PERFORMANCE OF COTTON PRODUCTION AND EXPORT IN THE MAJOR PRODUCING COUNTRIES

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BY
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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, the components of output growth and the relationship among production, export and price of cotton in the major cotton producing countries. To achieve the objectives, the secondary data related to area, production, productivity and export of the major cotton producing countries (China, India, USA, Pakistan, Brazil and Australia) were collected from different published sources 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 various statistical techniques were applied in the analyses viz., Exponential function for calculating compound growth rates of area, production, productivity and exports, Instability index model for estimating variability in production, area, productivity and exports, Decomposition analysis for measuring the relative contribution of area and yield to the total cotton output change and a Pearson's correlation coefficient and other regression techniques used to examine the relationship among production, export and price.

The compound growth rate results revealed that during the overall study period (1980-81 to 2009-10), India recorded the highest growth (4.59 per cent) in production followed by Australia (4.39 per cent), Pakistan (3.18 per cent), Brazil (2.94 per cent), China (2.42 per cent) and USA (1.06 per cent). This suggests that cotton production in India was the fastest growing in the world during 1980-81 to 2009-10.
As far as growth rates of area are concerned, during the overall study period (1980-81 to 2009-10), Australia recorded the highest rate of growth (2.65 per cent) followed by Pakistan (1.11 per cent), India (1.10 per cent) and USA (0.13 per cent), whereas a negative growth was also observed in China (-0.15 per cent) and Brazil (-3.25 per cent). During pre-liberalization period, pre and post Bt introduction period also, Australia ranked first in growth rate of area allocated to cotton. This suggests area allocated to cotton in Australia was the fastest growing in the world.

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 per cent) followed by India (3.40 per cent), China (2.45 per cent), Pakistan (2.00 per cent), Australia (1.70 per cent) and USA (1.41 per cent). This suggests that productivity of cotton in Brazil was the fastest growing in the world during 1980-81 to 2009-10.

In export, Australia was the fastest growing in the world during 1980-81 to 2009-10 as Australia witnessed the highest growth (6.75 per cent) in export followed by Brazil (6.34 per cent), India (6.01 per cent) and USA (3.45 per cent), whereas in China (-4.00 per cent) and Pakistan (-8.44 per cent), a negative growth was observed.

Surprisingly, China which had the highest growth rate (27.72 per cent) in export among the major producing countries in period of pre-liberalization, recorded negative growth rate (-3.53 per cent) in post-liberalization period, and again turned the highest growth rate (72.82 per cent) in pre-Bt introduction period. However, in post-Bt introduction period, negative growth rate (-27.07 per cent) was observed. This gradual rebound in China, might be partly driven by the global revival in the consumption of cotton.

India which had second position (31.14 per cent) in export growth during post-liberalization period, recorded a negative growth rate (-37.91 per cent) in pre-Bt introduction period. This fall could be because of government involvement in the export of cotton. Government implemented a cotton ban in export. However, in post-Bt introduction period, India registered the highest growth rate (78.30 per cent) in export.
and this growth rate was far more than that of the other major cotton producing countries. Increase in production as a result of improvement in yield due to Bt cotton adoption could partly be the contributing factor to this higher growth rate of export in India.

The results drawn from instability indices showed a composite picture in area, productivity, production and exports variability in major producing countries. Some countries witnessed higher instability while others experienced a relatively low instability. The country wise instability rates, for all the study period, for export ranged from 7.94 per cent to 137.92 per cent, for area, it ranged from 2.01 per cent to 46.99 per cent, for production it ranged from 5.15 per cent to 51.64 per cent and for productivity, it ranged from 3.03 per cent to 23.86 per cent.

