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Performance of Indian Cotton Sector-An Econometric Analysis

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Cotton is a high commercial profile crop serving as a lifebelt crop for millions. It is a predominant crop under cultivation in a large spectrum since the ancient period. Globally it is a significant income earning crop hence aptly termed as White Gold. India is a leading cotton producer, exporter, and consumer in the world. It has surpassed China's cotton production in 2021 and stands first in world cotton production. But India's cotton productivity is 466 kg/ha very low than the global average cotton productivity; ranking 42nd in world productivity. Cotton is cultivated in an area of 12.35 million hectares with a production of 5.79 million metric tonnes. The present study aims in estimating the growth rate and the factors influencing cotton acreage and production in India for the last four decades of 1981-82 to 2020-21. The compound growth rate was examined using exponential growth function and instability by Cuddy Della Valle instability index in three different periods *i.e* Period I 1981-82 to 2001-02 (Pre introduction of *Bt*), Period II 2002-02 to 2020-21(Post introduction of *Bt*) and Overall period (1981-82 to 2020-21).The data used in current study is secondary in nature and collected from sources namely Directorate of Economics and statistics, India stat and from FAO. The acreage and supply response was estimated using the Nerlovian double-lagged adjustment model. The findings revealed that a higher growth rate and instability have been

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witnessed after the introduction of *Bt* technology in India which symbolizes the magnanimous role of *Bt* technology in the Indian cotton sector. The responsiveness of cotton area towards the lag cotton area, cotton MSP, rainfall and lagged export price stands significant whereas cotton supply response is highly triggered by lagged cotton production, rainfall and *Bt* technology.

Keywords: Cotton; growth rate; supply response; cuddy della valle instability index.

1. INTRODUCTION

Cotton is the most important natural fiber crop for textile production in the world, accounting for over half of all fibers. It is more essential than various synthetic fibers and it is cultivated in around 80 nations. It is distinctive amongst crops as it is the primary source of natural fiber and edible oil, as well as seed by-products for fodder purposes. It is a agro-industrial crop grown both in developed and developing nations. Clothing and home furnishings are made from cotton fibers [1]. India is predominantly an agricultural country and its economy is heavily reliant on agriculture. In a developing country like India, agricultural expansion is essential not only for achieving high overall development but for expediting poverty reduction. Cotton is grown in India on the area of the largest scale in the world. It is the most widely used textile fiber in the world, accounting for 35% of total fiber usage. Cotton was first cultivated by the residents of the Indus River Valley some 7,000 years ago. Cotton has long been regarded as the backbone of India's non-food crop agricultural economy [2]. Agriculture accounts for around a quarter of our country's Gross Domestic Product (GDP). Almost 75% of the nation's population resides in villages and relies on agriculture for a living. Because of its importance in agricultural and industrial economy around the world, it is aptly termed as "White Gold" or "King of Fibers." Cotton is one of India's most important and profitable cash crops [3]. Cotton cultivation, commerce, processing, manufacture, and marketing employ several million people [4]. Cotton is being used as surgical lint and for a variety of household purposes in addition to textiles. Cotton plant parts are used in the production of industrial products such as paper cardboard, by blotting paper, and so on. Cotton seeds have become more popular as a source of edible oil in recent years.Thus cotton plays an pivotal role in the Indian economy, as it contributes to human utilization in a multitude of ways. Despite having a variety of cotton cultivars and access to technology, India has not been able to reach sufficiency in terms of productivity. Its productivity lags well behind that of the world's main cotton producers. Cotton textile demand is steadily increasing over the world. India, as the world's leading cotton producer, has a huge chance to increase the cotton textile sector and enhance the Indian economy in the years ahead. India is the only country on the globe that grows all four cultivated cotton species, namely *G. hirustum*, *G. arboretum*, *G. herbaceaum* and *G. barbadense*. India is one of the most diverse cotton-growing countries in the world, with a wide range of soil and agro-climatic conditions that allow for the production of all cotton kinds and staple lengths. India, China, the United States, Pakistan, Brazil, Australia, Uzbekistan, Turkey, Turkmenistan, and Burkina Faso are major world cotton producers [5]. In this scenario, the objective of the current study is to examines the trend, growth rate, instability of cotton area, production , productivity and determines the factors influencing cotton acreage and production in India. As most of the past studies have been done on regional basis hence to know the macrolevel cotton performance the current study was undertaken. This study significantly helps in understanding cotton sector performance and also enables in tracking the problems and prospects pertaining to cotton in India.

