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RESEARCH PAPER

Performance of cotton production and export in the major producing countries

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ABSTRACT

The present investigation was conducted to study the growth rates and instability indices in production, area, productivity and export of cotton, and the components of output growth in the major cotton producing countries. The study used secondary data covering a period of 29 years *i.e.*1980-81 to 2009-10. The analyses were carried out country wise separately for the five specific periods *viz*., overall study period (1980-81 to 2009-10), pre-liberalization period (1980-81 to 1993-94), post-liberalization period (1995-96 to 2009-10), pre-Bt introduction period (1995-96 to 2001-02) and post-Bt introduction period (2002-03 to 2009-10). The countries concerned in the study were China, India, USA, Pakistan, Brazil and Australia. The results of the study showed that there were variations in growth rates and instability of area, productivity, production and export during the five periods. The country-wise picture was composite. Some countries witnessed higher growth and instability while others experienced a relatively low growth and instability. The analysis of components of growth in cotton output showed that the main contribution to growth in Australia, Brazil, China and USA was predominately due to area effect. Whereas, in India and Pakistan the main contribution to cotton output growth was yield effect. Technological programmes to play a substantial role in achieving high growth rate of cotton production should be designed. Such programmes and policies should include developing new high yielding varieties and provision of irrigation facilities to cotton growing farmers. Research efforts are needed to strengthen agricultural extension and the cotton breeding programmes using new efficient technologies.

KEY WORDS : Export, Growth, Instability indices, Technology, Decomposition model

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Cotton is one of the most important and widely produced crops in the world and it is also heavily traded agricultural commodity. It is grown in more than 100 countries but the major producing countries are China, India, USA, Pakistan, Brazil and Australia which together they contribute more than 85 per cent of the world cotton production.

The Uruguay round of multilateral trade under the auspices of General Agreement on Tariffs and Trade

(GATT) came up as a historical opportunity to reform agricultural policies and liberalize trade. After establishment of WTO, due to Agreement on Agriculture (AoA), new situations had emerged in the global cotton industry. Such alterations included market liberalization and reduction of subsidies and taxes that restricted free, fair and predictable trade. In addition, between the late 1990's and during the start of 21st century, the new technology *i.e.* genetic modified seed (Bt cotton) was introduced and this influenced the productivity of cotton in many cotton producing countries. Therefore, it was important to examine the country wise growth rates and instability indices in production, area, productivity and export during different phases of development *i.e.* pre and post liberalization, and pre and post Bt introduction periods. Furthermore, various components influencing overall output growth of cotton are important issues that need scientific understanding.

The objectives of this paper were to estimate the growth rates and instability indices of area, productivity, production and export, and also to measure the contribution of different components to cotton output in the major cotton producing countries during overall study period (1980-81 to 2009-10), pre-liberalization period (1980-81 to 1993-94), post-liberalization period (1995-96 to 2009-10), pre-Bt introduction period (1995-96 to 2001-02) and post-Bt introduction period (2002-03 to 2009-10).

METHODOLOGY

The present study was based on secondary data for a 29 years period from 1980-81 to 2009-10. The analyses were carried out country wise separately for the five specific periods *viz*., overall study period (1980-81 to 2009-10), pre-liberalization period (1980-81 to 1993-94), post-liberalization period (1995-96 to 2009-10), pre-Bt introduction period (1995-96 to 2001-02) and post-Bt introduction period (2002-03 to 2009-10). The sources of data used were United States Department of Agriculture (USDA), UN COMTRADE WITS (United Nations Commodity Trade Statistics Database), FAOSTAT, United Nations Conference on Trade and Development (UNCTAD) and the International Cotton Advisory Committee (ICAC). The countries concerned in the study were China, India, USA, Pakistan, Brazil and Australia.

The methods used for estimating the growth rate, instability indices, and decomposition of growth components are described in the upcoming sections.

Measurement of growth rate :

The growth rate was measured following the procedure adopted by Green (2000) and the steps followed are presented below.

