

Growth and Instability of Cotton Production in India

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Abstract

India has attained the status of world's largest cotton producer (29.50 million bales of 480 lb) which happens to be 24.31 per cent of the world's total production surpassing the China (27.75 million bales of 480 lb) in 2020. The yield in India is less than that of even smaller cotton producing countries such as Australia, Egypt etc. Cotton is cultivated on about 12.30 million hectares of land in the country with the production of 32.80 million bales. The present study was undertaken to examine the trends, growth and instability in cotton production in India and to analyze sources of growth of cotton production in the country. The findings showed that India registered a negative growth of area of cotton at -0.21 percent which was non-significant during 1995-96 to 2003-04 (Period I). The Compound Annual Growth Rate (CAGR) of area increased significantly to 3.61 per cent during 2004-05 to 2017-18 (Period II) mainly due to introduction of BT cotton. The performance of production was not impressive in period I as it declined significantly at rate of -3.05 percent which might be due to decrease in area and yield during the said period. The productivity of cotton showed a positive growth in period II and overall period at the rates of 3.32 percent and 4.94 percent respectively. It was revealed that the significant growth in area, production and productivity of cotton in period II and overall period due to rapid spread of Bt cotton. Instability in area was less in period I as compared to period II whereas variability for yield was observed more in period I (12.81%) than that in period II (9.41%). The decomposition of cotton production in area, yield and interaction effect showed that the yield effect was responsible for increasing the production of cotton in India during period II.

Keywords: Cotton, growth rate, decomposition analysis

JEL Classification: Q10, Q11, Q24

Introduction

Cotton is one of the principal crops and popular textile fibres in the world and is recognized as a 'King of Fibres' or 'White Gold'. Cotton is grown in 77 countries, across the globe among which India continues to hold the largest area under cotton (34 % of world area) and has attained the status of world's largest cotton producer (29.50 million bales of 480 lb) which happens to be 24.31 per cent of the world's total production surpassing the China (27.75 million bales of 480 lb) in 2020. By producing more cotton than China in 2014 India achieved a historic milestone and attained the number one position in cotton production in the world (USDA, 2018).

The cotton cultivation has been started in the ancient world since 7,000 years ago, mainly by the inhabitants of the Indus Valley Civilization. This civilization held a large area of the northwest part of the Indian subcontinent, which today contains parts of north-western India and eastern Pakistan. USA, India, China, former USSR, Brazil, Pakistan, Egypt, Mexico, Turkey and Sudan are the major cotton producing countries in the world and accounting for nearly 85 percent of the cotton produced in the world. The top three cotton producers are United States of America, India and China which together contribute around two-thirds of cotton worldwide. In many developing countries, cotton is an important cash crop, supporting the livings of millions of poor families. Although the world's cotton area has been stagnated in the last five decades

yet there is increase in production due to increase in yield. The total area under the cotton cultivation in the world has increased from 32.7 million hectares to 33.6 million hectares. Similarly cotton production has raised from 57.75 million bales to 121.37 million bales (of 480lb) during 1960-61 to 2017-18. The main exporting countries for cotton are USA, India, Uzbekistan, Brazil and Australia whereas China, Turkey, Bangladesh and Pakistan are the major importers of cotton (Samuel *et al* 2015). Though China is the 2nd largest producer of cotton in the world, yet it imports medium and long staple cotton from India and exports its low quality cotton to other countries.

In 2017-18, India produced 32.80 million bales (of 170 kg each) of cotton under an area of 124.36 lakh hectares and an average yield of 477 kg/ha. (Anonymous, 2018). The current average yield of the country is significantly lower than that of the world average i.e. 766 kg per hectare (Kulkarni *et al* 2017). Cotton is cultivated throughout the country but the major cotton growing states divided into three distinct regions are: the northern part of Punjab, Haryana and Rajasthan; the central part of Gujarat, Maharashtra and Madhya Pradesh; and the southern part of Andhra Pradesh, Karnataka and Tamil Nadu.

