Original Research Article

Growth in area, production and productivity of cotton crop in India: A state wise analysis.

ABSTRACT

Aim: To analyze the compound annual growth rate in area, production and productivity of cotton across different state in India and to know the impact of Bt-cotton on the same.

Methodology: The present study is based on the secondary data. Time series data were analyzed for two sub period viz., Period Ⅰ (1987-88 to 2001-02) i.e., before the introduction of Bt cotton and period Ⅱ (2002-03 to 2019-2020) after the introduction of Bt cotton and for overall period (1987-88 to 2019-2020) for major cotton growing state in India and India as a whole. Compound annual growth rate (CAGR) of area, production and productivity was computed by using semi-log growth model (Log-Lin model).

Result: There was a significant increase in growth rate of area, production and productivity of cotton in India from 2.11, 1.97 and -0.12 per cent in period Ⅰ to 3.24, 6.2 and 2.87 per cent in period Ⅱ respectively.

Conclusion: Majority of the states showed increased growth rate with respect to area, production and productivity after the introduction of Bt Cotton. However, the cotton growing farmers still facing constraints related to quality of seeds, pest and disease attack, lack of awareness about new technology etc. The study therefore recommends to strengthen the extension system.

Keywords:*Bt Cotton, CAGR, Growth and development*

Comment [AC1]: Adjust the objective to the nature of the work, check the wording to make it more concise.

Comment [AC2]: It is recommended to improve the words by consulting international thesauri.

1. INTRODUCTION

Cotton, one of the most important commercial and fibre crops of global significance is called as the king of fibre, it is a multipurpose crop grown under various agro-climatic conditions[1]. Cotton accounts for around 25 per cent of total global fibre production. It plays a notable role in the sustainable economy of India and livelihood of the Indian cotton farming community (5.8 million cotton farmers). Cotton is the most favoured fibre among the Indian textile mills, as a major raw material for the textile industry. In the raw material consumption of the Indian textile industry the proportion of cotton is around 60 per cent[2].

According to India Brand Equity Foundation report on cotton industry and export (2021), the Indian textile industry contributes around 5 per cent to country's Gross Domestic Product (GDP), 14 per cent to industrial production and 11 per cent to total export earnings. It is also the second largest employer in the country after agriculture, providing employment to over 51 million people directly and 68 million people indirectly including unskilled workers. Because of this social and economic significance, it is famously renounced as "white gold"[3].

As per the Cotton Corporation of India Limited, Statistics (2021), world cotton production is estimated at 24.22 million metric tons, with the area of 32.04 million hectares. The major cotton growing countries in the world are India (12.96 million hectares),United States of America (3.52 million hectares), China (3.17 million hectares), Pakistan (2.19 million hectares), Brazil (1.52 million hectares) and Uzbekistan (1.03 million hectares)[4].

India has the highest cotton production and area, with 6.05 million metric tons and 12.96 million hectares accounting for 26 per cent and 41 per cent of global cotton production and area respectively. The cotton growing region in the country is classified in to 3 zone Northern zone comprises Punjab, Haryana and Rajasthan, Central zone comprises of Maharashtra, Madya Pradesh and Gujarat and Southern zones Comprises of Telangana, Andhra Pradesh, Karnataka and Tamil Nadu. Among

them, the 3 major cotton producing states are Gujarat (22.79 lakh hectares), Maharashtra (42.86 lakh hectares) and Telangana (24.51 lakh hectares)[4].

Bt Cotton is genetically engineered with Bt, a bio-toxin which comes from soil bacterium.The engineered Bt gene produces a protein that cuts the gut of pink bollworm, rendering the resistant against insect pests.Bt cotton was first approved for field trials in United States in 1993 and approved for commercial use in 1995.In 2002, a joint venture between Monsanto and Mahyco lead to introduction of Bt cotton in India with the approval of Genetic Engineering Appraisal Committee(Reddy *et al*., 2020).[1].

Comment [AC3]: End the introduction with the justification and impact of the research carried out.

2. METHODOLOGY

The present study is based on the secondary data obtained from Ministry of Agriculture and Farmers Welfare,Government of India, Ministry of textile, Government of India and Cotton corporation of India. Time series data were analyzed for two sub period viz., Period Ⅰ (1987-88 to 2001-02) i.e., before the introduction of Bt cotton and period Ⅱ (2002-03 to 2019-2020) after the introduction of Bt cotton and for overall period (1987-88 to 2019-2020) for major cotton growing state in India and India as a whole. Compound annual growth rate (CAGR) of area, production and productivity was computed by using semi-log growth model (Log-Lin model).