Exponential growth function

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

where:

Y= Dependent variable for which the growth rate is estimated *i.e.*, area, production, productivity and export

a= Intercept/constant

b= Regression co-efficient

t= Time variable

e= Error term

The compound growth rate was obtained from the logarithmic form of the equation as below:

$$\ln y = a + t \ln b \qquad (2)$$

The per cent compound growth rate (G) was derived using the relationship

$$G = (\text{Anti log of } b - 1) \times 100$$

The above mentioned exponential function was used by many researchers to work out compound growth rate in area, production, productivity and export (Agarwal, 2008; Ratna, 2009; Nithya and Arunkumar, 2007; Reddy, 2009 and Mohamed *et al*., 2010).

Measurement of instability :

An instability index model was used to estimate the variability in country-wise production, area, productivity and exports. Tarpara *et al*. (2010); Zhao and Tisdell (2009); Chand and Raju (2008); Singh *et al*. (1997) and Goyal *et al*. (2000) employed the instability index to estimate the level of instability in agriculture. The simple co-efficient of variation (CV) often contains the trend component and thus over estimates the level of instability in time series data characterized by long term trends. To overcome this problem, in this study the Instability index used by Cuddy and Della (1978) as follows was used:

$$I = C.V. \times \sqrt{1 - R^2} \qquad (3)$$

where,

I = Instability index

$$C.V.\% = \frac{SD}{Mean} \times 100$$

$$SD = \text{Standard deviation} = \sqrt{\text{variance}}$$

$$\text{Variance} = \frac{\sum_{i=1}^{n}(Y_i - \hat{Y})^2}{n-1}$$

R^2 is the co-efficient of determination of the trend regression which best fits the time series. For determining R^2 a linear and nonlinear (log linear) trend equation was estimated in this study.

Decomposition of growth components :

To measure the relative contribution of area and yield to the total cotton output change, a decomposition analysis model given as below was used. Several research workers used this model and studied growth performance of various crops (Mohamed *et al*., 2010; Zhao and Tisdell, 2009; Parikh, 1966; Chaudhry *et al*., 1996 and Salam *et al*., 2011). A systematic scheme for decomposing the growth trend was first presented by Minhas and Vaiyanathan (1965), which equates changes in output to changes in area, yield, cropping pattern, and interaction of these factors. This approach is referred to additive series since they decompose absolute growth in the value of output. These schemes contain residual components called interaction components (Jamal and Zaman, 1992). In this study, the change in production was divided into three effects *i.e.* area effect, yield effect and interaction effect. The following is the converted growth rate decomposition model of Minhas seven-factor decomposition scheme.

$$aP = A - a\,Y + Y - aA + aA\,aY \qquad (4)$$

Change in production = Yield effect + Area effect + Interaction effect

Thus, the total change in production is attributed due to area and yield that can be decomposed into three effects *viz*., yield, area and interaction effects.

ANALYSIS AND DISCUSSION

The findings of the present study as well as relevant discussion have been summarized under the following heads :

Growth performance :

In this section, the results of analysis of the growth rate in area, production, productivity and export of cotton in the major cotton producing countries during the specified periods as presented in Table 1 are discussed.

Growth rate in area :

It can be observed from Table 1 that China witnessed a positive growth rate in period II (0.47 %), period III (1.54 %) and period V (0.44 %), and recorded a negative trend in period IV (-2.97 %). The annual growth rate in India was 1.1 %, 1.38 %, and 5 % during period I, III, and V, respectively. A negative growth was observed during period II (-2.96) and IV (-0.88 %). There was a decline in growth rate in USA but it was comparatively higher in period IV (-0.12%) than period III (-2.72 %) and V (-4.23 %). A positive growth was observed during period I (1.11 %) and period II (0.88 %). Annual area growth rate in Pakistan was 1.11 %, 0.1 %, 0.25 % and 1.99 % during period I, II, III and V, respectively, whereas during period IV, it was a negative growth (-0.08 %). The cotton area growth rate in Brazil was positive during period III (2.76 %) and period V (3.54 %), and it registered a negative growth rate during period I (-3.25 %), II (-3.6 %), and IV (-2.97). It can further be observed that during period I (2.65 %), period II (8.11 %), period IV (5.13 %), and period V (9.42 %), Australia ranked first in growth rate of area allocated to cotton. This implies Australia was the fastest growing in land allocation to cotton. However, there was a negative growth in land allocated to cotton during period III (-3.38 %). This negative growth was in agreementwith the findings og Zhao and Tisdell (2009) and Carpio and Ramirez (2002). They indicated that the negative growth was as a result of switching of allocation of land to grain crops in place of cotton by some farmers. Grain prices were quite favorable for grain crops compared to cotton prices. However, in subsequent periods the magnitude of their competing crops' effect seems to have diminished.

