



## Growth and instability in cotton cultivation in punjab

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### Abstract

Cotton holds a paramount position as a commercial crop in India, particularly in the agricultural landscape of Punjab, where it is revered as 'white gold'. Cotton, often referred to as the "King of Fiber" crops, holds significant importance in both the global agricultural and industrial economies. In light of its relevance, this paper explores the growth and fluctuations in cotton cultivation in Punjab over the time period from 1994-95 to 2023-24. The study utilized secondary data regarding the Production, area, and yield of cotton. The performance of cotton cultivation is assessed using two key parameters: growth and instability. To estimate the compound annual growth rate, a log-linear model is applied to the data on cotton production, area and yield. The model was estimated using the Ordinary Least Squares (OLS) method. The growth instability was evaluated using the Cuddy-Della Valle instability Index.

The analysis revealed a negative compound annual growth rate for both cotton production and the area under cultivation, while the growth rate for cotton yield showed a positive trend during the period under study. In Punjab, the area devoted to cotton cultivation exhibited relatively low instability, whereas production and yield demonstrated significantly higher levels of instability.

**Keywords:** Growth, coefficient of Variation, instability, area and cotton

### Introduction

Cotton stands as one of the most crucial and extensively cultivated agricultural and industrial crops on a global scale. It finds production in more than 100 countries, emphasizing its widespread significance. Furthermore, cotton is a major player in international trade, being a heavily traded agricultural commodity involving over 150 countries. This widespread cultivation and trade highlight the versatile applications of cotton, not only as a raw material for textiles and industrial products but also as a key player in the global economic landscape.

The significance of cotton extends beyond its role in industrial production, as it directly sustains the livelihoods of approximately 6 million farmers in India. Moreover, the cotton trade and its processing provide employment opportunities for an extensive workforce, with an estimated 40-50 million people involved in these activities. Cotton is a versatile crop that produces five essential products: lint, seed meal, hulls, oil, and linters. Its diverse applications and high industrial demand contribute to its popularity among the farming community. "Cotton (*Gossypium* sp.) is a member of the Malvaceae family, the earliest fiber used by humans, and one of the world's most important commercial and domesticated plants" (Jadav *et al.*, 2020). In India, cotton cultivation dates back to pre-historic times. India was the country to manufacture and cultivate cotton on a large scale. "We get clear evidence from the excavations of Mohenjodaro that cultivation and manufacturing of cotton was there since the beginning of the Indus Valley Civilization" (Sankar, 2006) [7].

Punjab is among one of the most agriculturally productive regions globally, making it well-suited for cultivating cotton, wheat, Maze, rice, sugarcane, fruits, and vegetables. "Punjab is called the 'Granary of India' or India's bread-basket" (Yadav, 2013) [10].

The main irrigation sources in Punjab are tube wells and canals. Agriculture in the region mainly revolves around

two types of crops: Kharif and Rabi. Maize, cotton, peas, bajra, jowar, rice, sugarcane, and pulses are the primary kharif crops in Punjab. Gram, barley, wheat, fodder crops, potatoes, and oilseeds are the main Rabi crops in Punjab.

"The agricultural environment in Punjab makes cotton a highly valued commercial commodity, known as 'white gold' In Punjab's southwest areas, this cash crop primarily serves as the Kharif crop and is essential to the states' industrial and agricultural industries. Cotton serves as the fundamental raw material for the thriving cotton textile industry" (Khurana, 2009) [5].

"The productivity of this crop has experienced significant fluctuations in the state, primarily influenced by the uncertainties of the monsoon. The cultivation of cotton is closely tied to seasonal conditions, particularly during the southwest monsoon period. The cotton belt, encompassing approximately 30 percent of the state's geographical area, predominantly includes Bathinda, Mansa, Sri Muktsar Sahib, Faridkot, Moga, Ferozepur, Patiala, and Sangrur districts in Punjab" (Government of Punjab, 2011) [2].

"Cotton cultivation in Punjab occurs under irrigated conditions, with the state historically dedicating about one-sixth of its total cultivation area to cotton. Despite this relatively smaller proportion, Punjab contributes significantly, accounting for 8 to 13 percent of the national cotton production" (Singh, 2009) [8].

