



Growth Rates of Cotton Crop in India and Pesticide Consumption: A Challenge Ahead

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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

Aim: To analyze the dynamics of area, production, and productivity of the cotton across different states of India to understand 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) before the introduction of Bt cotton and period II (2002-03 to 2019-2020) after the introduction of Bt cotton for India and for major cotton growing states in India. Compound annual growth rate (CAGR) of area, production and productivity was computed by using semi-log growth model (Log-Lin model).

Results: The result revealed that growth rates of area, production and productivity of cotton crop marked a significant increase after the introduction of Bt cotton across the major cotton growing states.

Conclusion: There is an increased growth rate in area, production and productivity of cotton after the introduction of Bt Cotton. At the same time there is increase in consumption of pesticide, which is threatening the sustainability of the environment. Therefore, study recommends to create awareness among the farmers towards lesser and safer pesticidal applications.

Keywords: Growth rates; cotton; significant; major cotton growing states; pesticide consumption.

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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, Madhya 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].

With increase in area under cotton cultivation pesticide consumption also increases significantly as the crop yield is seriously affected by the pest attack. Loss of yield due to the attack of the pest was estimated at around 50-60 per cent in India [5]. Globally, synthetic pesticides have become major choice of the farmers because of easy availability and quick control rendered by the synthetic pesticides. As there is commercialisation of genetically modified cotton or Bt cotton varieties

since its introduction in 2002, the topic of pesticide usage becoming relevant [6]. Still the discussions are going on whether cultivation of Bt cotton has reduced pesticide usage [7]. There are studies showed although total usage of the pesticide notably reduced after the Bt cotton cultivation but there has been increasing pesticidal application due to the emergence of the minor pest like aphids and Jassids [8]. During the recent year pink bollworm against which Bt cotton was introduced has attacking even Bt cotton bolls. This continuous use of pesticides significantly increased cost of cultivation and also causes irreversible damage on environment and causes health complication for human beings and livestock [9].

The trends in area, production and productivity of cotton across different states in country are increasing significantly. There are many reasons for this improvement viz., Introduction of Technology Mission on Cotton (TMC) in the year 2000, which mainly focused on improving production, productivity and quality of cotton, followed by introduction of Bt cotton in 2002 was a major milestone in the growth of cotton production and assured Minimum Support Price (MSP) programme by Government of India through Cotton Corporation of India (CCI) significantly increased growth in cotton. The contribution of these factors towards the growth needs to be studied by the researchers and institutions to recommend suitable policy framework. In this view a study on growth in the area, production and productivity of cotton in India (A state wise analysis) for two sub period i.e., before and after the introduction of Bt cotton is taken up. Simultaneously, consumption of pesticide is expected to rise. It is the time to take steps towards environmentally and socially sustainable alternatives cultivation against conventional cotton production.

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 India and for major cotton growing states like Haryana, Punjab and Rajasthan in Northern zone, Gujarat, Maharashtra, and Madhya Pradesh in Central zone and Andhra Pradesh and Telangana in Southern zone. Compound annual growth rate (CAGR) of area, production and productivity was computed by using semi-log growth model (Log-Lin model) [10].

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

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

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

$$\ln Y_t = \beta_1 + \beta_2 t + u_t$$

In order to facilitate the use of Ordinary least square and for estimation of parameter, the growth equation was converted into logarithmic form. The data were analyzed by using the Excel software.

Where,

$\ln Y_t$ is the natural logarithm of time series data for area/ production/ productivity for year t

β_1 is the constant term

t is the time in years

u_t is the error term

β_2 is growth rate for the period under consideration (i.e., slope coefficient)

Compound growth rate was calculated using following equation:

$$\text{CAGR}(r) = (\text{Antilog of } (\beta_2) - 1) \times 100$$

3. RESULTS 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), 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 3.24 and 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 -0.12 in period I to 2.87 per cent per annum in the period II. In the overall period also the growth rate of area (1.92%), production (5.21%) and productivity (3.23%) were positive and significant. The results were in conformity with the findings of [11] which reported significant increase in growth rate of area and production of cotton which was attributed 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.

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 I to 1.64 per cent per annum in the period II. CAGR of production increased to 1.94 per cent in the period II from 0.85 per cent per annum in the period I. And there was a slight improvement in the growth rate of 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 [12] 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 [13] and [14] reported that the adoption of hybrids was very low in Haryana. However, the cultivation of open pollinated varieties of cotton were dominant.

3.3 Growth in Area, Production, Productivity of Cotton in Punjab

It was observed (Table 3) that in the state of Punjab in both period I and period II growth rate of cotton area and production was negative whereas with respect to productivity there was an improvement from negative growth rate -4.48 per cent in the period I to 1.02 per cent in the period II. During the overall period also the growth rate in area and production were negative. The frequent loss of the cotton crop due to attack of various pest like pink bollworm, whitefly etc., would discourage the farmers to expand the area under cotton crop and assured minimum support price for the crop like rice and wheat in the state made the farmers to orient towards these crops.

3.4 Growth in Area, Production, Productivity of Cotton in Rajasthan

It was observed (Table 4) that the growth rate of 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.

Except Rajasthan, Northern zone showed no significant growth in area and production. This is mainly because in northern states cotton usually grown under irrigated condition, lack of sufficient water availability, frequent yield loss due to pest attack and irregular supply of electricity would discourage the farmers to take up cotton crop. The above findings were in similarity with the results of [11] reported no significant growth in cotton area and production. And [15] 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.