Growth rate in production :

The compound growth rate results in production revealed that during the overall study period (1980-81 to 2009-10), India recorded the highest growth (4.59 %) followed by Australia (4.39 %), Pakistan (3.18 %), Brazil (2.94 %), China (2.42 %) and USA (1.06 %). This implies that India was the fastest growing in cotton production. These results were in agreement with those of Singh *et al.* (1997), they reported that increase in cotton production was on account of cotton yield. A further examination of growth rates in production shows that in pre-liberalization period, Australia recorded the highest growth (10.46 %) followed by Pakistan (7.05 %), India (4.14 %), USA (3.38 %), China (2.04 %) and in Brazil (-1.98 %) a

negative growth was observed. During post-liberalization period, Brazil recorded the highest rate of growth (10.77 %) followed by India (5.76 %), China (4.28 %), Pakistan (1.67 %), whereas for USA (-0.30 %) and Australia (-1.63 %) a negative growth was observed.

In pre-Bt introduction period, Brazil also registered a highest growth (18.06 %), followed by Australia (8.31 %), Pakistan (1.08 %), China (0.88 %), and USA (0.14 %). Whereas the growth rate in production under cotton was negative in India (-2.54 %). In post-Bt introduction period, India recorded the highest growth (9.06 %) followed by Australia (7.82 %), Brazil (6.56 %), China (3.32 %), Pakistan (0.99 %) whereas USA (-2.68 %) witnessed a negative growth.

Growth in productivity:

In case of productivity, during the overall study period (1980-81 to 2009-10), all countries registered a positive growth rate. Brazil recorded the highest rate of growth (6.48 %) followed by India (3.40 %), China (2.45 %), Pakistan (2.00 %), Australia (1.70 %) and USA (1.41 %). This suggests that Brazil was the fastest growing in as far as productivity is concerned. It is believed that ideal climatic conditions and highly mechanized cotton farming could be the major cause of this growth (Anonymous, 2006). In pre-liberalization period, Pakistan recorded the highest rate of growth (4.84 %) followed by India (4.38 %), USA (2.37 %), Australia (2.02 %), Brazil (1.58 %) and China (1.55%). Further, during post-liberalization period, Brazil showed the highest rate of

Table 1 : Growth rate in area, production, productivity and export (In %)

Country	Study periods				
	Overall	Pre-liberalization	Post-liberalization	Pre-Bt introduction	Post-Bt introduction
	1980-81 to 2009-10	1980-81 to 1993-94	1995-96 to 2009-10	1995-96 to 2001-02	2002-03 to 2009-10
Growth rate in area					
China	-0.15	0.47	1.54	-2.97	0.44
India	1.1	-2.96	1.38	-0.88	5
USA	0.13	0.88	-2.72	-0.12	-4.23
Pakistan	1.11	1.99	0.1	-0.08	0.25
Brazil	-3.25	-3.6	2.76	-2.97	3.54
Australia	2.65	8.11	-3.38	5.13	9.42
Growth rate in production					
China	2.42	2.04	4.28	0.88	3.32
India	4.59	4.14	5.76	-2.54	9.06
USA	1.06	3.38	-0.3	0.14	-2.68
Pakistan	3.18	7.05	1.67	1.08	0.99
Brazil	2.94	-1.98	10.77	18.06	6.56
Australia	4.39	10.46	-1.63	8.31	7.82
Growth rate in productivity					
China	2.45	1.55	2.52	3.95	2.39
India	3.4	4.38	4.32	-1.63	3.84
USA	1.41	2.37	2.35	1.63	1.4
Pakistan	2	4.84	1.55	1.81	0.73
Brazil	6.48	1.58	7.81	21.66	2.9
Australia	1.7	2.02	1.82	3.01	-1.56
Growth rate in export					
China	-4	27.72	-3.53	72.82	-27.07
India	6.01	0.35	31.14	-37.91	78.3
USA	3.45	0.88	6.95	-3.55	2.59
Pakistan	-8.44	-0.17	4.25	-7.68	7.01
Brazil	6.34	-6.29	56.16	51.31	21.99
Australia	6.75	16.57	-2.94	17.12	-10.41

