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Determinants of Production Performance of Cotton in Different Zones of India

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Abstract

Cotton farming plays a significant role in providing direct livelihood to 11 million farmers. The cotton crop mainly confined to northern, central and southern zones with about 90 per cent of the area comes under three zones. This study aims at sources of growth and factors affecting the cotton area and production using, time series data took from 1990 to 2021 for cotton producing zones of India. Furthermore, periods have been classified into period I (1990 to 2000), period II (2001 to 2010) and period III (2011 to 2021). There was a significant increase in growth in area from 2.68 to 3.22 per cent from period I to period III in southern zone and same findings has been observed in rest of the zones. In order to estimate sources of growth cobb-douglas production function and bai-perron test were employed. The results clearly indicate that the MSP; net irrigated area and lagged yield are significantly affecting the cotton acreage across zones and India. The bai and perron test clearly shows that there was abrupt increase in area and production of cotton after commercial release of BT cotton across the zones and India. Therefore, improvement in the procurement network of cotton under MSP and effective implementation of decentralized procurement policy could benefit the larger section of the farmers particularly in cotton producing zones. The productivity of the cotton could be improved by developing biotic and abiotic resistance variety helps in expansion of the cotton area.

Keywords : Cotton, MSP, Cobb douglas function, Bai and perron test

Cotton is one of the significant fibre and cash crop of India and play vital role in the cotton industrial and agricultural economy of the country which provides employment to about 11 million farmers and indirectly about 40-50 million people are employed in various stages of processing and trade of cotton and its derivatives (Ramesh *et al*., 2020). Cotton is considered as 'White gold' being cultivated since immemorial and major producer, consumer and exporter of cotton in the world (Ravi and Patil, 2018). In India, cotton is cultivated in 12.90 million hectares constituting of 41 per cent of the world area (Cotton Corporation of India, 2021). Further, during 2019-20 the cotton area reached new record of 13.40 million ha with 361 lakh bales production (170 kgs per bale).

Cotton occupies an enviable place among the commercial crops of our country. It grown in the country under diverse agro-climatic conditions (Prabhu *et al.,* 2017). It is unique among agricultural crops, because it is the main natural fiber crop, which provides edible oil and seed by-products for livestock feed.

In India, there are ten major cotton growing states and classified into three cotton producing zones, *viz.,* northern zone, central zone and southern zone. The Northern zone comprising of Punjab, Haryana and Rajasthan occupied an area of 18.45 lakh hectares with a production of 66 lakh bales (170 kg each). The Central zone comprising of Madhya Pradesh, Gujarat and Maharashtra occupied 71.01 lakh ha producing 197.50 lakh bales of cotton. The Southern zone comprising of Karnataka, Andhra Pradesh, Telangana and Tamil Nadu occupied 37.73 lakh ha producing 103 lakh bales of cotton (Ministry of Agriculture and Farmers Welfare). Besides these ten states, cotton cultivation in the country has gained momentum in Odisha and in non-traditional states of Uttar Pradesh, West Bengal and Tripura.

In recent period the area, production and productivity of cotton increased substantial mainly due to the inception of Technology Mission on Cotton (TMC) during 2000 followed byintroduction of Bt-cotton in 2002, modernization of market yards along with increased number of ginning mills, operation of Minimum Support Price (MSP) programme by Government of India through Cotton Corporation of India (CCI) significantly increased the sources of growth in cotton in India and also across the cotton producing zones in the country. The contribution of

each of these factors towards the sources of growth is a researchable issue needs to be addressed by researchers, institutions and policy makers for enhancing growth and development of cotton and in turn the trade at large. In view of these developments, a study on dimensions of growth and development of cotton is under taken with an aim to know the factors determining growth of cotton in India as well as across the different cotton producing zones.

Material and Methods

The study is based on secondary data compailed from official websites of various departments. The data pertains to area, production and productivity of cotton were collected from Directorate of Economics and Statistics (DES), Ministry of Agriculture and Farmers Welfare and Cotton Corporation of India Ltd. The time series data for the period from 1990-91 to 2020-21 were collected and categorised in to three periods *viz.,* period I (1990 to 2000), period II (2001-2010) and period III (2011-2021) for cotton producing zones of India.