The expansion of cotton cultivation had been gradual during the 1950s and 1960s but became rapid during the 1970s and 1980s particularly after introduction of high yielding hybrid cottons, doubling India's share of the world crop production during the decade of 1970s. To strengthen the cotton production in the country, India had established composite research stations for cotton, oilseed and millets in 17 regions in 1956. Subsequently, in 1976 India established a Central Institute for Cotton Research of Nagpur, in order to hasten the achievements of self-sufficiency in cotton production. Introduction of various schemes by Government of India viz. Intensive Cotton Development Programs (ICDP) through consecutive five-year plans to provide the necessary impetus for cotton production by increasing the area particularly irrigated area and development of improved hybrid cotton in 1970s. By then the country has become self-sufficient in cotton production. Besides, the government launched the Technology Mission on Cotton in the year 2000, to improve cotton yield, quality through improvement of seeds, integrated water, nutrient and pest management technologies, proper transfer of technology to the

grower and improving the quality of cotton processing, particularly waste and contamination eradication etc. by developing cotton market infrastructure and modernizing existing ginning and pressing processes (Sabesh *et al.*, 2014). Introduction of BT cotton in 2002 made special acceleration in the cotton productivity in India. Bt cotton has been developed against cotton bollworms to create resistance. Bt cotton upsurge profitability up to 88 per cent, increased yield gains up to 31 per cent and reduce significantly insecticide usage up to 39 percent. And it abetted in alleviating poverty for over 6 million resource poor farmers with small incomes in 2010 (Balakrishna, 2012). In view of these developments, the present study was undertaken (i) to examine the trends, growth and instability in cotton production in India and to analyze sources of growth of cotton production in the country.

Data Sources and Methodology

The study is based on secondary data compiled from official websites of various Departments. The data pertains to area, production and productivity of cotton were collected from www.dacnet.nic.in of Directorate of Economics and Statistics (DES), Ministry of Agriculture, www.cotcorp.gov.in of Cotton Corporation of India Ltd., Ministry of Textiles etc. The data of the time series nature from the year 1995-96 to 2017-18 were collected and analyzed between three periods viz. Period I (1995-96 to 2003-04) before introduction of Bt cotton, Period II (2004-05 to 2017-18) after introduction of Bt cotton and Overall period (1995-96 to 2017-18) for the country as a whole. Bt cotton, which confers resistance to important insect pests of cotton, was first adopted in India as hybrids in 2002. The early adopters of Bt cotton were Gujarat and Maharashtra followed by Andhra Pradesh and Karnataka. Triennium averages were worked out to even out the inter-year fluctuations in the data. The data were analyzed using Compound Annual Growth rate (CAGR), Instability Index and Decomposition model

Compound growth rate

The linear, exponential, log-linear and linear-log, important functional forms were tried in this study to analyse the growth rates. Among all the functional forms, exponential growth model was accepted as it gave the best results because of its suitability in real

situations. Hence, the annual compound growth rate (CAGR) for cotton area, production and yield of export cotton were calculated by adjusting the exponential form function, $Y_t = ab^t e^u$

Log transformation of the above function is

$$\ln Y_t = \ln a + t (\ln b) + u$$

$$\ln b = \ln (1+r)$$

$$b = 1+r$$

$$r = b - 1$$

$$r = [\text{Antilog} (\ln b) - 1]$$

The compound growth rates were estimated as

$$\text{CGR} (\%) = r \times 100$$

Where,

Y_t = area/production/yield/export of cotton for the year 't'

t = Time variable

a = Constant

$\ln b$ = Regression coefficient of time

u = Error term

r = CGR

The significance of these compound growth rates (CAGR) was tested at one per cent, five per cent and ten percent level of significance by using student's t-test.

Instability analysis

Several techniques are available to measure the instability index. Some of the techniques followed by the researchers are Cuddy-Della Valle index (1978). For calculating instability, Co-efficient of Variation (CV) can be used. But, CV does not describe exactly how the trend value inherits in the data of the time series nature. Hence, Cuddy-Della Valle (1978) suggested an instability index, which explains clearly the trend value inherited in the data of the time series. The present study used Cuddy-Della Valle index owing to its usage in recent years by many researchers to estimate variability in time series data. On the time series data as a better measure of variability.

$$\text{Instability Index (II)} = \text{CV} \times (1-R^2)^{0.5}$$

$$\text{CV} = (\text{Standard deviation} / \text{Mean}) \times 100$$

Where,

CV = Coefficient of Variation

R^2 = Co-efficient of multiple determination adjusted from trend value

Decomposition analysis

To measure the comparative contribution of area, yield to the total change in cotton crop production, decomposition analysis was used (Minhas and Vaidyanathan, 1965). The method states that if A_0 , P_0 and Y_0 , respectively are area, production and productivity in base year and A_n , P_n and Y_n are the values of the said variables in the element of n^{th} year.