Source: Calculated form data FAO statistics, USDA and UNCTAD

growth (7.81 %) followed by India (4.32 %), China (2.52 %), USA (2.35 %), Australia (1.82 %) and Pakistan (1.55 %). In pre-Bt introduction period, Brazil showed the highest rate of growth (21.66 %) followed by China (3.95 %), Australia (3.01 %), Pakistan (1.81 %), and USA (1.63 %). Whereas a tune of negative growth (-1.63 %) was recorded in India. As far as post-Bt introduction Period is concerned, India recorded the highest rate of growth (3.84 %) followed by Brazil (2.90 %), China (2.39 %), USA (1.40 %), and Pakistan (0.73 %) whereas in Australia a negative growth (-1.56 %) was observed. Further, it is noteworthy that in post-Bt introduction period (period V), the margins of country wise productivity growth rates were not as wider as in other periods. This could be partly be due to the introduction of Bt cotton in these countries making the productivity somewhat at the same quantum. Nazli *et al.* (2010) quoted on the basis of the results of various studies that the countries that adopted Bt cotton experienced a decline in pest infestation and enjoyed stable and better yields and higher profits after the adoption of Bt cotton.

Growth in export:

As it can be observed from Table 1, Australia was found comparatively to be the fastest growing in the world during 1980-81 to 2009-10 as Australia witnessed the highest growth (6.75 %). This was followed by Brazil (6.34 %), India (6.01%) and USA (3.45 %), whereas in China (-4.00 %) and Pakistan (-8.44 %), a negative growth was observed. However, Australia performance was much better during period IV (17.12 %), then Period II (16.57%). A negative growth was observed during period V (-10.41 %) and period III (-2.94 %). It can be observed from the results that China experienced higher growth during period II (27.72 %) and IV (72.82 %). However, It recorded a negative growth during period I (-4.00 %), period III (-3.54 %) and period V (27.07 %). This trend could be explained by the up and down global consumption of cotton, as well as China's trade ministry directives to allow local government and state farms to sell cotton directly on the international market (USDA, 1999). During post-liberalization period, Brazil registered the highest growth (56.16 %) followed by India (31.14 %), USA (6.95 %), and Pakistan (4.25 %). A negative growth was seen Australia (-2.94 %) and China (-3.53 %). Further, during period I (6.34 5), period IV (51.31 %) and period V (21.99 %) Brazil was the second fastest growing in the export of cotton. This trend was, according to Kiawu *et al.* (2011), due to trade liberalization and favorable exchange rate were a significant factors to year to year shifts in Brazilian cotton trade. During post-Bt introduction period India registered the highest growth rate (78.30 %) followed by Brazil (21.99 %), Pakistan (7.01 %) and USA (2.59 %), whereas China (-27.07 %) and Australia (-10.41 %) recorded negative growth. India, which recorded a second position, in period III (31.14%), experienced a negative growth during period IV (-37.91 %). This result was in agreement with those of Goyal *et al.* (2000). They observed that a negative growth was as a result for export controls by the government. USA experienced lowest positive cotton export growth during period I (3.45 %), and period V (2.59 %) with a negative growth recorded during period IV (-7.68 %). Pakistan recorded a negative growth during period I (-8.44 %), period II (-0.17 %) and period IV (-7.68 %). These results were similar to those by Hussain (2010). He gave the reasons for this poor performance as partly due to economic sanctions and unfair trade.

Instability indices :

In this section, the results of the instability indices in area, production, productivity and export of cotton in the major cotton producing countries during the specified periods are discussed.

Instability in area :

It can be observed from Table 2 that there were relatively more fluctuations in Australia as compared to other countries as it recorded the highest degree of instability during overall study period (46.99 %), during pre-liberalization period (16.00 %), post-liberalization period (46.81 %) and post-Bt introduction period(56.38 %). During pre-Bt introduction period it recorded second highest degree in instability (14.99 %). These results were in agreement with Zhao and Tisdell (2009) who reported that the area planted to cotton in Australia is more volatility. This is due to free market forces and availability of water.

Less fluctuation in area instability were observed in Pakistan as it recorded the lowest degree of instability during overall study period (5.57 %), pre-liberalization period (3.36 %), post-liberalization period (4.11 %) and post-Bt introduction period (4.88 %). During pre-Bt introduction period it recorded second lowest degree in

instability (14.99 %). These results were in line with the findings of Salam *et al*. (2011) who reported that the low instability in area was as a result of scarce supply of water resources. Thus, it can be concluded that Australia and Pakistan were the most unstable and most stable, respectively, among the major cotton producing countries in land allocation to cotton.

