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Trends and instability in area, production and yield of cotton in northern India

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Cotton is one of the principal crops of India and plays a vital role in the country's economic growth by providing substantial employment and making significant contribution to export earnings. The cotton cultivation sector not only engaged around 6 million farmers but also involved another about 40 to 50 million people relating to cotton cultivation, cotton trade and its processing. Despite having the largest area under cotton in the world, India ranked third in the world output of cotton due to its abysmally low average yield of 300-400 kg against the world average of 580 kg/ha during 2004-2005 (Singh *et al.*, 2011)

The pest problem on cotton crop became serious in 1990s causing fast deceleration in average yield at compound growth rate (CGR) of minus 0.41 per cent. This was a period of serious economic turmoil for cotton growers pushing a number of them in heavy debt and even in suicide trap. In Punjab state the productivity of cotton suffered most serious setback where it dipped from 582 kg/ha in terms of lint in 1991-1992 to just 180 kg/ha in 1998-1999 (Singh, 2010). However, revival of cotton crop due to introduction of *Bt* strain since 2002 has given a new lease of life to them. As a result, there has been spectacular increase in production and productivity of cotton. The area under cotton was about 9 million hectares with annual production of 19 to 21 million bales of 170 kg each in 2004-2005 which increased to 11.14 million hectares and production to 33.43 million bales during 2010-2011. The average productivity of cotton has reached to 510 kg/ha and India being net-cotton- importing nation, has become the world's second producer and exporter of cotton. But still the productivity of cotton in India is lower than the world average. Even the yield of cotton in China is two and half times more than that of India.

Although cotton is cultivated in large number of states in the country, the nine states of Punjab, Haryana, Rajasthan, Gujarat, Maharashtra, Madhya Pradesh, Andhra Pradesh, Tamil Nadu and Karnataka accounts for more than 95 per cent of area and output. The northern cotton region of India includes states of Punjab, Haryana and Rajasthan which occupies only 16 per cent of the total cultivated area but contributes about 21 per cent of the production. Further in these states the cotton crop is cultivated in specific pockets of the states. In Haryana state, the districts of Sirsa, Fatehabad, Hisar, Jind and Bhiwani constituted more than 90 per cent of the area in the state. In Punjab, the cotton is grown in south western region (popularly known as cotton belt) of the state. In this region, the districts include Bathinda, Muktsar, Faridkot, Ferozepur, Mansa and Moga which accounts for 95 per cent of area under cotton in the state. In Rajasthan, the districts of Sriganganagar and Hanumangarh are included; about 80 per cent of total cotton area of the entire state falls under these areas. A significant change was observed in the area, production and productivity of cotton in these states since 1980s. Thus, the present study has planned to analyze the trend/growth in area, production and productivity of cotton among different states of northern region (Punjab, Haryana and Rajasthan) of India. An attempt has also been made to analyze the instability in area, production and productivity of cotton in these states.

MATERIALS AND METHODS

The study is based on secondary data relating to area, production and productivity of cotton for the three important cotton growing states namely Punjab, Haryana and Rajasthan. The data has been collected from various sources such as Centre for Monitoring Indian Economy, Statistical Abstract of Punjab, Agricultural Statistics at a Glance and other published documents and reports.

Analytical techniques : To study the growth in area, production and productivity of cotton in northern states of India, the compound growth rates were estimated by using following formula:

$$Y = ab^{t}$$

Where;

Y = area/ production/yield of cotton

t = corresponding year

b = regression coefficient

r = compound growth rate (%) = (b-1) x 100

To estimate the variability in area, production and yield of cotton, the coefficient of variation (CV) was estimated using the formula:

$$CV = \frac{\text{Standard deviation}}{\text{Arithmetic mean}} \times 100$$

The instability index (II) is used to de trend the change in any series over time. The instability index given by Cuddy and Della Valle (1978) was used to measure instability in area, production and yield of cotton for different time periods.

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

Where;

CV = Coefficient of variation

$?^2$ = Adjusted Coefficient of multiple determination

For the purpose of analysis the whole period of 31 years (1980-81 to 2010-11) was divided into :

Period I: 1980-1981 to 1989-1990
Period II: 1990-1991 to 1999-2000
Period III: 2000-2001 to 2010-2011
Overall : 1980-1981 to 2010-2011

RESULTS AND DISCUSSION

Growth pattern of cotton : The area, production and productivity of cotton among cotton producing states of north zone of India have been incorporated in Table 1 and their decade-wise growth rates have been presented in Table 2 for the period 1980-1981 to 2010-2011. The area under cotton in northern region was 15.02 lakh ha during triennium ending (TE) 1989-1990 increased to 18.01 lakh ha during TE 1999-2000 and declined to 13.68 lakh ha during TE 2010-2011. In Punjab state, the area under cotton declined in successive decades from 7.04 lakh ha to 5.07 lakh ha from TE 1989-90 to TE 2010-2011. In Rajasthan and Haryana, the area under cotton was maximum during TE 1999-2000 at 5.89 lakh ha and 6.24 lakh ha, respectively.