"The introduction of BT (*Bacillus Thuringiensis*) cotton in India, a genetically modified hybrid cotton seed is a major breakthrough in cotton production. These seeds have pest resistance quality. BT cotton seeds were officially approved for commercial production by the Government of India in March 2005 in Punjab" (Gill *et al.*, 2010) [3].

"Research indicated that the diminished economic productivity in agriculture, attributed to the dearth of technology, insufficient division of labour, and inadequate investments in the agriculture sector, also affected the cotton production" (Khurana, 2009) [5].

“In 2023-24, the area under cotton cultivation in Punjab decreased to 2.14 lakh hectares compared to the previous year, 2022-23. Gujarat ranked first among all states in cotton production with 90.57 lakh bales, followed by Maharashtra with 80.45 lakh bales and Telangana with 50.80 lakh bales. Punjab's cotton production was significantly lower, totaling only 6.29 lakh bales” (CAB, 2024).

In addition, Punjab's average cotton productivity is low when compared to states like Gujarat and Orissa. Therefore, this study aimed to evaluate the trends and fluctuations in cotton production, yield, and cultivated area in Punjab.

**Objectives**

- To analyze the growth patterns of the yield, area and production of cotton in Punjab.
- To find out the growth instability in cotton cultivation in Punjab.

**Data and Research Methodology**

To analyze the growth trends, variability, and instability of cotton cultivation in Punjab, various statistical measures, including the coefficient of variation, mean, instability index and compound annual growth rate were employed. This study analyzed the area under cotton cultivation, as well as its production and yield, over the entire study period.

To achieve this, secondary data on cotton production, yield, and cultivated area in Punjab were obtained from the Cotton Advisory Board/COCPC for the period spanning 1994–1995 to 2023–2024 [1].

**Growth Rates**

The compound annual growth rate (CGR) was determined using log-linear models to analyze the trends in cotton area, production, and yield in Punjab. Particularly, the exponential model was used. The growth model was transformed into a semi-logarithmic form. This model was estimated using the Ordinary Least Squares (OLS) method, assuming an error term with a multiplicative structure to compute the compound growth rate. Thus, a log-linear estimation method was used to solve the exponential model with multiplicative error terms, employing the exponential growth function as follows:

**The following regression equation was used:**

$$Y_t = a + \beta t + \mu \tag{1}$$

In equation (1)

$Y_t$  = area/production/yield of cotton

a = constant

t = time variable (1, 2, 3, ..., n)

b = regression coefficient that represents the rate of change or growth in the series

The average annual compound growth rates for yield, production, and area will be examined by using.

**Annual compound growth rate:** Antilog (b) = Antilog of the logarithm of (1 + r)

Antilog (b) = 1+r

R = Antilog (b)-1

R = CAGR% = (Antilog (b)-1) x 100

To assess the significance of the regression coefficients, a standard t-test procedure is used. The parameters of the equation were estimated using the Ordinary Least Squares (OLS) method. CAGR indicates the rate of compound annual growth over the specified period

**Instability Analysis**

To calculate the instability in the Cotton area, production, and yield, the Cuddy-Della Valle index was applied in this study. This measure is an enhanced version of the Coefficient of Variation, specifically adjusted to account for patterns observed in time-series economic data. “The Cuddy-Della index considered more effective than other scale-dependent measures, such as Root Mean Square Error (RMSE) or Standard Deviation, derived from fitted trend lines of raw data, making it more appropriate for cross-comparison purposes” (Jadhav *et al.*, 2020) [4]. The Index is calculated as follows:

$$\text{Instability Index (CD)} = CV \times \sqrt{1 - r^2}$$

CV stands for the coefficient of variation of the variable.

R<sup>2</sup> denotes the adjusted multiple determination coefficient.

The standard statistical tool, i.e., the coefficient of variation, is used to calculate the instability of a specific aspect when the trends in time series data are non-significant.

The formula used to calculate the coefficient of variation is as follows:

$$CV (\%) = \frac{\sigma}{\mu} \times 100$$

σ: - represents the standard deviation of the variable

μ: - represents the mean of the variable.