Instability in production :

As it was with the case in area instability, it can be observed from the Table 2 that there were relatively more fluctuations in Australia as compared to other countries as it recorded the highest degree of instability during overall study period (47.07 %), during pre-liberalization period (22.82 %), post-liberalization period (43.06 %) and post-Bt introduction period (51.64 %). Further, during pre-Bt introduction period it recorded second highest degree in instability (10.12 %). These results were in agreement with Zhao and Tisdell (2009) who reported that the level of cotton production was shown to be more volatile than other countries because the area planted with cotton is so variable. It can further be observed that during overall study period (15.82 %), and post-liberalization period (9.96 %), Pakistan was comparatively very stable. The results further revealed that cotton production was also comparatively stable in India as it recorded the lowest in pre-liberalization period (9.97 %), pre-Bt introduction period (5.15 %), and post-Bt introduction period (9.03 %). Thus, it can be concluded from the results in Table 2 that during the overall study

Table 2 : Instability in area, production, productivity and export (In %)

Country	Study periods				
	Overall	Pre-liberalization	Post-liberalization	Pre-Bt introduction	Post-Bt introduction
	1980-81 to 2009-10	1980-81 to 1993-94	1995-96 to 2009-10	1995-96 to 2001-02	2002-03 to 2009-10
Instability in area					
China	14.24	13.45	11.76	10.09	9.69
India	9.8	4.99	10.2	2.01	5
USA	17.09	15.64	10.98	8.29	12.24
Pakistan	5.57	3.36	4.11	2.97	4.88
Brazil	27.13	14.93	20.28	17.39	19.3
Australia	46.99	16.00	46.81	14.99	56.38
Instability in production					
China	17.95	20.57	12.06	9.98	11.41
India	20.02	9.97	15.42	5.15	9.03
USA	18.6	16.77	17.66	11.77	19.64
Pakistan	15.82	21.56	9.96	8.54	10.72
Brazil	36.21	19.41	19.24	18.52	18.4
Australia	47.07	22.82	43.06	10.12	51.64
Instability in productivity					
China	9.59	13.19	5.58	3.03	6.34
India	14.47	9.35	12.93	4.11	11.66
USA	9.32	9.05	7.84	8.77	6.99
Pakistan	14.59	19.61	8.04	8.86	7.53
Brazil	23.86	13.72	12.5	10.57	6.42
Australia	10.72	11.59	10.26	6.44	8.35
Instability in export					
China	112.92	91.01	133.64	101.43	88.46
India	136.59	86.69	95.31	113.89	59.57
USA	28.65	22.75	23.11	26.46	14.68
Pakistan	81.78	59.91	102.06	124.2	41.82
Brazil	88.62	88.97	34.67	137.92	16.06
Australia	42.95	19.59	32.89	7.94	25.57

Source: Calculated form data FAO statistics, USDA and UNCTAD

period (1980-81 to 2009-10), the lowest instability was observed in Pakistan followed by China (17.95 %), USA (18.6 %), India (20.02 %), Brazil (36.21 %) and Australia (47.07 %).

Instability in productivity :

From Table 2, it is seen that Brazil recorded the highest degree of instability during overall study period (23.86 %) and pre Bt introduction period (10.57 %). During pre- liberalization period (13.72 %) and post-liberalization period (12.50 %), Brazil recorded a second highest degree of instability. Thus it can be concluded that Brazil was comparatively more unstable in productivity than the other major producing countries. These finding were in line with Lissdaniels and Madsen (2011) who reported that there high fluctuations were partly as a result of volatility of fertilizer prices and water availability. However, there were relatively fewer fluctuations in China as compared to other countries as it recorded the lowest degree of instability during post-liberalization period (5.58%), pre-Bt introduction period (3.03 %) and post-Bt introduction period (6.34 %). These results were in agreement with those of Zhao and Tisdell (2009), who reported that a steady improvement in productivity was partly due to transgenic pest resistant cotton varieties. Further, during overall study period (9.32 %), USA recorded relatively less fluctuations. According to Chand and Raju (2008), improved spread of technology spread brings about stability in productivity.