Decadal growth rate showed different picture, the CGR of area under cotton in northern region remained non significant in all the decades under study but coefficient was negative for eighties (1980-1981 to 1989-1990) and for 2000-2001 to 2010-2011 but positive during nineties. The area under cotton in Punjab state decelerated significantly at about one per cent during the study period. Decade wise scenario reveals that CGR of area under cotton was non-significant in Punjab state in all the decades indicating no significant decrease/increase in area in these decades. Overall the area and production of cotton registered a significant growth in Haryana with the annual rate of 1.59 and 2.59 per cent respectively. The area under cotton increased significantly in Haryana at 3.47

Table 1: Area, production and yield for cotton among different states of northern India

Triennium ending (TE)

Period	Punjab			Haryana			Rajasthan			Northern region		
TE	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
1989-1990	7.04	21.44	518	4.39	8.12	347	3.59	6.01	278	15.02	35.57	381
1999-2000	5.89	8.27	245	5.89	8.90	258	6.24	12.00	324	18.01	27.42	262
2010-2011	5.07	20.38	681	4.86	14.42	505	3.60	9.50	445	13.68	39.42	491

Area in lakh ha; production in lakh bales and yield in kgs/ha

per cent growth rate per annum during eighties and even during nineties at 2.28 per cent whereas the production and yield decelerated at 4.08 and 6.25 per cent during this decade, a period of failure of cotton crop. The rate of growth of area was negative at 1.83 per cent per annum during 2000-2001 to 2010-2011, a period of *Bt* cotton cultivation. In case of Rajasthan, the area under cotton increased significantly at the rate of 4.53 per cent/annum during nineties which was a complete failure of cotton crop period for Punjab state. Production of cotton was the lowest during nineties at 27.42 lakh tones in northern region. Moreover, during this period the production of cotton decelerated with 5.14 per cent/annum in northern region as a whole mainly because of significant decline in the yield with rate of 6.09 per cent/annum. The compound growth rate of production and yield was positive and significant in northern zone during 2000-2001 to 2010-2011 being 5.96 and 6.84 per cent/ annum, respectively. In case of Punjab and Haryana states similar trend was observed; the growth rate of production was significant during 2000-2001 to 2010-2011 and were as high as 6.79 per cent for Punjab and 7.28 per cent for Haryana. This happened mainly because of high growth rate of yield of cotton at 6.16 per cent and 9.39 per cent per annum due to *Bt* cotton crop cultivation during this period, the CGR of area was positive but non significant in Punjab whereas negative and significant for Haryana during this period. In Rajasthan the yield of cotton also increased significantly with 4.10 per cent/annum but the coefficient of CGR of production though positive but non-significant during this decade. Overall the period of 1990s was a failure of cotton crop in northern zone. The production increased significantly with high growth rate of yield during 2000-2001 to 2010-2011 but there no significant increase in area with the introduction of *Bt* cotton in the region.

Variability : To examine the variability in area, production and yield of cotton in northern cotton producing states of India the coefficient of variation (CV), a commonly used measures of dispersion and Cuddy and Della Valle (1978) Index of Instability (II) which de- trend the time series observations were used. The CV and II of area, production and yield of cotton in Punjab, Haryana, Rajasthan and for overall northern region has been depicted in Tables 3 and 4, respectively. Lower the value of this coefficient lower will be the variability and better it will be and *vice versa*. For the northern region as a whole, the CV of area ranged from 7.24 to 10.48 per cent in different decades being the highest during eighties and the lowest during 2000-2001 to 2010-2011. The CV of production and yield of cotton remained above 20 per cent and less than 25 five per cent. In Punjab state, the CV of area of cotton declined in successive decades being 13.22 per cent during eighties and declined to 10.45 per cent during 2000-2001 to 2010-2011. The CV of production of cotton was the highest during nineties at 36.04 per cent mainly because of high variation in yield (CV being 32.69%), CV of area, production and yield was the lowest during the period of *Bt* cotton production (2000-2001 to 2010-2011). In Haryana, CV of cotton production was the highest during the 2000-2001 to 2010-2011 because of higher variability in yield than area. The difference in CV of yield and production in these two states during 2000-2001 to 2010-2011 might due to variation in the adoption level of *Bt* cotton.