$$P_0 = A_0 \times Y_0 \text{ and}$$

$$P_n = A_n \times Y_n \quad (1)$$

Where, A_0 and A_n represent the area and Y_0 and Y_n represents the yield in the base year and n^{th} year respectively

$$P_n - P_0 = \Delta P,$$

$$A_n - A_0 = \Delta A$$

$$Y_n - Y_0 = \Delta Y \quad (2)$$

From equation (1) and (2) we can write

$$P_0 + \Delta P = (A_0 + \Delta A) (Y_0 + \Delta Y)$$

Hence, $\Delta P = A_0 * \Delta Y + Y_0 * \Delta A + \Delta A * \Delta Y$

Production = Yield effect + area effect + interaction effect

As a result, the total production change can be decomposed into three components viz. yield effect, area effect and interaction effect due to yield and area change.

Results and Discussion

Global cotton scenario

Cotton is an important fibre crop of global importance, which is grown in tropical and subtropical regions of more than 77 countries of the world. It is an important agricultural commodity traded all over the world. India is the largest producer of cotton in the world and occupies the top position with a share of 23.48 percent of the global production followed by China and USA (Table 1).

The other cotton producing countries are Pakistan, Uzbekistan, Turkmenistan, Egypt, Australia, Brazil and Mali. In total global cotton production, 70.23 percent of the cotton production came from four countries, which included India (23.48%) China (22.66%) USA (17.58%) and Pakistan (6.59%) in 2017-18. Although India occupies the top position in terms of area under

Table 1. Country wise area, production and yield of cotton in World (2017-18)

Countries	Area		Production		Yield kg/ha
	'000 ha	% share in Global area	' 000 Bales of 480 lb	% share in Global production	
India	12300	36.84	28500	23.48	471
Pakistan	2800	8.39	8200	6.59	638
China	3400	10.18	27500	22.66	1761
United states	4593	13.76	21263	17.58	1008
Uzbekistan	1200	3.59	3700	3.05	671
Brazil	1120	3.35	8000	6.58	1555
Australia	435	1.3	4400	3.63	2202
Turkmenistan	545	1.63	1425	1.17	569
Mali	730	2.19	1350	1.11	403
Egypt	91	0.27	300	0.25	718
Others	6171	18.48	16734	13.9	
World	33385	100	121372	100	792

Source: USDA 2018

cotton (36.84 percent of the world area), the cotton yields in the country is one third that of China and about 45 percent of USA. The yield in India is less than that of the smaller cotton producing countries such as Australia, Egypt etc. Global cotton production was estimated at 121.37 million bales of 480 lb (USDA 2018).

The average yield of cotton in the world during 2017-18 was found to be 792 kg/ha. The yield of cotton was found to be the highest in Australia (2202 kg / ha) while China and Brazil stood second and third place with 1761 kg/ha and 1555 kg/ ha respectively. The yield of cotton in Mali (403 kg/ ha) was found to be the lowest in the world.

Trends in area production and yield of cotton in India

The details of area, production and yield of cotton in India during TE 1995-96 To TE 2017-18 are presented in Table 2. The area under cotton has increased from 8075.70 thousand hectares in 1995-96 to 11901.47 thousand hectares in 2017-18. It was found that there was increase in area under cotton up to 1998-99 and then it found declined in subsequent years till 2004-05(8018.03 thousand hectares).

After introduction of Bt technology, the area under cotton crop was found increasing. The highest area

under cotton was recorded in the year of 2015-16 at 12357.00 thousand hectares. The area under cotton receded drastically to 11979 thousand hectares in TE 2016-17 and then to 11901.47 in TE 2017-18 due to fear of infestation of whitefly in north zone, infestation of pink bollworm in central and south zones including decision of Andhra Pradesh and Telangana states for diversion of cotton area to pulses and oilseeds.