During the overall study period (1980-81 to 2009-10), Australia recorded the highest degree of instability (47.07 per cent) in production followed by Brazil (36.21 per cent), India (20.02 per cent), USA (18.6 per cent), China (17.95 per cent) and Pakistan (15.82 per cent). Comparatively, Australia was the most unstable in cotton production as the highest degree of instability in production was found not only during overall study period but during all the study periods except pre-Bt introduction period. Further, by examining all the study periods, cotton production was comparatively found to be stable in India as compared to other major producing countries as instability in production was observed to be lowest in pre-liberalization period (1980-81 to 1993-94), pre-Bt introduction period (1995-96 to 2001-02), and post-Bt introduction (2002-03 to 2009-10), and it ranked third in overall study period (1980-81 to 2009-10) and fourth in post-liberalization period (1995-96 to 2009-10).

In case of instability of area, Australia recorded the highest degree of instability in all the study periods except pre-Bt introduction period in which it ranked second. This indicates among the major cotton producing countries, Australia was comparatively the most unstable country in allocation of area of cotton. Brazil was also comparatively very much unstable as it ranked second in overall study period, pre-liberalization period and post-Bt introduction period and first in pre-Bt introduction period.Comparatively, the lowest instability in area was observed in Pakistan during all the periods except pre-Bt introduction period, in which it was second lowest. This
indicates that the allocation of land under cotton in Pakistan was comparatively stable over the periods. Apart from Pakistan, India was also found to be comparatively more stable as it ranked second lowest in all the periods except during pre-Bt introduction period in which it was first lowest among major cotton producing countries.

So far as instability in productivity is concerned, during 1980-81 to 2009-10, Brazil recorded the highest degree of instability (23.86 per cent) followed by Pakistan (14.59 per cent), India (14.47 per cent), Australia (10.72 per cent), China (9.59 per cent) and USA (9.32 per cent). As Brazil was ranked first in instability in productivity during overall study period and pre-Bt introduction period and it was also ranked second in pre- and post liberalization periods, it can be concluded that Brazil was comparatively more unstable in productivity than the other major producing countries.

In export, during overall study period (1980-81 to 2009-10), India recorded the highest degree of instability (136.59 per cent) followed by China (112.92 per cent), Brazil (88.62 per cent), Pakistan (81.78 per cent), Australia (42.95 per cent) and USA (28.65 per cent). This indicates that comparatively India is the most unstable when it comes to export of cotton in the world. China also recorded highest degree of instability in export during pre-liberalization period, post-liberalization period and pre-Bt introduction period whereas it was ranked second during overall study period. This also indicates that there is unstable situation in export from China. Export of cotton from USA is the most stable among the major producing countries as instability of export was lowest in USA during overall study period, post-liberalization period and post-Bt introduction period and it was also second lowest in pre-liberalization period and pre-Bt introduction period.

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.

As positive and highly significant relationship between production and export was found in Australia (0.822), Brazil (0.775), India (0.7710) and USA (0.688), it can be inferred that total export of cotton is determined by the production of cotton in these countries.
DECLARATION

This is to declare that the whole of the research work reported in the thesis in partial fulfillment of the requirement for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in the subject of **AGRICULTURAL ECONOMICS** is the result of investigations done by undersigned under the direct guidance and supervision of **Dr. Y. C. Zala**, Professor and Head, Department of Agricultural Economics, B. A. College of Agriculture, Anand Agricultural University, Anand and no part of the research work had been submitted for any other degree so far.

Place : Anand

Date: / 08/ 2012

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I would like to thank God for seeing me throughout the course of my entire study and stay in India.

In writing this thesis, I have been fortunate to be assisted by many people. The thesis could not been finished without their help. First, I am deeply grateful to my major guide Dr. Y.C Zala, Professor and head, dept. of Agril. Economics, BACA, AAU, Anand, for his kindness and guidance. He not only directed me throughout my post graduate program but also tutored me to help me finish the thesis.