For computing compound growth rate of area, production and productivity of cotton for cotton producing zones in India the exponential function of the following form was used (Divya *et al*., 2013).

$$Y = a\ b^t e^{Ut} \qquad (1)$$

Where,

Y = Area / production / productivity
a = Intercept
b = Regression coefficient (*'a'* and *'b'* are the parameters to be estimated)
U_t = Disturbance term in year *'t'*

The equation (1) was transformed into log linear form and written as;

$$log\ Y = loga + tlogb + U_t \qquad (2)$$

Equation (2) was estimated by using Ordinary Least Squares (OLS) technique.

Compound growth rate (*g*) was then computed

$$g = (b - 1)\ 100 \qquad (3)$$

Where,

g: Compound growth rate in per cent per annum
b: Antilog of log b

The standard error of the growth rate was estimated and tested for its significance with 't' statistic.

To explore the factors determining growth in area under cotton, Cobb Douglas production function was fitted for the data (Beeraladinni *et al*,. 2016**)**. The below variables were selected based on previous literature and experts guidance in the field. The functional form of regression analysis is expressed as

$$Y = \beta_0\ X_1^{\beta 1}\ X_2^{\beta 2}\ X_3^{\beta 3}\ X_4^{\beta 4} e^u$$

Where, Y = cotton area (lakh ha.)

β_0 = Intercept

X_1 = MSP for cotton (Rs./Qtl.)

X_2 = Rainfall (mm)

X_3 = Lagged yield of cotton (kg/ha)

(Lagged yield of cotton was taken due to increased MSP which resulted in sustained increase in production over the years, which act as incentive for the farmers to take up crop in the coming years).

X_4 = Net irrigated area (thousand ha.)

β_1, β_2, β_3 and β_4= Regression co-efficient

u = Random error term

The Cobb-Douglas production function was converted into log linear form and co-efficient were estimated using Ordinary Least Square (OLS) as given below.

$$\ln Y = \ln \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \ldots\ldots\ldots + \beta_4 \ln X_4 + u \ln e$$

The regression co-efficient (β's) were tested using 't' test at chosen Level of Significance (LoS) and also examine the structural breaks in the area and production of the cotton for the same period by using Bai and Perron (1998, 2003) for estimating multiple structural breaks in the linear model (Kulkarni *et al.,* 2017).

Results and Discussion

Growth in Area, Production and Productivity of Cotton in India

The CAGR computed for three sub periods *i.e.,* Period I (1990 to 2000), Period II (2001 to 2010) and Period III (2011 to 2021) presented below.

In the central zone the area under cotton has been increased in the both periods (1990 - 2020 and 2001 -

2010) with CAGR of 2.04 and 2.84 per cent, respectively. However, the area has been declined to 0.01 per cent during 2011-21 due to the wide spread infestations of sucking pest in the region. The CAGR of area has declined in north zone from 1.23 to 0.10 per cent from 1990 to 2021 with overall negative growth rate of 0.91 per cent because of farmers switching over to other crops due to resurgence of sucking pest and leaf curl disease. Similarly, in southern zone area has been declined from 2.68 to 1.83 per cent during 1990 to 2010, however, increased during 2010-2021 with CAGR of 3.22 per cent at five per cent level of significance because of price support programmes initiated by government of India (Beeraladinni *et al*,. 2016). In India, the CAGR declined from 2.71 to 1.10 per cent from 1990 to 2021 with over all CAGR of 1.96 per cent.

TABLE 1

The CAGR of production of cotton in different producing zones of India (Lakh ha.)