**Results and Discussions**

**India s’ scenario**

The performance of each commodity contributing to agricultural output should be measured through the analysis of area, production, and yield growth rates. Table 1 illustrates the growth pattern in the cotton area, along with the production and yield of cotton in India from 1994-95 to 2023-24. There was a steady increase in both yield and production up to 2017-18. However, in 2018-19, a decline in production and yield was observed. Following this decline, a resurgence in cotton production and yield occurred from 2019 onwards. Prior to the introduction of BT cotton, yields were lower; however, after its introduction, cotton yields gradually increased until 2017-18. The highest cotton production during the period under study was recorded in 2013-14 at 398 lakh bales, whereas the lowest production was noted in 2002-03. Similarly, the highest yield was observed in 2013-14 at 565 kg per hectare, while the lowest yield was recorded in 2000-01 at 278 kg per hectare.

**Table 1:** Trends in Area, Production and Yield of Cotton in India

Years	Area (in lakh hectares)	Production (in lakh bales)	Yield (in kgs)
1994-95	79.21	138.90	298
1995-96	90.68	156.50	293
1996-97	91.70	176.50	330

1997-98	89.00	158.00	302
1998-99	92.9	165.00	305
1999-2000	87.30	156.00	304
2000-01	85.80	140.0	278
2001-02	87.00	158.00	308
2002-03	76.7	136.00	302
2003-04	76.00	179.0	404
2004-05	87.9	243.00	470
2005-06	88.20	244.00	478
2006-07	91.40	280.00	521
2007-08	94.14	307.00	554
2008-09	94.06	290.00	524
2009-10	103.10	305.00	502
2010-11	112.35	339.10	513
2011-12	121.78	367.00	512
2012-13	119.78	370.00	525
2013-14	119.60	398.00	565
2014-15	128.46	386.00	510.82
2015-16	122.92	332.00	459.16
2016-17	108.26	345.00	541.75
2017-18	124.44	370.00	505.46
2018-19	126.14	280.42	378
2019-20	134.77	360.65	455
2020-21	132.85	352.48	451
2021-22	123.72	311.18	428
2022-23	129.27	336.60	443
2023-24	126.88	325.22	436

Source: Cotton Advisory Board/COCPC

As indicated in Table 1, the highest area under cotton cultivation was recorded in 2019-20 at 134.77 lakh hectares, while the lowest was in 2003-04 at 76.00 lakh hectares. It is evident that there was a gradual decrease in the area under cotton cultivation up to 2003-04, with slight exceptions in 1998-99 and 2001-02. A slight increase in the area was observed in 2004-05, reaching its peak of 134.77 lakh hectares in 2019-20. Following that, the area gradually began to decline.

Cotton's area, output, and yield compound growth rates from 1994–1995 to 2023–2024 were calculated and are shown in Table 2. The area under cotton cultivation rose from 79.21 lakh hectares to 126.88 lakh hectares during the period under study. The cotton area shows positive and significant growth. The compound annual growth rate of cotton's area was calculated at 1.87%. Cotton production

rose from 138.90 lakh bales in 1994-95 to 325.22 lakh bales at the end of the period under study, showing a growth rate of 3.69% per year. The total cotton yield in India rose from 298 kg per hectare in 1994-95 to 436 kg per hectare in 2023-24, with a growth rate of 1.77% per year. The outcomes of the study showed that positive growth in cotton production during the period under study, primarily driven by the increased area under cotton cultivation. Although cotton yield exhibited positive growth. The expansion in area during the period under study was largely attributed to the introduction of genetically modified BT cotton, along with the adoption of crop development initiatives, the distribution of high-yield BT cotton varieties to farmers, and enhanced Minimum Support Prices (MSP), which further facilitated the growth of cotton cultivation in India.

Table 2: Growth in Area, Production and Yield of Cotton in India

Particulars	Area	Production	Yield
Beginning year (1994-95)	79.21	138.90	298
End year (2023-24)	126.88	325.22	436
Observation	30	30	30
Mean	104.87	270	429.87
CGR	1.87***	3.69***	1.77***
SE	0.184	0.415	0.3833
“t” Value	10.03	8.71	4.58

Note: Area in Lakh hectares; Production in Lakh bales; Yield kg per hectare.

To assess the level fluctuations in cotton area were evaluated using the Cuddy-Della Valle Index. The measures

of instability for cotton area, production, and yield in India during period under study are displayed in Table 3.