Comment [AC4]: Include the names of the states evaluated.

The compound growth rate was obtained using the logarithmic form of the equation as below.

Comment [AC5]: Include the bibliographical reference from where the model was taken or adapted.

$Y_t=Y_0(1+r)^t$

$\ln Y_t = \ln Y_0 + t \ln(1+r)$

$\ln Y_t= ß_1+ß_2t + u_t$

Where,
$\ln Y_t$is the natural logarithm of time series data for area/ production/ productivity for year t
$ß_1$is the constant term
t is the time in years
$u_t$is the error term
$ß_2$ is growth rate for the period under consideration (i.e., slope coefficient)

Compound growth rate was calculated using following equation:

CAGR(r) = (Antilog of ($ß_2$)-1 × 100

3.RESULT AND DISCUSSION

3.1 Growth in area, production, productivity of cotton in India

CAGR was calculated for two sub periods, Period Ⅰ (1987-88 to 2001-02) and period Ⅱ (2002-03 to 2019-2020) and overall period (1987-88 to 2019-2020) is presented below (Table 1)

CAGR of cotton area and production was increased to 3.24and 6.2 per cent per annum in the period Ⅱ from 2.11 and 1.97 per cent per annum in the period Ⅰ respectively, similarly CAGR of the cotton productivity increased remarkably from -0.12in period I to 2.87 per cent per annum in the period Ⅱ. In the overall period also the CAGR of area (1.92%), production (5.21%) and productivity (3.23%) were positive and significant.

The results were in conformity with the findings of[5]whichreportedsignificant increase in growth rate of area and production of cotton which wasattributed to introduction of Bt-cotton as a result of that productivity of cotton increased from 304 to 473 kg per ha. In addition, increase in irrigated area under cotton, support price programme by the Cotton Corporation of India, modernization of market yards and ginning mills further boosted the growth in cotton.

TABLE 1. CAGR OF AREA, PRODUCTION AND PRODUCTIVITY OF COTTON IN INDIA FROM

S.I. No.	Source of growth	CAGR in Period Ⅰ	CAGR in Period Ⅱ	CAGR in Overall period
1	Area (%)	2.11***	3.24**	1.92***
2	Production (%)	1.97*	6.2***	5.21***
3	Productivity (%)	-0.12^{NS}	2.87***	3.23***

1987-88 TO 2001-02, 2002-03 TO 2019-2020 AND 1987-88 TO 2019-2020.

* Significant at 10 % ** Significant at 5% *** Significant at 1 % NS -Non-Significant

3.2 Growth in area, production, productivity of cotton in Haryana

It was observed (Table 2) that CAGR of cotton area was decreased from 2.54 per cent in period Ito 1.64 per cent per annumin the period Ⅱ. CAGR of production increased to 1.94 per centin the period Ⅱfrom 0.85 per cent per annum in the period I. And there was a slight improvement in the CAGR of cotton productivity in the period Ⅱ(0.29%) which was negative in the period I (-1.64%).During the overall period the growth rate were significant and positive with regard area(0.76%), production(2.63%) and productivity (1.83%).

The above findings are in conformity with findings of[6]reported that,despite progress in irrigation and other infrastructural developments in Haryana, performance of cotton especially productivity and production was characterised by less growth and high instability levels. And[7]and[8]reported that the adoption of hybrids was very low in Haryana. However, the cultivation of open pollinated varieties of cotton were dominant.

TABLE 2. CAGR OF AREA, PRODUCTION AND PRODUCTIVITY OF COTTON IN HARYANA FROM 1987-88 TO 2001-02, 2002-03 TO 2019-2020 AND 1987-88 TO 2019-2020.

S.I. No.	Source of growth	CAGR in Period Ⅰ	CAGR in Period Ⅱ	CAGR in Overall period
1	Area(%)	2.54***	1.64***	0.76***
2	Production(%)	0.85^{NS}	1.94^{NS}	2.63***
3	Productivity(%)	-1.64^{NS}	0.29^{NS}	1.83***

3.3 Growth in area, production, productivity of cotton in Punjab

It was observed (Table 3) that in the state of Panjab in both period I and period Ⅱ CAGR of cotton area and production was negative whereas with respect to productivity there was an improvement from negative growth rate*i.e.,* -4.48 per cent in the period I to 1.02 per cent in the period Ⅱ. During the overall sub period also the growth rate in area and production were negative. But there was an improvement in productivity of about 1.79 per cent per annum.

