarat, Haryana, Madhya Pradesh, Rajasthan, and Tamil Nadu, with rates of -1.80%, -2.00%, -4.00%, -4.50%, -2.10%, and -2.70%, respectively. In contrast, Karnataka and Punjab showed positive growth rates of 0.30% and 1.80%, respectively. After the introduction of Bt cotton, farm harvest prices demonstrated positive growth rates across all states: Andhra Pradesh (7.60%), Gujarat (8.00%), Haryana (10.10%), Karnataka (8.90%), Madhya Pradesh (6.80%), Punjab (7.90%), Rajasthan (9.00%), and Tamil Nadu (9.20%).

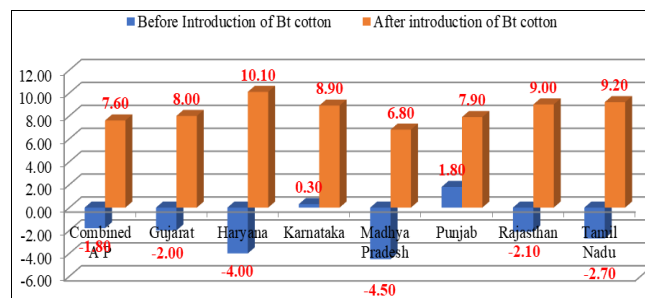


Fig 4: State wise Farm Harvest Prices of cotton before and after introduction of Bt cotton

Table No. 4: CAGR for state wise farm harvest prices and cost of production cotton in India from 1996-97 to 2016-17.

	Andhra Pradesh	Gujarat	Haryana	Karnataka	Madhya Pradesh	Punjab	Rajasthan	Tamil Nadu
Cost of Production	6.5	5.2	5.8	4.8	3.7	3.4	7	5.6
Farm Harvest Prices	5.4	6.1	7.5	6.2	5.3	6.8	6.9	6.5

The compound annual growth rate (CAGR) for state-wise farm harvest prices and cost of production of cotton in India from 1996-97 to 2016-17 is presented in Table No. 4. The data indicates that the CAGR of the cost of production was higher in the states of Andhra Pradesh and Rajasthan compared to the CAGR of farm harvest prices. In the remaining states, the CAGR of farm harvest prices was higher than that of the cost of production. In terms of the cost of production, Rajasthan recorded the highest growth rate, while Punjab showed the lowest. Regarding farm harvest prices, Haryana exhibited the highest growth rate, and Madhya Pradesh recorded the lowest.

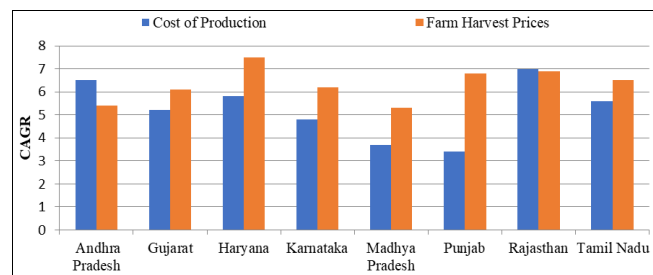


Fig 5: CAGR of State wise farm harvest prices and cost of production of cotton in India from 1996-97 to 2016-17.

Conclusion

The area, production, and productivity of cotton in India showed a significantly increasing trend after the introduction of Bt cotton (2002-03) compared to the period before its introduction. Following the adoption of Bt cotton, the cost of production decreased in the states of Gujarat, Haryana, Karnataka, and Madhya Pradesh, while it increased in Andhra Pradesh, Punjab, Rajasthan, and Tamil Nadu. Before the introduction of Bt cotton (1997-98 to 2001-02), farm harvest prices for cotton were predominantly negative in the states of Andhra Pradesh, Gujarat, Haryana, Madhya Pradesh, Rajasthan, and Tamil Nadu, with rates of -1.80%, -2.00%, -4.00%, -4.50%, -2.10%, and -2.70%, respectively. In contrast, Karnataka and Punjab recorded positive growth rates of 0.30% and 1.80%, respectively. The compound annual growth rate (CAGR) analysis revealed that the cost of production grew at a higher rate than farm harvest prices in Andhra Pradesh and Rajasthan. In the remaining states, the CAGR of farm harvest prices exceeded

that of the cost of production. Rajasthan exhibited the highest growth rate in cost of production, while Punjab had the lowest. In terms of farm harvest prices, Haryana recorded the highest growth rate, and Madhya Pradesh had the lowest.

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