2. MATERIALS AND METHODS

The present study completely relies on secondary data collected from various authenticated sources. The data on area, production, productivity, rainfall, Cotton MSP, and Export price were collected from India stat, Directorate of Economics and Statistics, and FAO. Data of a time series nature was collected and analyzed from 1981-82 to 2020-21 for three periods: Period I (1981-82 to 2001-02) before the introduction of *Bt* cotton, Period II (2002-03 to 2020-21) after the introduction of *Bt* cotton, and Overall period (1981-82 to 2020-21) for the nation as a whole. A brief description of tools employed in this study has been discussed below.

2.1 Compound Growth Rate

The exponential functional form of growth rate was used in this study as it gives the best results compared to other forms of linear and log-linear.

The compound growth rate of cotton area, production and productivity has been calculated using exponential form.

$Y_t = a\, b^t e^u$

Taking log on both sides

$\ln Y_t = \ln a + t \ln b + u$
$\ln b = \ln(1+r)$
$b = 1+r$
$r = b-1$
$r = [\text{antilog} \ln (b) -1]$

The Compound Growth Rate was calculated as

CGR %=r x 100

Y = Area, Production and Productivity of cotton for year t
t = time variable
a = constant
ln b = Regression coefficient of time
u = Error term
r = Compound Growth Rate

The significance of CGR is tested by using p-value at a significant level of 1 per cent, 5 per cent and 10 per cent.

2.2 Instability Analysis

The instability index can be measured using various methods. Cuddy-Della Valle index is one of the approaches used by the researchers (1978). The Coefficient of Variation (CV) can be used to calculate instability. CV, on the other hand, does not specify how the trend value is inherited in time series data [6]. As a result, Cuddy-Della Valle (1978) proposed an instability index, which clearly explains the trend value inherited in the time series data. Because many researchers have utilised the Cuddy-Della Valle index to evaluate variability in time series data in recent years, it was used in this study.

Instability Index = C.V $\sqrt{\mathbf{1-R^2}}$

C.V= Standard Deviation/ Mean X 100

Where,

CV- Coefficient of Variation
R^{2-} Adjusted R^2

2.3 Supply Response Analysis

In the present study the multiple Regression technique of the Nerlovian lagged adjustment model was used in double log form to analyse the acreage and supply response behaviour of cotton (Janaiah, et al., 1990). Nerlovian lagged adjustment model postulates that the actual acreage under a crop in each period is adjusted in proportion to the difference between the desired acreage in the long-run equilibrium and the actual acreage under it in the preceeding year. According to Nerlove, [7] mathematical expression is written as following.

The acreage response function is

$\text{Log } A_t = \log b_0 + b_1 \log A_{t-1} + b_2 \log P_t + b_3 \log RF_t + b_4 D_1 + b_5 \log EP_{t-1}$

Where,

A_t= Area of cotton crop in the current year (000 hectares)
A_{t-1}= Area of cotton crop lagged by one year (000 hectares)
Pt = MSP of cotton in current year (Rs/qtl)
RF_t = Actual Rainfall in the current year (mm)
D_1= Dummy variable for Bt technology
EP_{t-1} = Export price of cotton lagged by one year ($/kg)

The supply response function is

$\text{Log } Q_t = \log b_0 + b_1 \log Q_{t-1} + b_2 \log P_t + b_3 \log RF_t + b_4 D_1$

Where,

Q_t = Production of cotton in the current year (000 bales of 170 kg)
Q_{t-1} = Production of cotton lagged by one year (000 bales of 170 kg)
Pt = MSP of cotton in current year (Rs/qtl)
RF_t = Actual Rainfall in the current year (mm)
D_1= Dummy variable for *Bt* technology

Nerlovian model was estimated in double log form by the ordinary Least Square method. The best model is selected based on the coefficient of multiple determination (R^2), the significance of regressors included in the model and by detecting auto correlation using Durbin Watson test.