Comment [AC6]: No discussion of these data is presented.

TABLE 3. CAGR OF AREA, PRODUCTION AND PRODUCTIVITY OF COTTON IN PUNJAB FROM 1987-88 TO 2001-02, 2002-03 TO 2019-2020 AND 1987-88 TO 2019-2020.

S.I. No.	Source of growth	CAGR in Period Ⅰ	CAGR in Period Ⅱ	CAGR in Overall period
1	Area (%)	-1.88***	-4.17***	-2.58***
2	Production (%)	-6.27**	-3.19***	-0.83^{NS}
3	Productivity (%)	-4.48**	1.02^{NS}	1.79***

3.4 Growth in area, production, productivity of cotton in Rajasthan

It wasobserved(table 4) that the CAGR with respect to the area was slightly decreased in the period Ⅱ (3.16%) from period I (3.82%). CAGR of the production was improved notably from 1.60 per cent in the period I to 9.32 per cent per annum in the period Ⅱ.This was mainly contributed by increase in the growth rate of productivity which was negative in the period I (-6.28%) and increased to 5.98 per cent annum in the period Ⅱ.

TABLE 4. CAGR OF AREA, PRODUCTION AND PRODUCTIVITY OF COTTON IN RAJASTHAN FROM 1987-88 TO 2001-02, 2002-03 TO 2019-2020 AND 1987-88 TO 2019-2020.

S.I. No.	Source of growth	CAGR in Period Ⅰ	CAGR in Period Ⅱ	CAGR in Overall period
1	Area (%)	3.82***	3.16***	0.29^{NS}
2	Production (%)	1.60^{NS}	9.32***	3.05***
3	Productivity (%)	-6.28***	5.98***	3.05***

In Northern zone, except Rajasthan, there was no significant growth in area and production and there was an improvement in growth of productivity. The above findings were in similarity with the results of [5] reported no significant growth in cotton area and production. The productivity has increased from -4.6 to 3.09 per cent from period I to period II. and [9]reported that in Northern zone the rate of adoption of Bt cotton was 35 per cent in comparison with 80 per cent adoption in Southern and Central region in 2009.

Comment [AC7]: The discussion could be expanded to include information related to the agronomic component, environmental conditions, the incidence of pests or diseases, among others.

3.4 Growth in area, production, productivity of cotton in Gujarat

It was found (Table 5) that the CAGR of cotton area and production in the period Ⅰ was 5.06 and 7.36 per cent per annum whichwere higher than the growth rate in period Ⅱ with 2.58 and 5.46 per cent per annum respectively. CAGR of productivity increased slight to 2.81 per cent in the period Ⅱ from 2.16 per cent per annum in the period Ⅰ.

Comment [AC8]: No discussion of these data is presented.

TABLE 5. CAGR OF AREA, PRODUCTION AND PRODUCTIVITY OF COTTON IN GUJARAT FROM 1987-88 TO 2001-02, 2002-03 TO 2019-2020 AND 1987-88 TO 2019-2020.

S.I. No.	Source of growth	CAGR in Period Ⅰ	CAGR in Period Ⅱ	CAGR in Overall period
1	Area (%)	5.06***	2.58***	3.75***
2	Production (%)	7.36**	5.46***	8.54***
3	Productivity (%)	2.16^{NS}	2.81*	4.61***

3.5 Growth in area, production, productivity of cotton in Maharashtra

CAGR of area has increasedsignificantly from 1.86 per cent to 3.10 per cent per annumfrom period I to period Ⅱ. Similarly, CAGR of production increased from 4.09 per centto 6.19 per cent per annumfrom period I to period Ⅱ.whereas growth rate of yield has increased slightly from 2.16 per cent to 2.98 per cent per annum from the period I to period Ⅱ (Table 6). The resultswere in conformity with[10]reported significant increase in the growth rate of area, production and productivity of cotton after the introduction of Bt cotton in the state of Maharashtra. The increase in CAGR of cotton area was an indication that, farmers of the state have given preference to cotton crop over other competitive crop in their cropping pattern due to its profitability.

TABLE 6. CAGROF AREA, PRODUCTION AND PRODUCTIVITY OF COTTON INMAHARASHTRA FROM 1987-88 TO 2001-02, 2002-03 TO 2019-2020 AND 1987-88 TO 2019-2020.