Table 3: Instability in Area, Production and Yield of Cotton in India

Particulars	Area	Production	Yield
CV	0.182	0.33	0.22
CD	0.086	0.174	0.17

Table 3 clearly shows that the coefficient of variation of the cotton area was 18.20%, while the instability Index Cuddy-Della Valle (CDI) was 8.60% during the period under study. For cotton production, the coefficient of variation was 33.00%, and for cotton yield, it was 22.00%. The instability index Cuddy-Della Valle (CDI) for production was 17.40%, and for yield, it was 17.00%. Table 2 highlights that during the period under study the coefficient of variation (CV) for cotton area was significantly lower compared to yield and production. Additionally, instability in cotton area was

lower than that in production and yield during the study period.

**Punjab Scenario**

The performance of each commodity contributing to agricultural output should be measured through the analysis of area, production, and yield growth rates. The Cotton's area, output, and yield compound growth rates from 1994–1995 to 2023–2024 were calculated and shown in Table 4.

**Table 4:** Growth in Area, Production and Yield of Cotton in Punjab

Particulars	Area	Production	Yield
Beginning year (1994-95)	6.06	14.50	407
End year (2023-24)	2.14	6.29	500
Observation	30	30	30
Mean	4.66	12.94	491
CGR	-3.63***	-0.90	2.85***
SE	0.38	1	0.8
“t” Value	-9.74	-0.90	3.56

**Note:** Area in Lakhs hectare; Production in Lakhs bales; Yield kg per hectare.

Cotton production declined from 14.50 lakh bales in 1994-95 to 6.29 lakh bales by the end of the study period. The compound annual growth rate of production during this period was estimated at -0.90%. Similarly, the area under cotton cultivation decreased from 6.06 lakh hectares to 2.14 lakh hectares, indicating negative but significant growth. The growth rate (CGR) of the cotton area was calculated at -3.63% annually. On the other hand, cotton yield demonstrated a positive and significant growth trend. The yield increased from 407 kg per hectare to 500 kg per hectare throughout the study period in Punjab. The compound annual growth rate (CGR) of yield was found to be 2.85% per year.

The results indicated negative growth in cotton production during the period under study. This decline in production was primarily due to a reduction in the area under cultivation. Additionally, cotton yield showed a negative

growth trend after 2019-20, with the exception of 2023-24. However, the yield growth rate demonstrated a positive and significant trend. The area displayed variability throughout the study period, with the highest area under cotton cultivation recorded in 1995-96. Following this peak, the area began to decline. The expansion of the area between 2003-04 and 2007-08 was largely attributed to the introduction of genetically modified BT cotton, the distribution of high-yielding BT cotton varieties to farmers, and the implementation of crop development programs. Post-2007-08, the area experienced a significant decline. The level of instability in cotton cultivation area in Punjab was assessed using the Cuddy-Della Valle Instability Index. The measures of instability for cotton area, production, and yield in Punjab during the study period are shown in Table 5.

**Table 5:** Instability in Area, Production and yield of cotton in Punjab

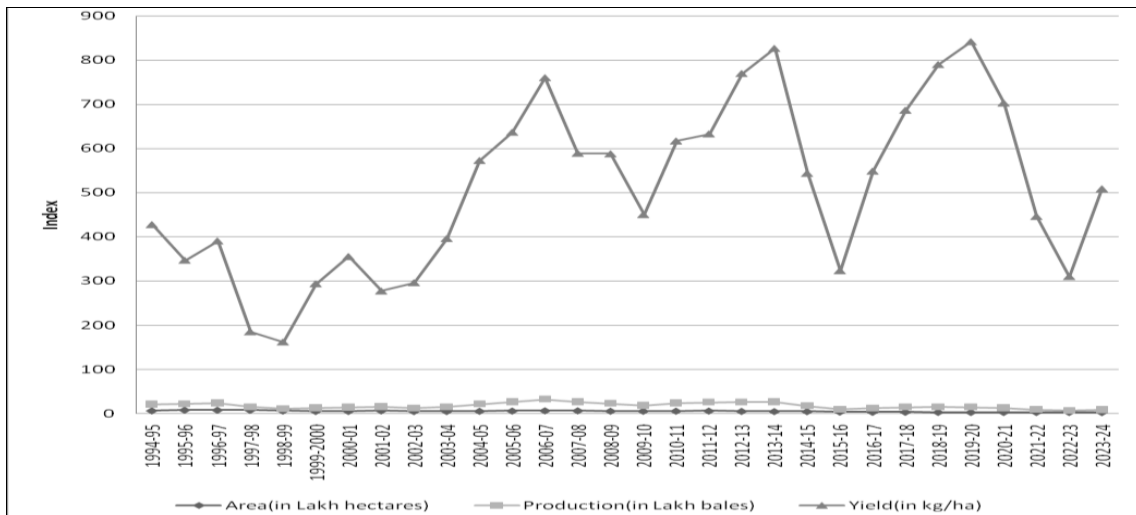
Particulars	Area	Production	Yield
CV	0.33	0.44	0.39
CDI	0.16	0.44	0.33