3.5 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 which were higher than the growth rates 2.58 and 5.46 per cent per annum in period II respectively. Growth rates of productivity increased slight to 2.81 per cent in the period II from 2.16 per cent per annum in the period I. Gujarat is the largest producer of the cotton in India and has the high productivity of 671 kg per hectare. [16]. However, In the recent years area under cotton is decreasing on the other hand oilseed and pulses are gaining momentum in the state.

3.6 Growth in Area, Production, Productivity of Cotton in Maharashtra

Growth rate of area has increased significantly from 1.86 per cent to 3.10 per cent per annum from

period I to period II. Similarly, growth rate of production increased from 4.09 per cent to 6.19 per cent per annum from 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 results were in conformity with [17] 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 growth rate of area under cotton is 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.

3.7 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. Growth rate of production has improved remarkably from 1.07 per cent to 9.24 per cent per annum and productivity improved from 1.82 per cent to 9.11 per cent per annum from the period I to period II respectively.

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 [11] reported significant growth of area and production in the central zone after the introduction of Bt cotton.

Table 1. CAGR of Area, production and productivity of cotton in India 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 (%)	2.11***	3.24**	1.92***
2	Production (%)	1.97*	6.2***	5.21***
3	Productivity (%)	-0.12 ^{NS}	2.87***	3.23***

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

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***

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***

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***

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***

Table 6. CAGR of area, production and productivity of cotton in Maharashtra 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***

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***

3.8 Growth in Area, Production, Productivity of Cotton in Andhra Pradesh

Growth rate 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 of productivity from 2.27 per cent to 2.83 per cent per annum from the period I to period II (Table 8). The similar results observed in the

study, growth and instability of cotton crop in major cotton growing states in India conducted by [18] reported significant growth rates in area and production of cotton cultivation in Andhra Pradesh in the Period 2000-01 to 2013-14.

3.9 Growth in Area, Production, Productivity of Cotton in Telangana

It was found (Table 9) that growth rate of area has increased to 8.37 per cent from 7.86 per cent per annum from the period I to period II. CAGR of production and productivity were decreased slightly

Table 8. 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***

Table 9. 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***

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. Because in the recent years area under paddy is increasing in the state due to new irrigation facility created by taking up Kaleshwaram project. The area under paddy cultivation in 2020-21 reached to a record level of 1.04 crore acres in the Telangana state [19].

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 decrease in growth rate of production and productivity in period II. The results were in conformity with [10] reported significant increase in the growth of cotton area, production and productivity after the introduction of Bt cotton.

3.10 Pesticide Consumption across Major Cotton Growing States

It is noticed from the table the pesticide consumption in 2020-21 is decreased in the states like Gujarat, Haryana, and Tamil Nadu when compared to previous year. However, in majority of the state and India as whole consumption of the pesticides showed an increased trend. Overall pesticide consumption in India is stood around 62,193 metric tons in the year 2020-21 as against 61,702 metric tons in the previous year.

(Quantity in metric tons)

States	2018-19	2019-20	2020-21
Andhra Pradesh	1689	1559	1559
Gujarat	1608	1784	1573
Haryana	4015	4200	4050
Karnataka	1524	1568	1930
Madhya Pradesh	540	540	691
Maharashtra	11746	12783	13243
Punjab	5543	4995	5193
Rajasthan	2290	2088	2330
Tamil Nadu	1901	2225	1834
Telangana	4894	4915	4986
India	59670	61702	62193

(Source: www.indiastat.com)

This increased usage of chemical pesticides has a detrimental negative externality on the environment, biodiversity and fertility and productivity of the soil. The pesticide residues in food cause series health related problem in human being. The residues of the pesticide also pollute the ground water this in turn affect the quality of food and health of the soil and plants. Since the onset of the green revolution, it is estimated that nearly 8,00,000 people in developing countries have died due to pesticides. Around 20000 people in developing countries die each year because of consumption of pesticide, indirectly through food product [20].

4. CONCLUSION

From the above analysis it is noticed that area, production and productivity of cotton in India as well as in the states, Maharashtra and Andhra Pradesh witnessed a positive growth rate after the introduction of Bt cotton which were statistically significant at 1 per cent. Madhya Pradesh and Rajasthan showed positive growth in production and productivity which were significant at 1 per cent level. In Punjab there was no significant improvement in growth rates. Growth rate of area and production in Telangana were higher than other state in both periods. Along with this significant increase in growth rate, there are concerns for increased pesticide usage as cotton is widely grown in millions of hectares in India. Cotton crop is alone consuming nearly 36–50 per cent of the total pesticides in the country [20]. Farmers use wide variety of pesticides ranging from extremely hazardous to moderately hazardous in their effects. This in turn has a series negative impact on the environmental sustainability and global stability. Many organisms and microbes are facing threat of survival because of over usage of pesticides [9]. Therefore, study recommends to create awareness among the farmers about the pesticidal application and their effect on soil and environment. Extension system need to be strengthened to aid the farmers in the way of reduced and recommended usage of the pesticides. Cotton farmers should be encouraged to change from conventional cotton production to organic and sustainable cotton cultivation.

DISCLAIMER

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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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