S.I. No.	Source of growth	CAGR in Period Ⅰ	CAGR in Period Ⅱ	CAGR in Overall period
1	Area (%)	1.86***	3.10***	1.75**
2	Production (%)	4.09**	6.19***	6.02***
3	Productivity (%)	2.16^{NS}	2.98**	4.19***

3.6 Growth in area, production, productivity of cotton in Madhya Pradesh

It was seen (Table 7) there was no significant growth rate of cotton area in both period I and period Ⅱ.There was a negative growth rate in cotton area in period I (-0.72%) where as in period Ⅱ it was just 0.10 per cent per annum. CAGR of production has improved remarkably from1.07 per cent to 9.24 per cent per annumand productivity improved from 1.82 per cent to 9.11 per cent per annumfrom the period I toperiod Ⅱ respectively.

TABLE 7. CAGR OF AREA, PRODUCTION AND PRODUCTIVITY OF COTTON IN MADHYA PRADESH: FROM 1987-88 TO 2001-02, 2002-03 TO 2019-2020 AND 1987-88 TO 2019-2020.

S.I. No.	Source of growth	CAGR in Period Ⅰ	CAGR in Period Ⅱ	CAGR in Overall period
1	Area (%)	-0.72^{NS}	0.10^{NS}	0.61***
2	Production (%)	1.07^{NS}	9.24***	7.17***
3	Productivity (%)	1.82^{NS}	9.11***	6.52***

In the central zone except in Gujarat there was notable increase in the growth rate specially with respect to production and productivity. This was mainly attributed to increase in the productivity after the introduction of Bt cotton. The above results are in similarity with [5]reported significant growth of area and production in the central zone after the introduction of Bt cotton and the production growth of cotton in central zone increased from 4.97 to 8.20 per cent per annum from period I to period II.

3.8 Growth in area, production, productivity of cotton in Karnataka

It was found (Table 8) that there was no significant growth rate of cotton area, production and productivity in the period I.whereasCAGR ofarea (4.27%), production (10.97%) and productivity (6.43%) remarkably increased in the period Ⅱ.

Comment [AC9]: No discussion of these data is presented.

TABLE 8. CAGR OF AREA, PRODUCTION AND PRODUCTIVITY OF COTTON IN KARNATAKA FROM 1987-88 TO 2001-02, 2002-03 TO 2019-2020 AND 1987-88 TO 2019-2020.

S.I. No.	Source of growth	CAGR in Period Ⅰ	CAGR in Period Ⅱ	CAGR in Overall period
1	Area (%)	-0.23^{NS}	4.27***	-0.02^{NS}
2	Production (%)	-0.05^{NS}	10.97***	2.82***
3	Productivity (%)	0.17^{NS}	6.43***	2.85***

3.9 Growth in area, production, productivity of cotton in Andhra Pradesh

CAGR of area has increased to 6.11 per cent in the period Ⅱ from 1.92 per cent per annum in the period I.Production of cotton registered a negative growth rate in the period I (-2.40%) and it has significantly increased to 7.70 per cent per annum in period Ⅱ.There was slightest improvement in the growth rate productivity from2.27 per cent to 2.83 per cent per annum from the period I to period Ⅱ (Table 9).

Comment [AC10]: No discussion of these data is presented.

TABLE 9. CAGR OF AREA, PRODUCTION AND PRODUCTIVITY OF COTTON IN ANDHRA PRADESH FROM 1987-88 TO 2001-02, 2002-03 TO 2019-2020 AND 1987-88 TO 2019-2020.

S.I. No.	Source of growth	CAGR in Period Ⅰ	CAGR in Period Ⅱ	CAGR in Overall period
1	Area (%)	1.92**	6.11***	1.83***
2	Production (%)	-2.40^{NS}	7.70***	5.16***
3	Productivity (%)	2.27*	2.83***	3.40***

3.10 Growth in area, production, productivity of cotton in Telangana

It was found (Table 10) that CAGR of area has increasedto 8.37 per centfrom7.86 per cent per annum from the period I to period Ⅱ. CAGR of production and productivity were decreased slightly in the period Ⅱ to 11.38 per cent and 2.97 per cent from 13.84 per cent and 3.98 per cent in the period I respectively.

TABLE 10. CAGR OF AREA, PRODUCTION AND PRODUCTIVITY OF COTTON IN TELANGANA FROM 1987-88 TO 2001-02, 2002-03 TO 2019-2020 AND 1987-88 TO 2019-2020.