As shown in Table 5, the coefficient of variation for the area under cotton cultivation was significantly lower at 33%, compared to 44% for production and 39% for yield. The instability index Cuddy-Della Valle (CDI) was estimated as 16% for the area, 44% for production, and 33% for yield, highlighting greater instability in the cotton production relative to cultivated area and yield during the period under study.

During the period under study, cotton production was more unstable than the area and yield in Punjab. The cotton production showed considerable variability and instability throughout the period under study, influenced by variations in both area and yield. The Cotton yield showed moderate fluctuations, reflecting consistent productivity improvements or steady farming practices. In contrast, the

area under cotton demonstrated relative stability with minimal fluctuations. Overall, while the cotton area experienced lower instability, production and yield of cotton were notably more instable. This suggests that advancements in yield and improvement in area under cotton cultivation may have mitigated some of the adverse impacts of fluctuations in production.

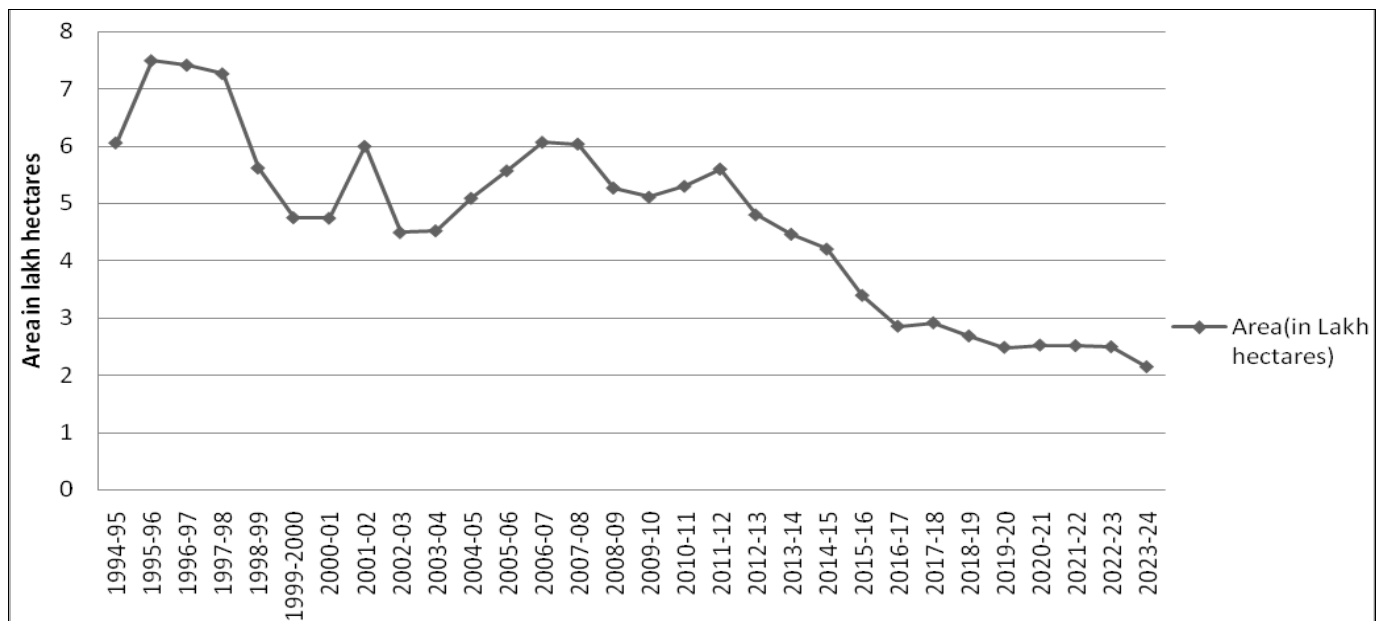
The patterns in cotton area, production, and yield of cotton in Punjab from 1994-95 to 2023-24 are depicted in Figure 1. The area under cotton cultivation increased steadily until 1997–98 but began to decline thereafter. Following the introduction of BT cotton (GM), the area under cultivation experienced resurgence, showing an upward trend. However, from 2006–07 onward, the area consistently declined until the end of the period analyzed.