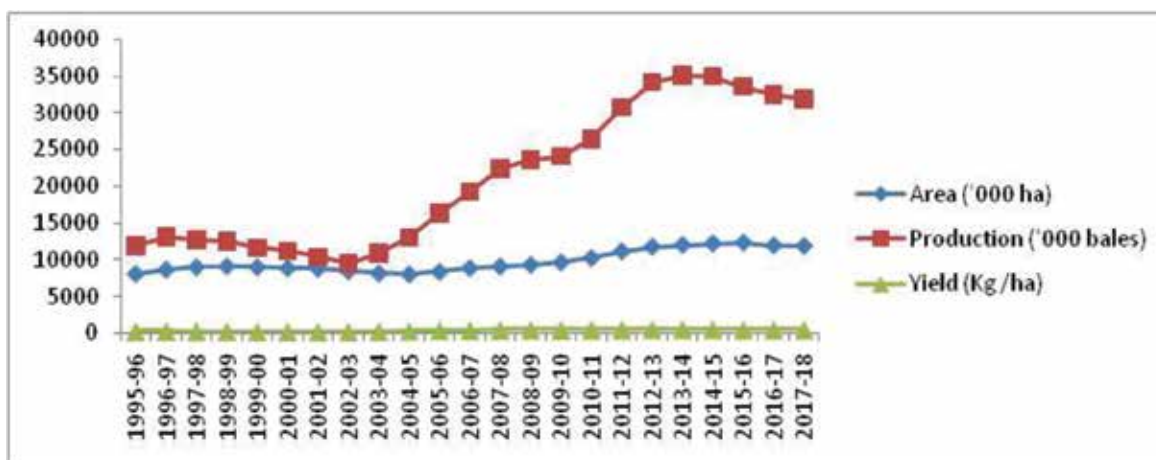
A perusal of Table 2 reveals that the production of cotton in India has increased from 11830.00 thousand bales in TE 1995-96 to 31795.80 thousand bales in TE 2017-18. The production of cotton varied between 10349.00 bales to 12993.33 thousand bales during TE 1995-96 to 2001-02. The progress of cotton production in the country remained impressive from the TE 2004-05 to 2016-17 due to the adoption of Bt hybrids by the farmers in the country and adoption of modern technologies. Bt cotton has played a catalytic role in enhancing cotton production in India.

Yield of cotton in India increased from 249.33 kg/ha in TE 1995-96 to 456.67 kg/ha in TE 2017-18. Cotton yield in India has witnessed substantial increase over the years. In the TE 1995-96 the average yield of the country was 249.30 kg/ha and it declined to 167.00kg/ha TE 2001-02. The yield of cotton started increasing to 463.0 kg/ha in 2016-17 which might be attributed to the wide spread adoption of Bt cotton during the

Table 2. Trends in area, production and yield of cotton in India (TE 1995-96 to 2017-18)

TE	Area (' 000 Hectare)	Production (' 000 Bales of 170 kg each)	Yield (Kg./Hectare)
1995-96	8075.70	11830.00	249.30
1998-99	9110.33	12456.33	232.33
2001-02	8791.90	10349.00	167.00
2004-05	8018.03	12927.10	272.00
2007-08	9078.43	22338.30	416.67
2010-11	10257.80	26432.67	435.00
2013-14	12038.33	35107.33	495.67
2016-17	11979.13	32462.47	463.00
2017-18	11901.47	31795.80	456.67

Source: Anonymous, 2018

Figure 1. Trends in area, production and yield of cotton in India

period. In TE 2017-18 There was slight decrease in productivity of cotton to 456.67 kg/ha.

Growth in area, production and yield of cotton in India

The CAGR of area, production and yield of cotton in India is presented in Table 3. The CAGR of area has increased from -0.21 percent in period -I to 3.61 percent in period II. But in period- I the decrease in area was not significant while in period II the increase in area was found significant at one percent level. A growth rate of 1.93 percent in area was observed in overall period which was significant at one percent level. In period-I, the performance of production was not impressive as cotton production declined significantly at the rate of 3.05 percent which might be due to decrease in area and significant decline in yield by 3.63 percent..

The period II witnessed significant higher growth in production of 6.97 percent. which was attributed to significant increase in area (3.61%) and yield (3.32%) It was noticed that during overall period, the production of cotton increased significantly at the rate of 6.64 percent. As the productivity growth during period I in the country was negative significantly (-3.63%) it showed a positive growth in period II and overall period at the rates of 3.32 percent and 4.94 percent respectively. It can be revealed that there was significant growth in area production and productivity of cotton in period II and overall period due to introduction and rapid spread of Bt cotton.