S.I. No.	Source of growth	CAGR in Period Ⅰ	CAGR in Period Ⅱ	CAGR in Overall period
1	Area (%)	7.86***	8.37***	6.48***
2	Production (%)	13.84***	11.38***	10.54***
3	Productivity (%)	3.98**	2.97***	3.22***

3.11 Growth in area, production, productivity of cotton in Tamil Nadu

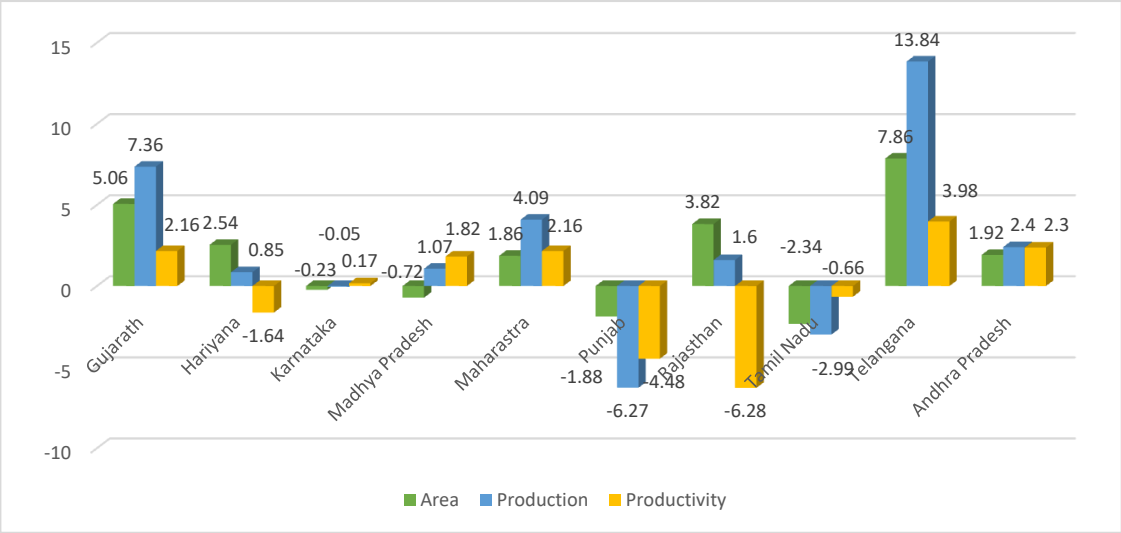
It was found (Table 11) that the CAGR of area, production and productivity was negative in periodI.The growth rate has significantly increasedwith respect to area, production and productivity in the period Ⅱto 3.43 per cent,8.06 per cent and 4.47 per cent per annum respectively.

TABLE 11. CAGR OF AREA, PRODUCTION AND PRODUCTIVITY OF COTTON IN TAMIL NADU FROM 1987-88 TO 2001-02, 2002-03 TO 2019-2020 AND 1987-88 TO 2019-2020.

S.I. No.	Source of growth	CAGR in Period Ⅰ	CAGR in Period Ⅱ	CAGR in Overall period
1	Area (%)	-2.34***	3.43***	-2.33***
2	Production (%)	-2.99***	8.06***	-0.53^{NS}
3	Productivity (%)	-0.66^{NS}	4.47***	1.83***

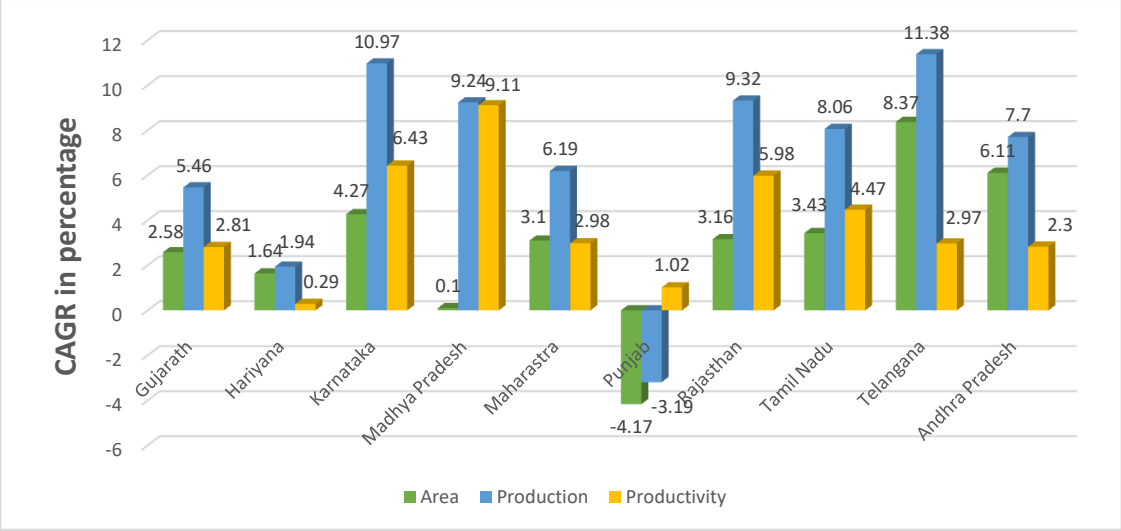
Southern states also showed significant increase in the growth rate of area production productivity. In Telangana state there was significant growth rate in both the period but there was slight decreasein growth rate of production and productivity after the introduction of Bt cotton. The results were in conformity with[5] reported significant increase in the growth of cotton area, production and productivity in the period Ⅱ and CAGR of area production and productivity has increased significantly from 2.59 to 5.01 per cent, -0.76 to 10.17 per cent and -1.74 to 3.43 per cent from period I to period II respectively.