**Fig 1:** Time Series Plot of Area, Production, and Yield of Cotton in Punjab

The introduction of BT cotton also had a notable impact on cotton yield and production. Prior to its adoption, yields were relatively low, but they gradually improved until 2013–14. Following a brief decline, yields increased again until 2019–20. Cotton production mirrored these trends, rising after the introduction of BT cotton until 2006–07, followed by a decline, then another increase. After 2013–14, however, production showed a steady downward trend due to reduced cultivation area and lower yields. Despite these developments, India’s cotton productivity remains significantly lower than that of other leading cotton-producing nations. Punjab, in particular, lags behind states like Gujarat and Orissa in terms of yield. This disparity is largely attributed to poor management practices, including delayed sowing, incorrect seed rates, inadequate pre-sowing treatments, and a lack of new cotton varieties tolerant to diseases and bollworm pests. The time series plots of cotton area, production, and yield in Punjab from 1994–95 to 2023–24 are shown in Figures 1, 2,

and 3, respectively. These figures reveal that the highest area under cotton cultivation was recorded in 1995–96, at 7.5 lakh hectares, while the lowest area was observed in 2023–24, at 2.14 lakh hectares. Punjab ranks as one of the largest cotton producers, contributing 12 percent to India’s total cotton production. Cotton production peaked in 2006–07, reaching 26 lakh bales, while the lowest production was recorded in 2022–23. During the period under study, the highest yield was achieved in 2019–20, at 827 kg per hectare, whereas the lowest yield was noted in 1998–99, at 151 kg per hectare. Figure 2 illustrates that the area under cotton cultivation was relatively high in 1995–96, at approximately 7.5 lakh hectares. A gradual decline in the area was observed up to 2016–17, with minor increases in 1996–97 and 1997–98. After 2018–19, the area stabilized at around 2 lakh hectares, with minimal variation in subsequent years. The area under cotton cultivation in Punjab began to decline after 2018-19 due to white fly and pink bollworm attacks on crop.