3. RESULTS AND DISCUSSION

3.1 Indian Cotton Scenario

Cotton area in India has increased from 7883 thousand hectares in TE 1983-84 to 12892 thousand hectares in TE 2019-20. India is possessing the largest cotton area and contributing 37 per cent to the global cotton area. The diversion of a huge area to cotton cultivation is because of substantial domestic demand for cotton, meteorological conditions supporting cotton cultivation and the prevalence of efficient domestic and global markets.

In terms of production, a drastic increase was spotted i.e 7268 thousand bales of cotton in TE 1983-84 to 32304 thousand bales of cotton in TE 2019-20. The tremendous production increase was about fourfold because of *Bt* cotton technology introduction in 2002-03 and a good level of adoption by farmers [8]. The performance of cotton production has skyrocketed because of the timely introduction of GMO *Bt* cotton and due to the high-income earning nature of White gold. Though India holds 37 per cent of the global cotton area, production contribution is only 24 per cent.

Productivity of cotton is also showing an increasing trend of 157 kg/ha in TE 1983-84 to 425 kg/ha in TE 2019-20. Even though productivity increases, India's cotton productivity is far below the global average of 800 kg/ha ranking 42 in world cotton productivity. The stagnating productivity is due to o lack of introduction of new technology after 2006 and the development of resistance against bollworm by *Bt* cotton [9].

3.2 Compound Growth Rate

In 2002, *Bt* cotton was first introduced in India. Cotton production, area, and productivity in India have all changed dramatically since then. A comparison of the growth rate in India before and after the introduction of *Bt* cotton is presented in Table 1 and also in Fig. 2, which shows a large rise in acreage, production and yield in the post-*Bt* era compared to the pre-*Bt* era. The growth in the area, production and productivity in the post-*B*t introduction were 2.88, 6.38 and 3.39 per cent respectively as against the pre-*Bt* introduction of 1.09 ,3.06 and 2.13 per cent.

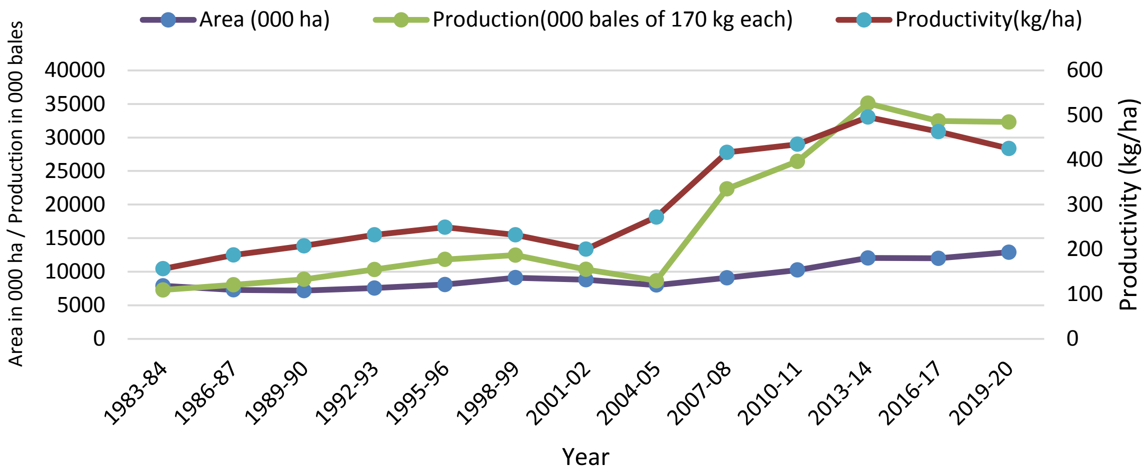

Fig. 1. Trend in area, production and productivity of cotton in India (1981-82 TE to 2019-20 TE)

Table 1. Estimates of compound growth rate in cotton area, production and productivity of India

Particulars	Area	Production	Productivity
Period -1 (1981-82 to 2001-02)	1.09^{NS} (0.17)	3.06*** (0.00)	2.13*** (0.01)
Period-2 (2002-03 to 2020-21)	2.88 ** (0.03)	6.38*** (0.00)	3.39*** (0.00)
Overall period (1981-82 to 2020-21)	1.59 *** (0.01)	4.71*** (0.00)	3.11^{NS} (2.88)