Instability in export :

It can be observed from Table 2 that there were relatively more fluctuations in India as compared to other countries as it recorded the highest degree of instability during overall study period (136.59 %). This was followed by China (112.92 %), Brazil (88.62 %), Pakistan (81.78 %), Australia (42.95 %) and USA (28.65 %). This indicates that India is comparatively more unstable when it comes to export of cotton. These results were in line with results of Goyal *et al*. (2000) and Mahadevaiah *et al*. (2005) who reported high volatility in cotton exports. They reported that the sources of instability in export included large domestic consumption, fluctuations in production due to vagaries of weather, competition from other cotton-growing countries and insufficient exportable surplus of cotton production during certain years and the absence of a steady export policy. Fewer fluctuations in export were observed in USA. USA observed lowest instability during overall study period (28.65 %), post-liberalization period (23.11 %) and post-Bt introduction (14.68 %) and it was also second lowest in pre-liberalization (22.75 %) and pre-Bt introduction (26.46 %). This implies that comparatively export of cotton from USA is more stable than that of the other major producing countries. This may partly be due to their competitiveness in cotton export because of heavy domestic support (subsidies) given to USA cotton farmers (ICAC, 2005).

Decomposition of growth components :

The relative contribution of area, yield and their interaction to changes in cotton output in major cotton producing countries is presented in Table 3. It is observed that the main contribution to the growth of output in China (61.68 %), USA (110.17 %), Brazil (52.15 %) and Australia (122.16 %) during the overall study period came from area. Whereas in India and Pakistan, the growth in cotton output was mainly due to yield effect at about 71.01% and 69.68 %, respectively. These results were in agreement with results of Nithya and Arunkumar, 2007; for India, Salam *et al*., 2011; for Pakistan, Osakwe, 2009; for Brazil, and Zhao and Tisdell, 2009; for Australia.

The pre-liberalization period results show that the area effect of 41.22 %, 98.81 %, 64.15 %, and 50.75 % was the major source of growth output in China, USA, Brazil and Australia, respectively. Whereas in India and Pakistan yield was found to be the main driving force in cotton output *i.e.* 88.62 % and 81.71 %, respectively. The decomposition analysis of the growth of cotton over post-liberalization period revealed that the main contribution to change in production in China, USA, Brazil and Australia was due to change in area which was 86.56 %, 63.17 %, 121.99 % and 149.10 %, respectively. As for India and Pakistan the main contribution came from yield which was 71.27 % and 65.81 %, respectively.

It is further observed that the main contribution to the growth of cotton output during the pre-Bt introduction period in China (106.39 %), Brazil (57.68 %) and Australia (192.54 %) came from area. Whereas, yield was observed to be the main contributing factor to cotton output in India (65.41 %), USA (95.67 %) and Pakistan (108.15 %). During the post-Bt introduction period, the main contribution to change in cotton output in USA (77.50 %), Brazil (116.11 %) and Australia (119.50 %)

was due area effect, whereas in India (113.02 %) and Pakistan (56.96 %), yield was observed to be the major factor. The results of decomposition analysis of the growth in cotton output in China revealed that area-yield interaction (39.54 %) was the major driving force in the change in cotton output during post-Bt introduction period.

Summary and Conclusion :

There is a growing interest among the policy makers and academia in conducting impact assessment especially to assess the effectiveness of the policies after implementation of liberalization package and introduction of Bt cotton. The knowledge of the impact of liberalization programmes and Bt cotton introduction in the major cotton producing countries will eventually help the policy makers to come out with better policies and corrective measures.

It can be seen from the results that growth rates and instability indices are different for each period from country to country. The analysis of annual growth rates clearly show that the growth rate performance was better in pre-or post-liberalization period than that of under pre-or post-Bt cotton introduction period in some countries and vice versa in other countries. In some countries growth rate was almost similar in those two periods. The results show that the growth rate performance of cotton production in Australia, Pakistan and USA was better during the pre-liberalization and pre-Bt introduction periods. Whereas, in China and India, the growth performance of cotton production was better during post-liberalization and post-Bt introduction periods. As for Brazil it was during post-liberalization and pre-Bt introduction periods. Comparatively, during the overall study period (1980-81 to 2009-10) India was found to be the fastest growing in cotton production. Further, it is clear from the results that growth rates performance of cotton export was better during post-liberalization and post Bt introduction periods in India, USA, and Pakistan,