Fig. 1. CAGR of area, production and productivity of cotton across different state in period Ⅰ



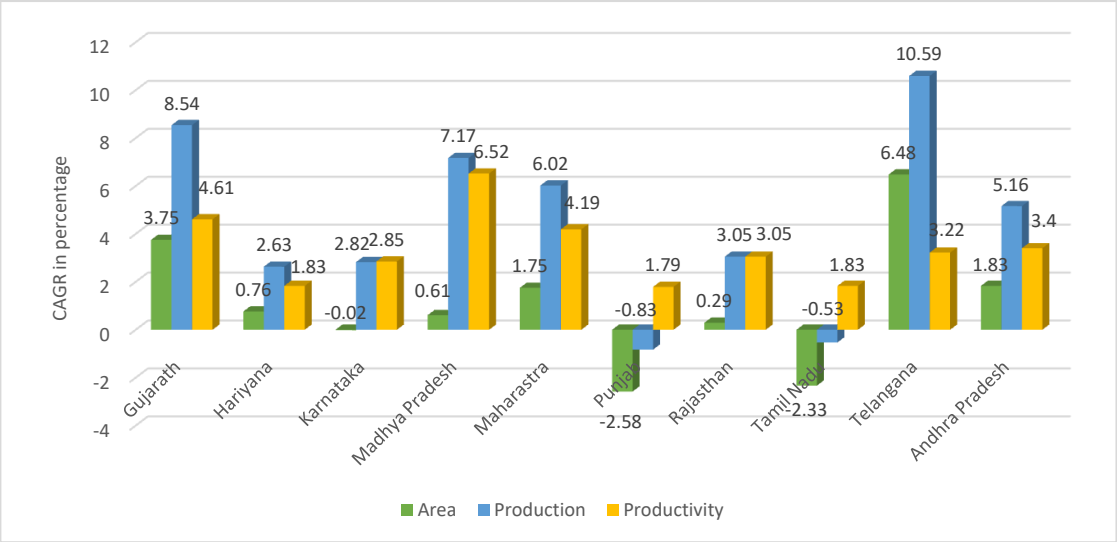
CAGR of area, production and productivity in the period I is highest in the Telangana state with 7.86 per cent and 13.84 per cent and 3.98 per cent per annum respectively followed by Gujarat state (Fig 1).

Fig. 2. CAGR of area, production and productivity of cotton across different state in period Ⅱ



CAGR of area, production in the period Ⅱ alsowas highest in the Telangana state with 8.37 per cent and 11.38 per cent per annum respectively. CAGR of productivity was highest in Madhya Pradesh with 9.11 per cent per annum.Except Punjab and Gujarat other state show significant increase in growth rate of area, production and productivity of cotton in period Ⅱ *i.e.,* after the introduction of Bt cotton (Fig 2).

Fig 3. CAGR of area, production and productivity of cotton across different state in overall period



CAGR of area, production in the overall period alsowas highest in the Telangana state with6.48 per cent and 10.59 per cent per annum. CAGR of productivity in the overall period is highestMadhya Pradesh with6.52 per cent per annum (Fig 3).

Except the case of few states, majority of states and India as a whole showed significant improvement in the growth rate of area production and productivity after the introduction of Bt cotton. However, the cotton growing farmers still facing constraints related to quality of seeds, pest and disease attack, lack of awareness about new technologyetc.The study therefore recommends to strengthen the extension system to make the farmer aware about new scientific technology which have the potential to reduce the cost and thereby increase their returns.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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