Value in parenthesis indicates P value at significant level of 1% (***) , 5%(**) and 10%(*)

Table 2. Estimates of cotton area, production and productivity instability index of India

Particulars	Area (%)	Production (%)	Productivity (%)
Period-1 (1981-82 to 2001-02)	7.53	14.04	12.78
Period-2 (2002-03 to 2020 -21)	7.78	16.71	14.35
Overall period (1981-82 to 2020-21)	9.78	21.76	18.09

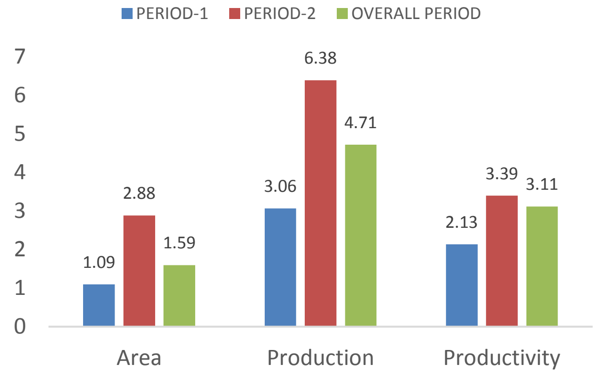

Fig. 2. CGR of cotton area, production and productivity

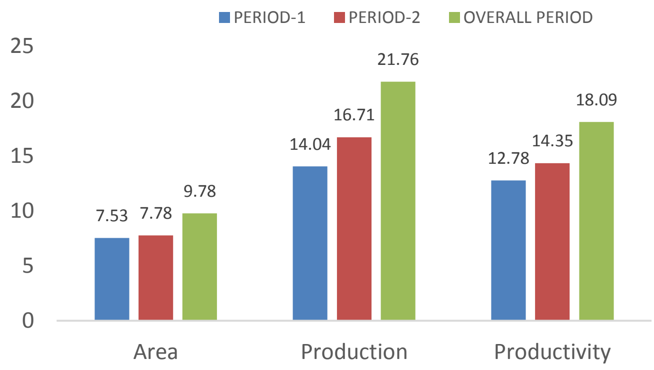

Fig. 3. Magnitude of cotton area, production and productivity instability

3.3 Instability Analysis

Instability in area, production and yield of cotton before and after introduction of *Bt*-cotton in India is shown in Table 2 and also in Fig. 3 Instability, for area, production and yield of cotton was higher in post-*Bt* cotton introduction than pre-*Bt* introduction. During post-*Bt* period, the instability in the production of cotton was maximum (16.71%) followed by yield (14.35%) and area (7.78%) whereas in pre *Bt* period, the instability of area, production and productivity were (7.53%), (14.04%) and (12.78%) respectively and in terms of overall period instability was found to be again maximum with production (21.76%) followed by productivity (18.09%) and area (9.78%)

3.4 Cotton Acreage Response Function

The estimated coefficients of the acreage response function is listed in Table 3 for the time period of 1981-82 to 2019-20 for India. The adjusted R^2 measure is high, estimated as 91.6 per cent, indicates that significant variation in cotton acreage is attributed to variation in listed explanatory variables. With the exception of *Bt* technology all other variables in cotton acreage response function are statistically significant. The results of cotton acreage stands similar to regional study in Karnataka which shows that cotton acreage was influenced by lagged cotton area, price and yield [10]. The cotton acreage with respect to lag cotton area is positive and statistically significant at 1 % level and also it stands positive with its own cotton price at significant level of 5 % level. The coefficient of rainfall variable is positive and significant at 10% level, indicating that cotton acreage in India depends on rainfall as 70 per cent of total cotton area is under rainfed conditions. The lagged year export price of cotton hugely influences cotton acreage at significant level of 5 % depicting magnitude of exports has major impact on cotton acreage In India. Within the listed variables lagged cotton area of coefficient (51.4%) has greater influence on cotton acreage followed by export price (13.5%) Rainfall (13.1%) and Cotton MSP (9.1%).The elasticity of cotton acreage response with respect to its own price is estimated to be 0.09 and 0.185 in short run and long run respectively and with respect to lagged export price is estimated to be 0.135 and 0.277 in short run and long run. The findings suggest that implementing a favourable forward-looking price policy for cotton, while keeping other variables constant, could drive greater area under cotton. The estimated non price elasticity of cotton acreage was 0.13 and 0.26 for rainfall in short and long run while, *Bt* technology short run and long run elasticity was 0.02 and 0.04. Since the values of non- price elasticities are positive, an increase in rainfall and *Bt* technology adoption can increase area under cotton. The estimates of elasticity were presented in Table 4.