Instability in area, production and yield of cotton in India

The instability indices of area, production and

Table 3. Compound annual growth rate (CAGR) of area, production and yield of cotton in India, TE1995-96 to TE 2017-18

Periods	Area	Production	Yield
Period I (1995-96 to 2003-04)	-0.21 ^{NS} (0.73)	-3.05* (0.00)	-3.63* (0.06)
Period II (2004-05 to 2017-18)	3.61*** (0.00)	6.97*** ((0.00)	3.32*** (0.00)
Overall period (1995-96 to 2017-18)	1.93*** (0.00)	6.64***(0.00)	4.94*** (0.00)

(Note: Figures in parentheses indicate P- value *, ** and *** indicate significance at 10 per cent, 5 per cent and 1 per cent level, respectively)

Table 4. Instability in area, production and yield of cotton in India, 1995-96 to 2017-18

Periods	Area (%)	Production (%)	Yield (%)
Period I (1995-96 to 2003-04)	4.61	6.44	12.81
Period II (2004-05 to 2017-18)	4.68	12.39	9.41
Overall period (1995-96 to 2017-18)	8.43	19.4	18.31

yield were estimated and are presented in Table 4. Area indicated instability of 4.61 per cent, 4.68 per cent and 8.43 per cent during period I (1995-96 to 2003-04), period II (2004-05 to 2017-18) and overall period (1995-96 to 2017-18). Similarly the production showed of 6.44 percent, 12.39 per cent, and 19.4 percent respectively during period I, II and overall period. Instability in area was found more in period I as compared to period II and overall period. The variability in yield was observed more in period I (12.81%) than that in period II (9.41%) however area production and yield were found instable more during overall period than that in period I and period II.

Sources of growth of cotton production

The decomposition of cotton production in area, yield and interaction effect has been presented in Table 5 and the results demonstrate the percent contribution of area, yield and their interaction for change in production of cotton in India. In period I, the CAGR of production was negative(-3.05%) and the results clearly indicated that the yield effect of 108.23 per cent was more responsible for decline in the production of cotton in India with area effect of -8.99 percent and interaction effect of 0.76 per cent. It is revealed that due to significant negative growth and high instability of

yield in period I, there was significant decline in cotton production in the country. In period II, the yield effect had got domination over the area and interaction effect. In period II, the production of cotton was increased due to both area and yield. The area effect was found 32.46 per cent whereas yield effect and interaction effect were 45.50 per cent and 22.04 per cent respectively.

During overall period, yield effect had recorded domination over area and interaction effect. The area, yield and interaction effect were 27.87 per cent, 48.95 per cent and 23.18 per cent respectively. So it is concluded that in this period, yield effect was responsible for increasing for production of cotton in India.

Table 5. Per cent contribution in area, yield and their interaction towards change in production of cotton in India (1995-96 to 2017-18)

Time period	Area effect	Yield effect	Interaction effect
Period I	-8.99	108.23	0.76
Period II	32.46	45.5	22.04
Overall- Period	27.87	48.95	23.18

Note: Period I(1995-96 to 2003-04), Period II (2004-05 to 2017-18), Overall period (1995-96 to 2017-18)

Conclusion and Policy Implications

India has maintained number one position by producing more cotton in the world and attained a breakthrough by surpassing China in cotton production. There is significant growth in area, production and productivity of cotton due to introduction of Bt cotton in India during 1995-96 to 2017-18 but the country witnessed instability in area, production and yield of cotton. The average yield of cotton in India was found lower than that of world average i.e. 766 kg / hectare therefore there is a need to enhance productivity and production of cotton. The area under cotton was found more stable than production and yield during the study period in India. Therefore, policies should be framed to reduce the risks in production. Decomposition analysis revealed that yield effect was responsible for increasing the production of cotton in India.

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Annexure

Trends in area, production and yield of cotton in India (TE 1995-96 to 2017-18)

TE	Area (' 000 Hectare)	Production (' 000 Bales of 170 kg each)	Yield (Kg./ Hectare)
1995-96	8075.70	11830.00	249.30
1996-97	8675.67	12993.33	254.67
1997-98	9008.00	12647.67	238.33
1998-99	9110.33	12456.33	232.33
1999-00	8973.17	11556.00	185.67
2000-01	8861.97	11112.33	179.67
2001-02	8791.90	10349.00	167.00
2002-03	8445.27	9380.23	189.00
2003-04	8133.10	10783.23	228.00
2004-05	8018.03	12927.10	272.00
2005-06	8353.87	16218.87	329.00
2006-07	8869.40	19186.47	367.00
2007-08	9078.43	22338.30	416.67
2008-09	9321.63	23597.37	430.33
2009-10	9650.70	24060.70	424.33
2010-11	10257.80	26432.67	435.00
2011-12	11181.57	30740.60	464.33
2012-13	11796.67	34140.00	492.00
2013-14	12038.33	35107.33	495.67
2014-15	12252.00	34975.67	486.00
2015-16	12357.00	33570.67	462.33
2016-17	11979.13	32462.47	463.00
2017-18	11901.47	31795.80	456.67

Source: Anonymous, 2018

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