**Fig 2:** Time Series Plot of Cotton Area in Punjab

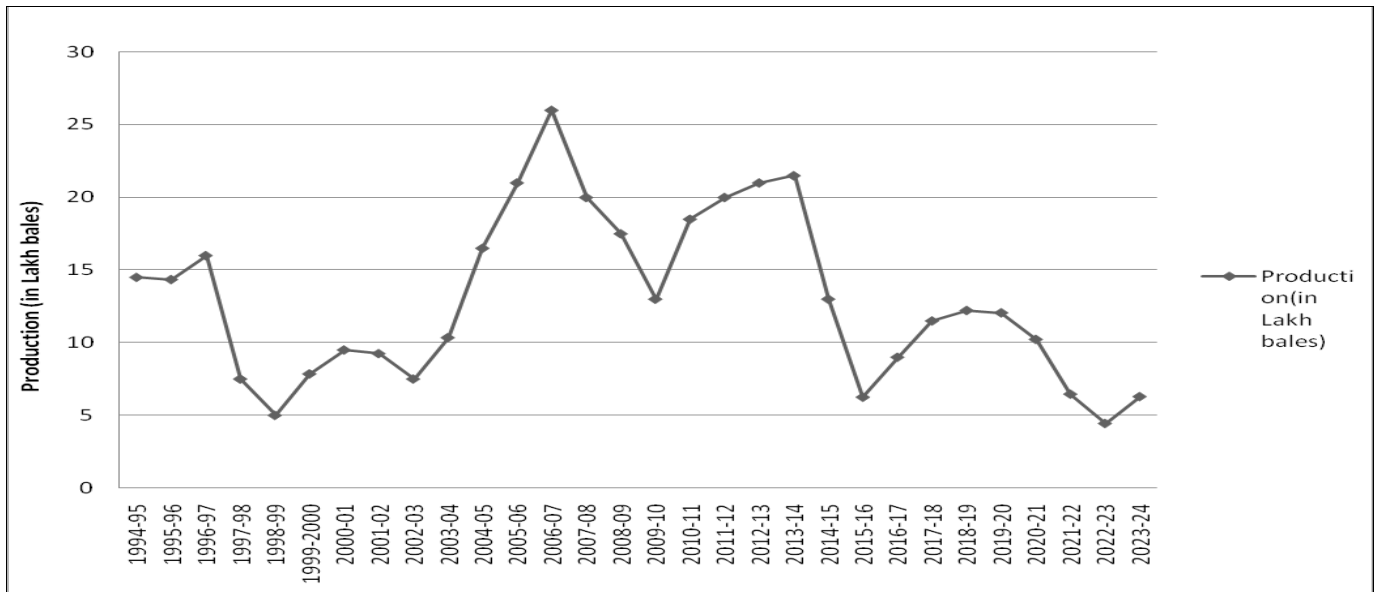


Fig 3: Time Series Plot of Production in Punjab

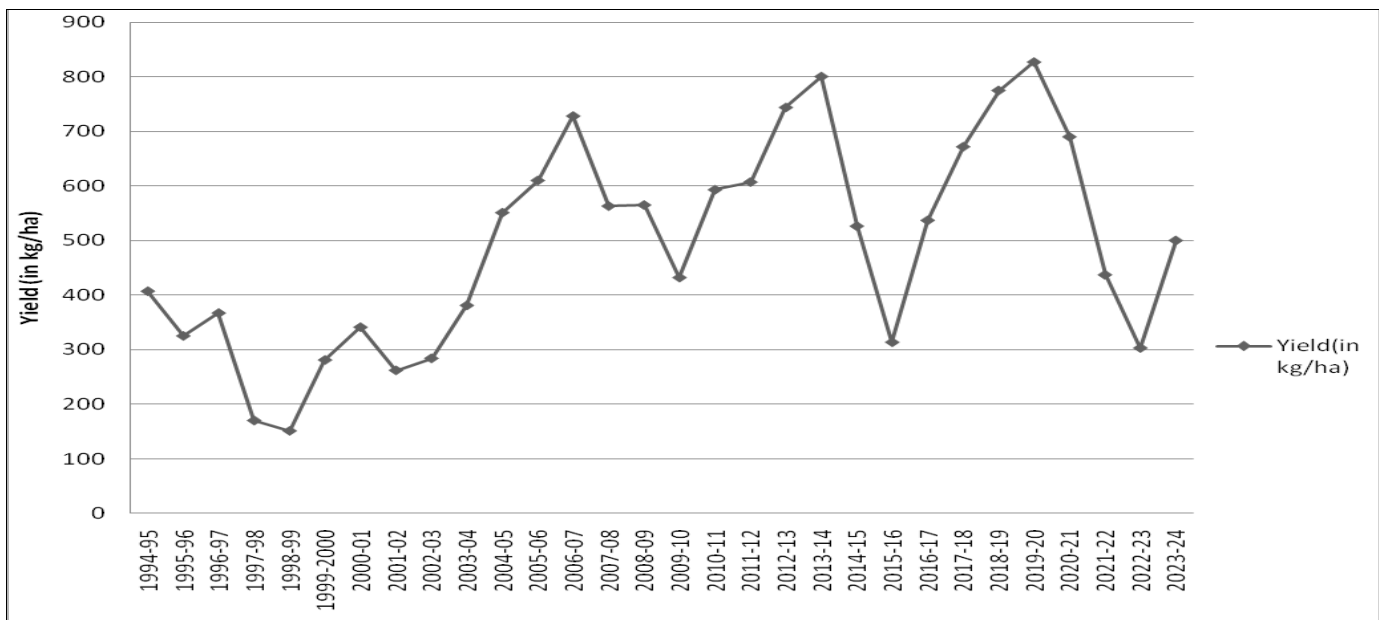


Fig 4: Time Series Plot of Cotton Yield in Punjab

The highest recorded area under cotton cultivation in 1995–96, was at 7.5 lakh hectares, while the lowest was in 2023–24, at 2.14 lakh hectares. During the period under study 1994–95 to 2023–24, cotton production declined by 2.3 times, and area decreased by 3 times. This notable reduction in area and production highlights the need to investigate underlying factors and adopt sustainable strategies to improve cotton cultivation. Punjab has lower per/hectare yield in comparison to Gujarat 574kg/ha and Orissa have 555kg/ha. The yield of cotton in Punjab was significantly affected by pests and diseases.

**Suggestions**

- Well-developed market should be available in the area under study.
- Ensure farming equipment access to small farmers at affordable rates and subsidies.
- Best pest control method should be developed and make it affordable for small farmers.

- Infrastructure should be well developed. Public as well as private investment should be promoted which may solve the problem of transportation and infrastructure.
- Farmers should get the price of their crop at the minimum support price which should be double than its cost. This will increase their income.
- Agro-processing units should be invested more and more in the rural areas. Because of that, they don't have to go far to sell the crop.

**Conclusion**

In conclusion, the discussion highlights that while the area under cotton cultivation in Punjab showed negative but statistically significant growth, production experienced negative and non-significant growth. However, the yield of cotton in Punjab showed a positive and statistically significant trend (i.e., -3.63%, -0.90%, and 2.85%, respectively). It is evident that India's cotton area, yield, and production growth rates are positive, whereas Punjab's area

and production growth rates are negative. India's overall performance with regard to area, production, and productivity of cotton is favorable and statistically significant (1.87%, 3.69%, and 1.77%, respectively).