Zones/ periods	1990-2000	2001-2010	2011-2021	overall
Northern zone	1.23	-1.12	0.19	-0.91
Central zone	2.04 *	2.84 ***	0.01	2.24 ***
Southern zone	2.68 **	1.83	3.22 **	2.96 ***
India	2.71 ***	2.03 **	1.10 *	1.96 ***

Note : ***, ** & * indicates 1, 5 and 10 % level of significance

In northern zone the production of cotton increased significantly with a CAGR of -4.63 to 8.43 per cent during 1990 to 2010 - 11, however declined during 2011-2021 for about the 1.34 per cent although non-significant. The similar observation is made in the central and southern zone cotton production increased with a CAGR of 6.61 to 18.46 per cent and 1.82 to 8.52 per cent from 1990 to 2010, respectively. The cotton production in India increased significantly with a CAGR of 2.30 to 13.61 per cent and declined during 2011-21 with CAGR of 0.30 per cent although non-significant. In sum, cotton production has increased from period I to period II due to introduction of *Bt* cotton and declined in the period III due to infestation of pink boll worm pest.

In north zone CAGR of productivity of cotton increased significantly with a CAGR of negative 5.40 to 9.39 during 1990 to 2010, respectively (Table 3). however,

TABLE 2

CAGR of production of cotton in different producing zones of India (Lakh bales)

Zones/ periods	1990-2000	2001-2010	2011-2021	overall
Northern zone	-4.63 *	8.43 ***	1.34	1.66 ***
Central zone	6.61 **	18.46 ***	-1.25 *	7.17 ***
Southern zone	1.82	8.52 ***	1.15	5.95 ***
India	2.30 *	13.61 ***	0.30	5.41 ***

Note : ***, ** & * indicates 1, 5 and 10 % level of significance

declined during 2011 to 2021 for about negative 0.30 per cent although non-significant. The similar observation is made in the central and southern zone cotton production increased with a CAGR of 4.21 to 14.65 per cent and negative 0.41 to 5.77 per cent from 1990 to 2010, respectively. However, declined productivity in both the zones to negative 0.79 and

TABLE 3

CAGR of cotton productivity in different producing zones of India (Kg/ha.)

Zones/ periods	1990-2000	2000-2010	2010-2021	overall
Northern zone	-5.40 **	9.39 ***	-0.30	2.25 ***
Central zone	4.21 *	14.65 ***	-0.79	5.12 ***
Southern zone	-0.41	5.77 ***	-1.41	4.08 ***
India	-0.39	11.34 ***	-13.15 *	1.58

Note: ***, ** & * indicates 1, 5 and 10 % level of significance

1.41 per cent during the 2011-21. CAGR of productivity of cotton in India increased significantly from 0.39 to 11.34 per cent and declined during 2011-21 with a CAGR of negative 13.15 per cent. In sum, cotton productivity has increased from period I to period II due to introduction of *Bt*-cotton had significantly increased all the sources of growth even though the technology mission on cotton was introduced much earlier.

Factors Determining Sources of Cotton Growth Across Zones and India

In order to estimate the factors influencing the sources of growth in cotton across cotton producing zones and India for this, the Cob Douglas production function is fitted with MSP (minimum support price), rainfall, lagged yield, net irrigated areas are the independent variables and dependent variable is area under cotton.

The findings of the results show that the minimum support price found to be significant only in the northern zone of India with the coefficient of 0.65 at 5 per cent LoS. Implies that one percent in increase in the MSP results into 0.65 per cent increase in the acreage of cotton in the region. However, this is not true in other zones mainly due to the lack of awareness among the farmers and operation of the MSP is limited to confined area.

The net irrigated area found to be a significant factor in influencing the cotton acreage. However it has contributing positive and negative in some region for instance, in central cotton producing zone the parameter positive influencing in acreage implies that one per cent increase in the net irrigated area led to 0.34 per cent increase in the acreage of cotton. However, it found to be negative in the southern zone indicating that as increase in the area under irrigation which motivates those farmers to go for water intensive crops (rice and sugarcane) from the cotton crops due to well established market in the region. It was also observed that negatively contributing to the overall cotton acreage with 2.88 per cent of coefficient at five per cent LoS.

The previous year obtained yield contributes significantly to cotton acreage in India. The lagged yield of cotton found to be significant with coefficient of 0.55 at five per cent LoS implying that one per cent in increase in lagged yield which contributes of an about 0.55 per cent increase in the acreage of cotton crop.

The variables considered in the model explains the total variations of the cotton acreage to the extent of 0.89 per cent in India, while it is 0.88 per cent in central and Southern cotton producing zones and 0.75 per cent in the northern zones.