In case of Rajasthan, the CV of area increased in successive decades *i.e.* from 10.74 per cent in eighties to 15.60 per cent in 2000-2001 to 2010-2011. In contract to Punjab and Haryana, CV of production and yield in Rajasthan was the lowest during nineties at 12.97 per cent and 9.93 per cent, respectively. The instability index (II) which shows the instability in area, production and yield of cotton among different states of north India (Table 4) also give similar results as that of CV. The II for area decelerated in successive decades and remained lower than the II of production and yield in northern region of India. The II of production and yield was almost same in all the decades indicating the variation in productivity to be the sole factor of production not area. In other words, whatever the instability occurred in cotton production, it happened due to variability in its yield alone. Among different states, the II of area, production and yield did not follow the same pattern. Similarly, in a study of Punjab state, (Kaur *et al.*, 2011) reported that CV and II of area, production and productivity for pulses were higher than that of food grain indicating less production risk in food grain and

Table 2. Compound growth rate of area, production and yield of cotton in northern India

Period	Punjab			Haryana			Rajasthan			Northern region		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Period I	0.5	9.54***	9.00***	3.47***	2.2	1.09	-0.64	4.18	4.85	1.02	6.74***	5.27***
(1980-1981 to 1989-1990)	-0.29	-3.33	-3.05	-2.62	-1.31	-0.56	(-0.49)	-0.91	-1.18	(-0.79)	(-3.86)	-2.87
Period II	-2.41	-10.52***	-8.34***	2.28**	-4.08**	-6.25***	4.53***	3.07***	-1.53	1.24	-5.14***	-6.09***
(1990-1991 to 2000-2001)	(-1.68)	(-3.77)	(-2.92)	-2.24	(-2.07)	(-3.39))	-4.04	-2.59	(-1.33)	-1.15	(-2.80)	(-3.35)
Period III	1.05	6.79**	6.16***	-1.83**	7.28***	9.39***	-1.74	1.94	4.10**	-0.81	5.96***	6.84 ***
(2000-2001 to 2010-2011)	(0.99)	-2.86	-3.41	(-2.46)	-2.95	-3.73	(-1.19)	(0.77)	-2.53	(-1.14)	-2.78	-3.59
Overall	-0.84***	1.26	2.188***	1.59***	2.59***	0.73	0.21	2.69***	2.39***	0.22	1.42***	1.31***
(1980-1981 to 2010-2011)	(-2.94)	-1.71	-3.12	-4.84	-5.06	-1.29	-0.47	-3.48	-4.67	(0.75)	-2.8	-2.67

Figure in parentheses are t values. ***, ** indicate significant at 1% and 5% level respectively.

Table 3. Coefficient of variation of cotton among different states of northern India

Period	Punjab			Haryana			Rajasthan			Northern region		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Period I (1980-1981 to 1989-1990)	13.22	32.34	28.85	14.07	15.06	15.02	10.74	36.49	31.69	10.48	24.26	20.37
Period II (1990-1991 to 1999-2000)	12.68	36.04	32.69	10.43	19.04	22.74	15.43	12.97	9.93	9.58	20.60	22.13
Period III (2000-1901 to 2010-2011)	10.45	27.48	22.28	9.33	25.13	28.71	15.60	21.99	16.38	7.24	23.438	23.38
Overall (1980-1981 to 2010-2011)	15.77	33.34	34.63	19.63	31.72	25.11	23.47	35.72	25.94	14.21	25.39	24.98

Table 4. Instability Index for cotton among different states of northern India

Period	Punjab			Haryana			Rajasthan			Northern region		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Period I (1980-1981 to 1989-1990)	13.15	20.38	19.17	10.24	13.65	14.73	10.58	34.68	29.15	10.09	14.05	14.12
Period II (1990-1991 to 1999-1900)	10.09	14.05	14.12	10.92	22.51	23.22	8.14	15.46	14.85	8.87	14.83	14.55
Period III (2000-2001 to 2010-2011)	9.92	19.60	14.46	7.24	17.61	17.52	14.52	21.29	12.41	6.77	16.97	14.70
Overall (1980-1981 to 2010-2011)	13.85	31.76	29.88	14.55	22.98	24.41	23.38	29.88	19.49	14.07	22.49	22.35

high production risk in pulses cultivation in the state. Thus cotton crop remained a risky crop due to high variability in productivity.

Overall it is concluded that the cotton cultivation remained a risky crop in northern region of India. The CV and instability index were high for production, which is mainly because of high variability in yield rather than area. In spite of the high growth rate of yield and production after the introduction of *Bt* cotton, the area under cotton cultivation remained stagnant in northern states of India.

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