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Date     : July, 2012

(Dhumisani Moyo)
ACRONYMS & ABBREVIATIONS:

AoA : Agreement on Agriculture
Bt : Bacillus thuringiensis
CAAS : Chinese Academy of Agricultural Sciences
CV : Coefficient of Variation
EPA : Environmental Protection Agency
FAO : Food and Agriculture Organization of the United Nations
GATT : General Agreement on Tariffs and Trade
GDP : Gross Domestic Product
GEAC : Genetic Engineering Approval Committee
ICAC : International Cotton Advisory Committee
IMF : International Monetary Fund
IPM : Integrated Pest Management
MAHYCO : Maharashtra Hybrid Seed Company
NCCA : National Cotton Council of America
TMT : Thousand Metric Tons
UNCTAD : United Nations Conference on Trade and Development
USDA : United States Department of Agriculture
WTO : World Trade Organization
Chapter – I

INTRODUCTION

Cotton (*Gossypium sps*) is a soft, usually white, fibrous substance composed of cellulose walls. It is the most important vegetable fiber used in textile industry. Cotton is produced for various purposes. It may meet the basic consumption needs of farm families; it may be exported to earn foreign exchange; or it may provide the raw material for textile production for domestic markets or for export (ICAC, 2001). At the household level, cotton is an important cash crop for millions of farmers worldwide, and the income which it generates, contributes to rural household food security, especially in developing countries.

Cotton is one of the most important and widely produced agricultural crops in the world. Estimates for world production are about 25 million tonnes annually, accounting for 2.5 per cent of the world's arable land, making it one of the most significant in terms of land use after food grains and soybeans (FAO, 2008).

Cotton is also a heavily traded agricultural commodity. For example, nearly 170 countries were involved in the export or import of cotton in 2009 (Cotlook, 2009). In addition, through the export of textiles, cotton contributes to national economic growth, as a result of the significant multiplier effects deriving from employment and earnings in the manufacturing sector. Such contributions have become increasingly important for many developing countries as a result of the migration of textile manufacturing industries to them in order to benefit from relatively lower cost structures.

Cotton does serve as an engine of economic growth in both industrial and developing countries worldwide. As discussed above, cotton production induces
additional employment and export revenue from textile and clothing manufacturing. The export revenue from textiles and clothing and employment opportunities in the cotton ginning, spinning, weaving, processing, marketing and transporting have very important income and food security implications for the country and households. Hence, cotton is crucially important to several industrial and developing countries worldwide.

1.1 Origin of cotton

Cotton (*Gossypium* spp.), the king of fibre, is closely linked to human civilization itself. Cotton has been planted for a long time. Cotton fibre were discovered more than 4000 years ago in Coastal Peru and at Mohanjodaro in the Indus Valley. Cotton was first cultivated in the old world 7,000 years ago (5th millennium BC), by the inhabitants of Western Pakistan, for example as the site of Mehrgarh where early cotton thread has been preserved in copper beads (Moulherat *et al.*, 2002).

Although the cotton plant is native to tropical countries, cotton production is not limited to the tropics. In general, the conditions required for the cultivation of cotton are met within the seasonally dry tropics and subtropics in the Northern and Southern hemispheres, but a large proportion of the cotton grown today is cultivated in areas with less rainfall that obtain the water from irrigation. Indeed, the emergence of new varieties, as well as advances in cultivation techniques led to the expansion of its culture. India was the first country in the world to commercialize cotton hybrids. Although cotton is widely planted in both hemispheres, it remains a sun-loving plant highly vulnerable to freezing temperatures. Cotton cultivation became more widespread during the Indus Valley Civilization, which covered a huge swath of the Northwestern part of the South Asia,
comprising today parts of Eastern Pakistan and Northwestern India (Moulherat, et al., 2002).

