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# Growth rates and decomposition analysis of cotton production in Maharashtra

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**Abstract**
Maharashtra is one of India's most important cotton-producing states, ranking first in production and area. An investigation was conducted to investigate the growth performance, instability, and decomposition of cotton in the state from 1960–61 to 2021–22. Cotton growth and instability were also studied during the pre-introduction (1982-83 to 2001-02) and post-introduction of Bt cotton periods (2002-03 to 2021-22). Compound growth rates were estimated for this purpose by fitting the exponential function, and the coefficient of variation was calculated to determine instability. The cotton area and production increased significantly during the 1960s, 1990s, and 2000s. Cotton production and yield increased the most from 2000-01 to 2009-10. According to instability analysis, the cotton area was more stable than production and yield. The post-Bt introduction period saw higher growth in area, production, and yield than the pre-Bt introduction period. During this time, there was also a high level of instability, indicating that cotton production increased over time. According to the decomposition analysis, yield was one of the most important factors in the overall growth of cotton production, followed by the interaction effect. Improvements in cotton area, yield, and production in Maharashtra have increased due to favorable climatic conditions, improved farming practices, and faster technology transfer. As a result, the paper suggests that policies be implemented to reduce risk in cotton production through proper technology transfer and extension services. It also says that the high growth rate of the past few years should be kept up by making cotton production profitable.

**Keywords:** Coefficient of variance, cotton production, decomposition analysis, growth rates, instability

## Introduction
Cotton is one of India's most important cash crops and accounts for approximately 22 percent of global fibre production (www.cotcorp.org.in). In India, it is also one of the most important commercial crops. Cotton constitutes approximately 59% of the Indian textile industry's raw material consumption basket. Annual cotton consumption exceeds 300 million bales (170 kg each) (Fernandes, 2022) [4]. It is crucial to the sustenance of an estimated 5.8 million cotton farmers and 40–50 million people engaged in cotton processing and trade. India has the largest cotton cultivation area in the world, accounting for between 12.0 million and 13.5 million hectares, or approximately 37% of the global cotton cultivation area (www.cotcorp.org.in).
India cultivates all four types of cultivated cotton, including Gossypium arboreum and herbaceum (Asian cotton), G. barbadense (Egyptian cotton), and G. hirsutum (American Upland cotton). Gossypium hirsutum accounts for over 95% of India's hybrid cotton production, and all current Bt cotton hybrids are G. hirsutum. G. hirsutum is the dominant species, accounting for more than 90% of global production. Arboreum and harbaceum cover less than 5% of the land, and barbadense is so rare that it is almost nonexistent (Anonymous, 2017) [8].
The majority of India's cotton production comes from nine major cotton-growing states, which are grouped into three distinct agro-ecological zones: the northern zone consisting of Punjab, Haryana, and Rajasthan; the central zone consisting of Gujarat, Maharashtra, and Madhya Pradesh; and the southern zone consisting of Telangana, Andhra Pradesh, and Karnataka. Additionally, cotton is grown in the Indian states of Tamil Nadu and Orissa. Small areas in non-traditional states, such as Uttar Pradesh, West Bengal, Tripura, etc., have also witnessed an increase in cotton cultivation. Cotton production and productivity in India have increased significantly over the past few decades. India is one of the world's largest cotton producers, accounting for approximately 22% of global cotton production. The current yield per hectare, 469 kg/ha, is lower than the global average yield of approximately 787 kg/ha (www.cotcorp.org.in). India is now one of the world's largest cotton consumers, accounting for approximately 22% of global cotton consumption.

Maharashtra has the most cotton acreage (39.41 lakh ha), followed by Gujarat (22.51 lakh ha), Telangana (18.78 lakh ha), Rajasthan (7.08 lakh ha), and Haryana (6.88 lakh ha) (www.pjtsau.edu.in). Cotton is grown on 42 lakh hectares in Maharashtra, with 85 lakh bales production. Maharashtra accounts for more than one-third of the cotton area and nearly one-fifth of the cotton production in India. The state's average yield is 398 kg/ha (www.cotcorp.gov.in). Despite being the country's largest cotton growing state, cotton productivity is low when compared to other leading cotton-growing states. The main reason for Maharashtra's low cotton productivity is its large-scale rainfed cultivation (97 percent).