Structural Breaks in Area and Production of Cotton

The multiple structural breaks have been estimated through employing Bai-perron test for area and production of cotton across cotton producing zones and India. The findings indicated that in northern zone we have two periods (2002 and 2017) and average growth rate found to be -0.66 per cent in 2002 and 9.86 per cent in 2017 of cotton acreage implies that due to commercial release of *Bt*-cotton in 2002 contributed phenomenal increase in the area under cotton as results of this increase in the cotton production with 7.73 per cent growth in the cotton during 2004.

In the selected zones the cotton acreage and production increased after the *Bt*-cotton release which could be observed from the multiple breaks for instance central zone 2006 and 2017 are the break period in the area and 2003 and 2007 in the production. Similarly in southern zone 2010 for area and 2007 for the cotton production. This is true for overall India with regard to area and production of cotton.

TABLE 4

Regression estimates of factors determining area under cotton in India

Particulars	North zone		Central zone		Southern zone		India	
	Coefficients	t value	Coefficients	t value	Coefficients	t value	Coefficients	t value
Intercept	0.08 (0.13)	0.61	0.09 (0.07)	1.4	0.30*** (0.09)	3.23	0.28 (0.04)	7.21
MSP	0.65** (0.29)	2.24	-0.14 (0.12)	1.11	-0.27 (0.54)	0.51	0.12 (0.12)	1.00
Rainfall	-1.35 (0.91)	1.47	0.26 (0.20)	1.3	1.38*** (0.33)	4.21	0.45 (0.13)	3.37
Lagged yield	0.16 (0.16)	0.99	0.20 (0.06)	3.69	0.55*** (0.12)	4.62	0.15*** (0.06)	2.67
Net irrigated area	9.51 (8.02)	1.19	0.34*** (1.62)	0.21	-10.23* (5.03)	2.04	-2.88*** (1.73)	1.67
Adjusted R^2		0.25		0.88		0.88		0.89
MSE		0.17		0.24		0.11		0.06
F value		3.46		54.12		54.12		60.92
Observations		31		31		31		31

Note: ***, ** & * indicates 1 , 5 and 10 per cent level of significance

TABLE 5

Structural breaks in area and production of cotton in India from 1990-91 to 2020-21

Zones	Area		Production	
	Break years	Growth rates	Break years	Growth rates
Northern zone	2002	-0.66 (1990-2002)	1997	-2.16 (1990-1997)
	2017	9.86 (2002-2017)	2004	7.73 (1997-2004)
		7.22 (2017-2021)		0.87 (2004-2021)
Central zone	1995	2.33 (1990-1995)	2003	3.29 (1990-2003)
	2006	1.23 (1995-2006)	2010	13.65 (2003-2010)
	2010	5.02 (2006-2010)		-1.17 (2010-2021)
		-0.13 (2010-2021)		
Southern zone	2010	0.65 (1990-2010)	2007	1.32 (1990-2007)
		2.88 (2010-2021)		4.95 (2007-2021)
India	1995	2.96 (1990-1995)	2004	1.06 (1990-2004)
	2010	1.02 (1995-2010)	2010	8.71(2004-2010)
		0.89 (2010-2021)		0.20(2010-2021)

Cotton is one of the significant fibre and cash crop of India and vital role in the cotton industrial and agricultural economy of the country which provides employment to about 11 million farmers and indirectly about 40 - 50 million people are employed in various stages of processing and trade of cotton and its derivatives. The tremendous increase in the area and production of cotton after the commercial release of *Bt*-cotton in 2002 which could be observed in all the zones later on due to wide infestation of sucking pests the area has been declined. The MSP; net irrigated area and lagged yield are significantly affecting the cotton acreage across zones and India. However, as the expansion of irrigated area has detrimental effect on the cotton area. The concerned departments may recommend the suitable crop planning in the respective zones. The operation of MSP is limited to specific area and crops and improvement in the procurement network of cotton and effective implementation of decentralized procurement policy could benefit the larger section of the farmers particularly in cotton producing zones. The productivity of the cotton is important yardstick for cotton crop growth and to meet the demand in this regard productivity of cotton could be improved and developing biotic and a biotic resistance varieties.

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