There are about 45 diploid and 5 allotetraploid species of *Gossypium* in the world. However, the modern concept of cotton normally refers to only four domesticated species in the genus *Gossypium*: two old world species i.e. *G. herbaceum* and *G. arboretum* (both contribute 2 per cent), and two New World species, *G. barbadense* (contributes 8 per cent) and *G. hirsutum* (contributes 90 per cent) (Bell & Gillham, 1989)

### 1.2 Cotton production in the world

Cotton is grown in more than 100 countries in the world. Cotton accounts for 40 per cent of the total global fibre production and in the most important fibre in the world. Table 1.1 shows the global position of the six major cotton producing countries. These are listed according to their average annual cotton production in a recent 5-year period (2005-06 to 2008-09). Table 1.1 Sizes and ranks of the six major cotton producing countries by their volume of cotton production, area planted, productivity and exports. The data in the table show that India, China, Australia, and USA rank first in area, production, productivity and export, respectively. Thus, China ranks first in production of cotton, followed by India, USA, Pakistan, Brazil and Australia. These six countries represent more than 85 per cent of world cotton production in 2010-11(USDA, 2011) (Fig. 1.1).
Table 1.1 Sizes and ranks of the six major cotton producing countries by their volume of cotton production, area planted, productivity and exports (averaging of 5 years period: 2005-06 to 2008-09)

<table>
<thead>
<tr>
<th>Country</th>
<th>Area (1000 HA)</th>
<th>Rank</th>
<th>Production (1000 tons)</th>
<th>Rank</th>
<th>Productivity (KG/HA)</th>
<th>Rank</th>
<th>Export Tons</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>5300(17%)</td>
<td>2</td>
<td>6981(32%)</td>
<td>1</td>
<td>1317</td>
<td>6</td>
<td>8878(0.1%)</td>
<td>43</td>
</tr>
<tr>
<td>India</td>
<td>10190(32%)</td>
<td>1</td>
<td>5018 (24%)</td>
<td>2</td>
<td>492</td>
<td>33</td>
<td>1328220(19%)</td>
<td>2</td>
</tr>
<tr>
<td>USA</td>
<td>3603(11%)</td>
<td>3</td>
<td>2572(12%)</td>
<td>3</td>
<td>714</td>
<td>14</td>
<td>2553160(36%)</td>
<td>1</td>
</tr>
<tr>
<td>Pakistan</td>
<td>2965(9%)</td>
<td>4</td>
<td>2095 (10%)</td>
<td>4</td>
<td>706</td>
<td>20</td>
<td>78241(1%)</td>
<td>11</td>
</tr>
<tr>
<td>Brazil</td>
<td>826(3%)</td>
<td>6</td>
<td>1189(6%)</td>
<td>5</td>
<td>1439</td>
<td>4</td>
<td>504917(7%)</td>
<td>3</td>
</tr>
<tr>
<td>Australia</td>
<td>197(1%)</td>
<td>9</td>
<td>387(2%)</td>
<td>6</td>
<td>1964</td>
<td>1</td>
<td>317239(4%)</td>
<td>4</td>
</tr>
<tr>
<td>Other</td>
<td>8976 (28%)</td>
<td></td>
<td>2969 (14%)</td>
<td></td>
<td></td>
<td></td>
<td>2348920 (33%)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>32057(100%)</td>
<td></td>
<td>21211.63(100%)</td>
<td></td>
<td></td>
<td></td>
<td>7139575 (100%)</td>
<td></td>
</tr>
</tbody>
</table>

Source: FAOSTAT (www.faostat.fao.org)
lines which were introduced in the 1950s and 1960s respectively. In Xinjiang, an extremely fine and long staple cotton species, a derivative of *Gossypium barbadense* Pima cotton, is produced (Bell & Gillham, 1989).

China has made a major investment in biotechnology research. These investments began in the mid-1980s and were accelerated in the late 1980s by the Ministry of Science and Technologies' 863 Project. With funding primarily from government research sources, a group of public research institutes led by the Chinese Academy of Agricultural Sciences (CAAS) developed Bt cotton varieties using a modified Bt fusion gene (Cry1ab and Cry 1Ac). The gene was transformed into major Chinese cotton varieties using China's own methods (pollen-tube pathways). Researchers tested the varieties for their impact on the environment and then released them for commercial use in 1997. Monsanto, in collaboration with the cotton seed company Delta and Pineland, developed Bt cotton varieties for the USA which were approved for commercial use there in 1996. They began to collaborate with the Chinese National Cotton Research Institute of CAAS at Anyang, Henan in the mid-1990s. Several of their varieties worked quite well in China. In 1997, several varieties were approved by the Chinese Biosafety Committee for commercialization. At the same time, scientists in the Cotton Research Institute were working on their own varieties, and the research team began to release their varieties in the late 1990s (Pray et al., 2002).