In 2002-03, Bt cotton was made available for commercial cultivation in Maharashtra. Since the introduction of Bt Cotton technology, it has emerged as a viable alternative to traditional cotton varieties by preventing bollworm infestation and enhancing crop yield and revenue. This has accelerated the adoption of Bt cotton as opposed to conventional cotton. The introduction of Bt cotton has significantly increased cotton production in Maharashtra (www.nfsm.gov.in). BT cotton now comprises 95% of the state's total cotton acreage. These changes highlight the significance of examining the growth performance and instability of cotton before and after the introduction of Bt cotton. The present study was conducted in order to analyze the growth and instability of cotton area, production, and yield from 1960-1961 to 2021-2022.

## Methodology

The current study is based on secondary data and covers the years 1960–1961 to 2021–221. The Cotton Advisory Board, the Ministry of Agriculture, and Epitome of Maharashtra provided data on the area, production, and yield of Maharashtra's cotton crop. The period of analysis is 1960–1961 to 2021–22. The entire period was divided into six ten-year sub-periods. To study growth before and after the introduction of Bt cotton, the period from 1982-83 to 2001-02 was used as the pre-introduction of Bt cotton period, and the period from 2002-03 to 2021-22 as the post-introduction of Bt cotton period.

## Analytical Procedures

In order to examine the growth performance and instability in area, production and yield of cotton in Maharashtra were worked out for different periods as well as for entire period of analysis.

## Growth Trend

Growth rates are calculated to examine the tendency of a variable to increase, decrease, or remain constant over time. It also indicates the magnitude of the variable under consideration's rate of change per unit of time. The compound growth was used in this study to estimate the growth in cotton area, production, and yield. The function's exponential form is as follows:

$$X_t = ab^t$$

$$\text{Log } X_t = \text{Log } a + t \log b$$

$$B = (1 + r) / 100$$

Where,
$X_t$ = Area/Production/Yield of cotton in the year 't'
t= time element which takes the value 1, 2, 3, ……n
a = intercept
b = regression coefficient
Compound growth rate was worked out as follows:
CGR (r) = (antilog b -1) x 100
Student 't' test was used to test the significance of the CGR.

## Measurement of Instability

An index of instability was computed for examining the nature and degree of instability in area, production and yield of cotton in Maharashtra. It was analyzed by estimating coefficient of variation (C V) using the formula.

$$CV = (\sigma / \mu) \times 100$$

Where,
σ = Standard deviation
μ = Mean

## Decomposition Analysis

The decomposition method of growth trend was first presented by Minhas and Vaidyanathan (1965) [6]. They estimated the change in the value of agricultural output by segregating the changes into three major factors: area, yield and interactions. They have used the additive method for working out the effects of the three factors. To estimate the effect of area, yield and their interaction on the overall growth performance of soybean production was estimated by using decomposition approach (Kalita, 2011) [5]. The algebraic form of equation is given below:

$$P = A_0 (Y_n - Y_0) + Y_0 (A_n - A_0) + \Delta A \Delta Y$$

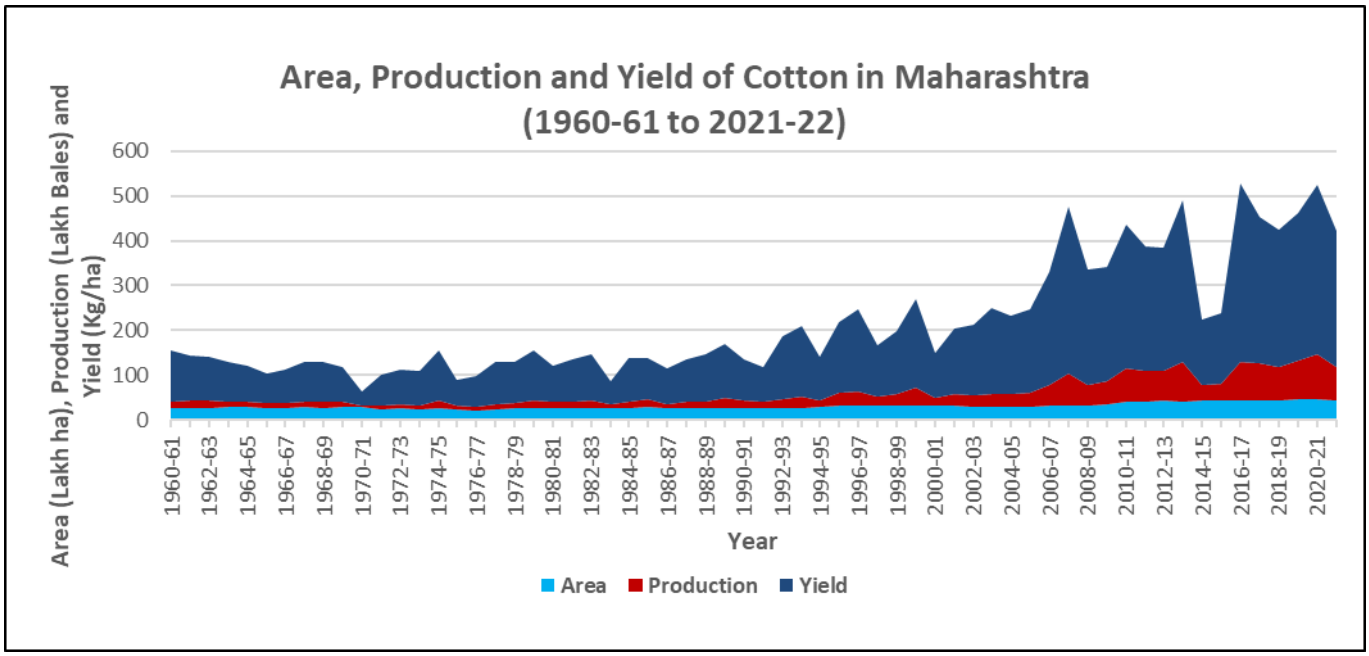
$$1 = [(Y_0 \Delta A)/P] + [(A_0 \Delta Y)/P] + [(\Delta A \Delta Y)/P]$$

Where,
P = Change in production
$A_0$ = Area in base year
$A_n$ = Area in current year
$Y_0$ = Yield in base year
$Y_n$ = Yield in current year
$\Delta A$ = Change in area ($A_n - A_0$)
$\Delta Y$ = Change in yield ($Y_n - Y_0$)

## Results and Discussion

### Cotton area, production and yield scenario during 1960-61 to 2021-2022

The area, production, and yield of cotton in Maharashtra from 1960-61 to 2021-22 are presented in figure 1. In Maharashtra, cotton cultivation began on 25 lakh hectares in 1960–1961 and eventually expanded to 30.77 lakh hectares in 2000–01 and 41.82 lakh hectares in 2021–2022. The analysis period saw a nearly four-fold increase in cotton production. Production of cotton during 1960-61 was 16.72 lakh bales. In 2021-22, the production of cotton was 75.28 lakh bales in Maharashtra. After 2000–01, Maharashtra saw an increase in cotton production. Due to drought conditions in Maharashtra in 2014–15, cotton production decreased to 39.14 lakh bales in 2015–16 from 74.72 lakh bales in 2010–11. Over time, there has been a noticeable increase in cotton yield. Between 1960–1961 and 2021–2022, the average cotton productivity increased from 114 kg/ha to 306 kg/ha. Area, production, and yield increases became more noticeable after 2002–2003.