Since 2011-12, the area under cotton cultivation has been declining in Punjab. The coefficient of variation for area is lower compared to production and yield. Instability in cotton area throughout the study period is less than that in production and yield across Punjab. Additionally, the coefficient of variation for cotton area, production, and yield in Punjab is higher than India's, indicating greater volatility in cotton cultivation in Punjab compared to the national level. Punjab also has a lower per-hectare yield compared to states like Gujarat and Orissa. The region faces severe attacks from pests and diseases, with pink bollworms and white flies being the most detrimental to cotton production in Punjab.

Therefore, it is important to promote sustainable cotton farming in Punjab through the adoption of productivity-enhancing practices, such as varietal improvement, efficient pest management, and the use of suitable technologies.

### References

1. Cotton Advisory Board COCPC. As per provisional report November 2024. Cotton Association of India, 2024. <https://caionline.in/>
2. Government of Punjab. Statistical Abstracts of Punjab. Economic and Statistical Organisation, Chandigarh, 2011.
3. Gill SS, Singh S, Brar JS. Economic and Environmental Sustainability of the Asian Region, Routledge India, 2010.
4. Jadhav DS, More SS, Choudhari SD, Chaudhari SA. Growth and instability in area, production, and yield of cotton in India. International Journal of Current Microbiology and Applied Sciences, 2020;11:1411–1417.
5. Khurana D. An economic analysis of cotton production in Punjab with special reference to BT cotton. Department of Rural Economics Co-operation, BV. Rural institute, Bichpuri, Agra, 2009, 123-125.
6. Narala A, Reddy AR. Analysis of growth and instability of cotton production in India. World Cotton Research Conference-5, Mumbai, India, 2011, 449-453.
7. Sankar SA. Economics of cotton farming a case study in Guntur district in Andhra Pradesh. Department of economics school of social and behavioural sciences, Shri Venkateswara University, Tirupati, 2006, 172-175.
8. Singh NB. *Revolution in Indian Cotton*. National center of integrated pest management ICAR, Pusa campus, New Delhi, 2009.
9. Sankar SA, Naidu VB. Growth and instability of cotton crop in major cotton growing states in India. International Journal of Advanced Educational Research, 2016;1(5):15-19.
10. Yadav K. Punjab- the leader in agriculture sector. Agropedia, 2013, 40-43.