Chinese government policies heavily influence the cotton industry. Chinese cotton producers are mostly small-scale producers. In the last few decades, the Chinese government monopolized cotton procurement. To protect the domestic cotton industry, the Chinese government subsidized cotton producers in different ways such as fertilizer
allocations and guaranteed grain rations for producers. Since 1978-79, procurement prices have gradually increased, which made the domestic cotton price higher than average world cotton prices. To encourage cotton exports in order to balance trade, the Chinese government offers export subsidies, and to discourage imports, imposes heavy import tariffs and quotas. Nevertheless, after accession to the WTO in 2001 China agreed to an initial tariff-rate quota at least 743 Thousand Metric Tons (TMT) for cotton fiber and was also planning to eliminate all cotton export subsidies by 2005. In this case, cotton imports are expected to increase (World Bank, 1995). Cotton only occupies two and three percent of the total cultivated area but the value is seven to ten per cent of total agricultural output. The textile industry employs 9 million workers and contributes about 25 per cent of the total export value (Jin, 2003).

1.5. Cotton sector in India

Cotton is one of the important fibre crop and cash crop in India and plays a dominant role in the industrial and agricultural economy of the country. It is generally regarded as king of textile fibers which has made significant contribution to the national economy. It provides sustainable livelihoods for millions of rural population (Biradar, 2007). The textile industry is nourished by cotton for over a century. In addition, the textile industry has grown to be the largest industry in India. India textile industry largely depends upon the textile manufacturing and export. The export of raw cotton, yarn, textiles, garments, cotton seed cake, oil and other byproducts earn valuable foreign exchange. India earns about 27 per cent of its total foreign exchange through textile exports. Further, the textile industry of India also contributes nearly 14 per cent of the total industrial production of the country. It also contributes around 3 per cent to the
Introduction

Gross Domestic Product (GDP) of the country. India textile industry is also the largest in the country in terms of employment generation. It not only generates jobs in its own industry, but also opens up scopes for the other ancillary sectors. India textile industry currently generates employment to more than 35 million people. India has the potential to increase its textile and apparel share in the world trade from the current level of 4.5 per cent to 8 per cent and reach US$ 80 billion by 2020 (Anonymous, 2012).

India has the largest area under cotton in the world. This is almost 32 per cent of the world cotton area. In the world, though India ranks first in area it ranks second in production. The main reason is its low productivity (Biradar, 2007).

India is the only country which grows all the four species of cultivated cotton i.e. *Gossypium arboreum* and *G.herbaceum* (Asiatic cotton), *G. barbadense* (Egyptian cotton) and *G. hirsutum* (American upland cotton) besides hybrid cotton. In India, about 45 per cent area is covered by hybrids, 31 per cent by upland varieties and 24 per cent by diploid cultivars (ICAC, 1997).

India made its long-awaited entry into commercial agricultural biotechnology in March 2002 with the approval of three Bt-cotton hybrids for commercial cultivation. The Genetic Engineering Approval Committee (GEAC), Ministry of Environment and Forests, Government of India granted the approval, at its 32nd meeting held in New Delhi. The transgenic hybrids were developed by MAHYCO (Maharashtra Hybrid Seed Company Limited) in collaboration with Monsanto. These contained Monsanto’s lepidopteron specific Bt gene, cry1Ac with Event MON 531 (Bollgard®) which offers protection against all the major species of Indian bollworms - *Helicoverpa armigera* (Old world bollworm), *Pectinophora gossypiella* (Pink bollworm), *Earias vittella* (Spotted
bollworm) and E. insulana (Spiny bollworm). The approval of Bt-cotton or Bollgard® (Bollgard® is the registered brand name for Monsanto’s Bt-cotton) in India was preceded by about 500 field trials carried out in different agro-climatic regions between 1998 and 2001 to assess its efficacy against bollworms and the concomitant agronomic benefits. Thus, in about 6 years, the area under Bt-cotton had increased by more than 210 times to record 6.2 m ha and the number of Bt-farmers by 190 times to reach 3.8 m in 2007. Further, Bt-cotton had occupied 66 per cent of the 9.4 m ha of the total cotton area in India in 2007 (Shantharam, 2008).