Table 3: Components of growth in cotton production in the major cotton producing countries (In %)

Country	Study periods				
	Overall	Pre-liberalization	Post-liberalization	Pre-Bt Introduction	Post-Bt introduction
	1980-81 to 2009-10	1980-81 to 1993-94	1995-96 to 2009-10	1995-96 to 2001-02	2002-03 to 2009-10
China					
Area	61.68	41.22	86.56	106.39	35.78
Yield	27.89	39.63	19.25	9.37	19.22
Interaction	1.21	7.44	-7.49	-11.1	39.54
India					
Area	33.94	26.07	44.05	15.62	44.17
Yield	71.01	88.62	71.27	65.41	113.02
Interaction	3.06	-12.41	-7.43	17.35	-48.79
USA					
Area	110.17	98.81	63.17	85.55	77.5
Yield	32.74	32.43	32.28	95.67	12.24
Interaction	-38.96	-22.63	2.58	-67.66	11.07
Pakistan					
Area	10.04	2.3	17.24	12.19	16.52
Yield	69.68	81.71	65.81	108.15	56.96
Interaction	18.54	14.93	13.09	-15.4	23.42
Brazil					
Area	52.15	64.15	121.99	57.68	116.11
Yield	39.82	54.27	46.54	18.93	14.35
Interaction	24.07	-20.79	-56.7	17.05	-25.39
Australia					
Area	122.16	50.74	149.1	192.54	119.5
Yield	6.37	26.68	7.19	35.55	2.62
Interaction	-28.92	18.23	-46.39	-109.41	-23.61

Source: Calculated form data FAO statistics, USDA and UNCTAD

whereas in China and Australia it was during pre-liberalization and pre-Bt introduction periods. As for Brazil, better performance was observed during post-liberalization and pre-Bt introduction periods. Comparatively, during the overall study period (1980-81 to 2009-10) Australia was found to be the fastest growing in cotton export. The analysis of instability indices in cotton production showed that production was more stable in India, USA, and Australia during pre-liberalization and pre-Bt introduction periods, whereas in china and Pakistan it was during post-liberalization and pre-Bt introduction periods. Brazil was more stable in production during post-liberalization and post-Bt introduction periods. Comparatively, during the overall study period (1980-81 to 2009-10) Pakistan was more stable in cotton production.

The analysis of instability indices in cotton production showed that production was more stable in India, USA, and Australia during pre-liberalization and pre-Bt introduction periods, whereas in china and Pakistan it was during post-liberalization and pre-Bt introduction periods. Brazil was more stable in production during post-liberalization and post-Bt introduction periods. Comparatively, during the overall study period (1980-81 to 2009-10) Pakistan was more stable in cotton production. The analysis of instability indices in cotton export showed that in India, USA and Pakistan were more stable during pre-liberalization and post-Bt introduction periods, whereas in China it was during pre-liberalization and post-Bt introduction periods, Brazil was more stable during post-liberalization and post-Bt introduction periods, whereas Australia was more stable during pre-liberalization and pre-Bt introduction periods. Comparatively, during the overall study period (1980-81 to 2009-10) USA was more stable in cotton export.

The analysis of components of growth in cotton output in the major producing countries showed that the main contribution to growth in Australia, Brazil, China and USA was predominately due to area effect. Whereas, in India and Pakistan the main contribution to cotton output growth was yield effect. The results of decomposition analysis have important policy implications because each growth component alone has a limited scope to expand overtime. For example, land's growth potential (the area effect) is limited due to the competition for land due to increased population pressure. If the current yield trends continue, the growth in cotton production will decline overtime because of the limitations on land growth potential. In addition, some arable land would likely be reduced to accommodate the residential land needs of a growing population, which would have some negative effect on per capita cotton production. There is an urgent need to come up with technology that will increase cotton crop production. As such, efforts have to be directed toward further increasing the productivity. The future government policy should focus on developing new high-yielding varieties and provision of irrigation facilities to cotton growing farmers. Research efforts are needed to strengthen the cotton breeding programmes using new efficient technologies. Further, developing and establishing the bio-technology programmes should be intensified to develop high yielding varieties of the crops suitable to the ever changing agro-climate conditions due to global warming.

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