**Source:** www.cicr.org.in and www.krishi.maharashtra.gov.in

**Fig 1:** Area, Production and Yield of Cotton in Maharashtra

**Growth rate of Area, Production and Yield in Maharashtra**

Table 1 displays the decadal growth rates of cotton area, production, and yield. Cotton's growth rate was negative for three decades. However, t-values revealed that this negative growth was statistically insignificant in terms of area but statistically significant in terms of production and yield. Growth rate was positive in other periods as well as overall period. Cotton area increased significantly between 1961 and 1970, 1991 and 2000, 2001 and 2010, and 2011 and 22; the respective growth rates were 0.77, 2.67, 1.22, and 0.74 percent. The cotton area growth rate was not significant during other periods. Cotton area growth was positive and significant over the entire period.

From 1961-1970, cotton production experienced a significant decline, whereas from 1971-1980, 1991-2000, and 2001-2010 it increased significantly. The cotton production growth rate was highest between 2001-2010. In Maharashtra, cotton production increased from 2011-2012, but the increase was not statistically significant. During the entire period of analysis, cotton production increased at a rate of 3.70 percent per year.

With the exception of the 1961-1970 period, which experienced a negative growth rate, cotton yield increased during each period. All decades with a positive growth rate were statistically significant, with the exception of 1981-90 and 2011-22. During 2001-2010, yield growth was greatest. Due to the introduction of Bt cotton, cotton yield increased at a rate of 11.18 percent per year during this time period. The growth rate for the entire period was also significant and positive. During the entire period, yield increased at a rate of 2.74 percent per year.

**Table 1:** Trend in Growth Rate of Area, Production and Yield in Maharashtra

| Period | Area | Production | Yield |
|---|---|---|---|
| 1960-61 to 1969-70 | 0.77* (1.9737) | -3.49** (-2.3026) | -3.43** (-2.6059) |
| 1970-71 to 1979-80 | -0.65 (-0.7103) | 8.44** (2.3441) | 8.41** (2.4269) |
| 1980-81 to 1989-90 | -0.33 (-1.2797) | 2.86 (0.8069) | 3.38 (1.3789) |
| 1990-91 to 1999-00 | 2.67*** (5.2133) | 9.56*** (3.3769) | 6.87** (2.4559) |
| 2000-01 to 2009-10 | 1.22* (1.8646) | 12.52*** (5.6929) | 11.18*** (5.1390) |
| 2010-11 to 2021-22 | 0.74*** (3.1885) | 2.82 (1.0432) | 2.10 (0.7682) |
| Overall (1960-61 to 2021-22) | 0.89*** (10.8912) | 3.70*** (13.4542) | 2.74*** (12.0216) |

***1 per cent Significance level; **5 per cent Significant level; *10 per cent Significant level.
Figures in parenthesis indicates t-value.

**Instability**

In Maharashtra, a coefficient for area, production, and yield of cotton was calculated and is shown in Table 2. The analysis shows that there was less instability in the cotton-growing region when compared to production and yield. The area had a coefficient of variation of only 21.25 percent, whereas production and yield had coefficients of variation of 84.0 percent and 62.25 percent, respectively. Cotton was the region with the least instability from 1981-1990, followed by 2011-22. 1991–2000 saw the highest levels, followed by 1971–80 and 2001–10. Cotton production was the most unstable from 2001-2010 and the least stable from 1961-1970. The highest yield coefficient was also found between 2001-2010, and then again between 1971-1980.

**Table 2:** Decade-wise Instability of Area, Production and Yield of Cotton in Maharashtra

| Period | Area | Production | Yield |
|---|---|---|---|
| 1960-61 to 1969-70 | 4.02 | 16.73 | 15.81 |
| 1970-71 to 1979-80 | 8.14 | 35.79 | 31.54 |
| 1980-81 to 1989-90 | 2.40 | 29.46 | 20.35 |
| 1990-91 to 1999-00 | 8.97 | 34.94 | 29.06 |
| 2000-01 to 2009-10 | 6.68 | 41.18 | 36.68 |
| 2010-11 to 2021-22 | 3.76 | 26.35 | 26.02 |
| Overall | 21.25 | 84.00 | 62.25 |

**Pre and Post-Bt Cotton in Maharashtra**

**Growth and Instability**

In Maharashtra, Bt cotton was made available for commercial cultivation in 2002–2003. The area, production, and yield of cotton significantly changed after the introduction of Bt hybrids for commercial cultivation. Table 3 displays a comparison of Maharashtra's growth rate before and after Bt cotton was introduced. According to the table, growth rate in area, production, and yield increased significantly after the introduction of Bt compared to the pre-Bt period. The growth in area, production and yield during post-Bt introduction were 2.85, 5.72 and 2.85 per cent respectively, as against the pre-Bt introduction of 1.13, 4.89 and 1.74 per cent.