In India, cotton crop is grown throughout the country. However, there are nine major cotton producing states, viz. Punjab, Haryana, Rajasthan, Madhya Pradesh, Maharashtra, Gujarat, Andhra Pradesh, Karnataka and Tamil Nadu. These states contribute about 90 per cent to the national cotton production. Based on cotton cultivation, India is divided into three major zones viz. North zone (Punjab, Haryana and Rajasthan), Central zone (Madhya Pradesh, Maharashtra and Gujarat) and South zone (Andhra Pradesh, Karnataka and Tamil Nadu) (ICAC, 2009). These zones differ from each other in soil type, topography, irrigation facilities, species cultivated etc.
mainly to a drop in cotton area. Consumption of cotton, on the other hand, declined from a peak of 2.5 million tons in 1997-98 to 998,000 tons in 2007-08. The United States is the largest exporter of cotton with an estimated 3 million tons exported in 2007-08, accounting for approximately 40 per cent of the world total. Like cotton production, US’s cotton exports have experienced a general upward trend until 2005-06 when they peaked at 3.8 million tons before starting to decline. The top export destination is China (Mainland). The US exported approximately 32 per cent of its cotton to China in 2007-08. Other major markets are Turkey, Mexico, Indonesia, Thailand and Vietnam (ICAC, 2009).

According to Osakwe (2009), in the USA, the cotton crop is planted from March to May and harvested from August to December. The majority of the crop is planted in 17 southern States from Virginia to California. Major production regions include areas of the Texas High and Rolling Plains, the Mississippi, Arkansas, Louisiana Delta, California's San Joaquin Valley, Central Arizona, and Southern Georgia. The total cotton area was 4.2 million hectares in 2007-08 (approximately 24,000 cotton farms).
advances in technology (seed varieties, fertilizers, pesticides, and machinery) and production practices (reduced tillage, irrigation, crop rotations, and pest management systems) resulting in consistently high yields (USDA, 2008).

Bt cotton technology for managing insect pests was approved for commercialization in the United States by the U.S. Environmental Protection Agency (EPA) in October 1995 and is available from several seed companies in this country, as well as in many other cotton-growing countries around the world. Cotton varieties containing the Cry1Ac Bt protein provide protection against three major U.S. cotton pests—tobacco bud-worms, bollworms, and pink bollworms. Bt cotton also reduces survival of other caterpillar pests such as beet armyworms, cabbage loopers cotton leaf perforators, fall armyworms, southern army worms, and soybean loopers. Generally, the USA cotton industry is highly privatized and consequently market oriented with government intervention in the form of the USDA’s work and participating agencies (USDA, 2001).

1.7. Cotton sector in Pakistan

Pakistan is the 4th largest cotton producer (USDA, 2011). The cotton industry is an integral aspect of the economy. This is also true of the textile sector on which the economy is heavily dependent. As such cotton is a principal crop. Mill consumption of cotton has increased from 1.3 million tons in 1990-91 to 2.6 million tons in 2007-08 (Osakwe, 2009).

Production in 2007-08 totaled approximately 1.9 million with an average yield of 620 kg/ha. The cotton industry employs approximately 15 million people. Pakistan has been an importer of cotton since the mid-1990s. This is due to expansion in domestic
demand for cotton. Pakistani’s cotton exports have been below 65,000 tons for the past three seasons. The imports are significantly higher. Pakistan’s cotton imports have been increasing. Pakistan was the 2nd largest importer of cotton (behind China Mainland) with 880,000 tons in 2007-08. Pakistan imports a large amount of its cotton from the United States, specifically the Pima/Extra Long Staple cotton. In addition, in 2007-08, Pakistan imported significant quantities of short to medium staple cotton from India. Cotton imported from India is more cost effective since it is cheaper to trade and transport over land than sea (ICAC, 2009).