3.5 Cotton Supply Response Function

The estimated coefficients of supply response function is listed in Table 5 for the time frame of 1981-82 to 2019-20 for India. The adjusted R^2 measure is high, estimated as 93.7 per cent, indicates that significant variation in cotton supply is attributed to variation in listed explanatory variables. With the exception of cotton price all other variables in cotton supply response function are statistically significant. The cotton supply with respect to lag cotton production is positive and statistically significant at 1 % level. The coefficient of rainfall variable is positive and significant at 5% level, indicating that cotton production in India depends on Rainfall. *Bt* technology has also triggered the cotton supply which is evident from the significant level of 1%. Within the listed variables lagged cotton production of coefficient (71%) has greater influence on cotton supply followed by Rainfall (40.4%) and *Bt* technology (27.2%).The price elasticity of supply response for cotton was estimated to be low. The estimated elasticity from OLS estimators showed that one percent increase in price of cotton increased supply by 0.053 and 0.182 unit under short run and long run respectively, consistent with standard production theory a positive response to its own price. Coming to non- price elasticity, short run and long run elasticity of rainfall were 0.40 and 1.39 unit and for *Bt* technology is 0.27 and 0.93 respectively in short run and long run (Table 6).

Table 3. Results on acreage response of cotton (1981-82 to 2019-20)

Explanatory variables	Estimated parameters	P value
Constant	2.812	0.0321**
A_{t-1}	0.514	0.0006***
Pt	0.091	0.0057**
RF_t	0.131	0.0887*
BT	0.022	0.5146
EP_{t-1}	0.135	0.0164**
R^2	0.927	
Adjusted R^2	0.916	
Durbin Watson stat	2.23	

*(* significant at 1 %level,** significant at 5% level , *** significant at 10% level)*

Table 4. Estimated elasticity of acreage response of cotton

	Price elasticity		Non- Price elasticity	
	Price (P_t)	**Export Price (EP_{t-1})**	**Rainfall (RF_t)**	**BT (D_1)**
Short-run elasticity	0.09	0.13	0.13	0.02
Long-run elasticity	0.18	0.27	0.26	0.04

Table 5. Results of supply response of cotton (1981-82 to 2019-20)

Explanatory variables	Estimated parameters	P value
Constant	-0.463	0.7273
Q_{t-1}	0.710	0.0000***
P_t	0.053	0.4617
RF_t	0.404	0.0303**
BT	0.272	0.0034***
R^2	0.943	
Adjusted R^2	0.937	
Durbin Watson stat	1.86	

(significant at 1 %level, ** significant at 5% level, *** significant at 10% level)*

Table 6. Estimated elasticity of supply response of cotton

Price elasticity		Non-price elasticity	
	Price (P_t)	**Rainfall (RF_t)**	**BT (D_1)**
Short-run elasticity	0.05	0.40	0.27
Long run elasticity	0.18	1.39	0.93

4. CONCLUSION

India's contribution to global cotton sector stands distinguished. The objective of the present study was to analyse growth performance of cotton. While analysing Compound Growth Rate it was inferred that higher growth rate was achieved in post *Bt* period than pre *Bt* period. The Similar findings were reflected in Instability analysis. The acreage response analysis revealed that price (MSP), rainfall and Export Price were significant factors attributing to cotton cultivation. The analysis also confirmed that all the significant factors exerted positive influence on cotton area. Similarly, supply response analysis revealed that Rainfall and *Bt* technology were significant factors influencing cotton output and exerted positive influence on cotton supply. The results and findings affirms about the cotton sector performance. Thus in upcoming research, studies related to institutional role in cotton sector, Indian cotton zone wise regional level performance studies , *Bt* technology impact on cost saving and yield enhancement and labour problem in cotton regions can be addressed as cotton is widely hand picked in India.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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