**Table 3:** Growth rate of Area, Production and Yield of Cotton in Maharashtra – Before and After Introduction of Bt Cotton

| Period | Area | Production | Yield |
|---|---|---|---|
| Pre-Bt Introduction (1986-87 to 2001-02) | 1.13*** (5.4391) | 4.89 ** (4.1369) | 1.74 (0.8169) |
| Post-Bt Introduction (2002-03 to 2021-22) | 2.85*** (10.1916) | 5.72** (4.9035) | 2.85 ** (2.5633) |
| Overall (1986-87 to 2021-22) | 1.51*** (12.096) | 5.59 *** (13.7721) | 4.04*** (10.9156) |

***1 per cent Significance level; **5 per cent Significant level; *10 per cent Significant level.

Figures in parenthesis indicates t-value.

Table 4 shows the variability in cotton production, area, and yield in Maharashtra before and after the introduction of Bt cotton. Coefficient of variation which is the indicator of instability, for area, production and yield of cotton was higher in post-Bt introduction. Instability in cotton production peaked during the post-Bt period at 67.02 percent, with yield (51.06 percent) and area (20.28 percent).

**Table 4:** Instability in Area, Production and Yield of Cotton in India – Pre and Post Bt Introduction

| Period | Area | Production | Yield |
|---|---|---|---|
| Pre-Bt Introduction (1982-83 to 2001-02) | 8.52 | 38.94 | 29.47 |
| Post-Bt Introduction (2002-03 to 2021-22) | 17.09 | 39.28 | 31.82 |
| Overall (1982-83 to 2021-22) | 20.28 | 67.02 | 51.06 |

A decomposition analysis was conducted to ascertain how area, productivity, and their interaction contributed to the overall growth of cotton production in Maharashtra during the study period. According to the decomposition analysis of cotton growth, the increase in yield prior to the introduction of Bt was primarily caused by a yield effect of about 70.90 percent. The post-Bt period results also demonstrate that the main driver of output growth during that time was a yield effect of 45.78 percent. In both time periods, there was little interaction effect to increase cotton production in the state. The analysis suggested that the interaction effect contributed the most to the overall change in output growth, followed by the yield effect as one of the factors in the overall development of cotton production.

**Table 6:** Share of Area effect, Yield effect and Interaction effect on Production growth of Cotton

| Period | Area effect *(%)* | Yield effect *(%)* | Interaction effect *(%)* |
|---|---|---|---|
| Pre-Bt Introduction (1982-83 to 2001-02) | 16.87 | 70.90 | 12.22 |
| Post-Bt Introduction (2002-03 to 2021-22) | 29.27 | 45.78 | 24.95 |
| Overall (1982-83 to 2021-22) | 11.75 | 54.55 | 33.70 |

**Conclusion**

The analysis above shows that there was a significant increase in area, production, and yield, as well as a high growth rate during the post-Bt period. This might be because Bt cotton was introduced to Maharashtra in 2002-03. Additionally, there was a lot of instability during this time, which suggests that cotton production rose over time. An increase in cotton production, yield, and area in Maharashtra has been made possible by favorable climatic conditions, better farming techniques, and accelerated technology transfer. One of the crucial elements that affected the state's overall growth in cotton production during the study period in Maharashtra was the yield effect. The paper, therefore recommends that policies be created to lower the risk of cotton production through proper technology transfer, the provision of irrigation systems, the adoption of better technologies, and strengthening extension services. Also, it suggests that cotton production should be made profitable by lowering risks, so that stability can be reached and the fast growth rates of the past few years can be kept.

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