Cotton trading in Pakistan is facilitated by the fact that the government has no quantitative restrictions or duties on imports and exports of cotton. The Pakistan economy is linked to the success of the cotton and textile sectors. They account for 8.2 per cent of the value added in agriculture and 2 per cent of GDP (IMF, 2009). Furthermore, the cotton and textile industries dominate exports, accounting for 55 per cent of export value. The textile industry has been growing and is of considerable volume. Figures place the number of textile mills at 461. Although cotton is produced domestically, some textile mills are shifting their focus to higher quality cotton (such as the Extra Long Staple from the US); this is especially true for the export oriented textile market (Osakwe, 2009).

The major cotton producing areas in Pakistan are Punjab and Sindh. Approximately 80 per cent of cotton is produced in Punjab and the rest in Sindh. According to recent figures, there are approximately 1.3 million cotton farmers. 3 million hectares are currently allocated for cotton farming with an average farm size of
Biotech was introduced to Pakistan since 2002 (Nazli, et al., 2010). The cultivation of these varieties, although formally unapproved and unregulated, increased rapidly after 2005. In 2007, nearly 60 per cent of the cotton area was under Bt varieties although it was not officially and commercially approved for at least a season (ICAC, 2009).

1.8 Cotton sector in Brazil

Brazil is the 5th largest producer (USDA, 2011). Relative to other crops planted, cotton is not a principal crop in Brazil. Production in 2007-08 totaled approximately 1.6 million tons with an average yield of 1,487 kg/ha. The figures for production and yield declined 5 per cent and 2 per cent from the previous season respectively. The cotton industry employs an estimated 1.3 million people (ICAC, 2009).

Brazil is the third largest exporter of cotton preceded by India and the USA (USDA, 2011). Brazil exported 486,000 tons in 2007-08. This is an increase from 283,000 tons from the previous year. Exports have been steadily increasing although they experienced a brief decline in 2006-07. This decline is also apparent in production figures; factors that influence the decline are lower prices and consequently lower profitability, higher operational costs, issues with infrastructure and a reduction in area allocated for farming. Brazil’s imports have remained low for the past few seasons, with a serious drop occurring in 2007-08 season. Throughout Brazil there are approximately 1000 large cotton farms. The major cotton producing area is the Brazilian Savannas (Matto Grosso); this area accounts for 96 per cent of total farming area. This is an approximate area of 1 million hectares. The remaining cotton farming takes places in the Northeast. This is an area of approximately 4,100 hectares (Osakwe, 2009).
Regarding GM cotton in Brazil, the old CTNBio took the decision on March 2005 to approve the commercialization of Bollgard Bt Cotton and to set the limit of 1 per cent for transgene contamination in conventional cotton seed. On August 2006, the new CTNBio approved a record amount of proposals for controlled field experiments with transgenic crops. Out of 47 approved proposals six were related with transgenic cotton (Paiva, 2007).

Cotton imports dropped from 112,000 to a mere 36,000 tons during 2007-08 season. However, Argentina has been a consistent buyer of Brazilian cotton. This is due to fact that trade is greatly facilitated by being a neighboring country. Furthermore they are both members of the Mercado Comum do Sul (MERCOSUR) trading block (i.e. no import taxes). In addition, Indonesia and Pakistan are countries that have become frequent buyers of Brazilian cotton. Imports of fabric, yarn and textiles from Asia (particularly India and China) have increased in recent years (ICAC, 2009).

Brazil is in the top ten textile producers in the world with one of the largest industrial plants. The garments and textile industry is the second largest employer in the Brazilian industry directly providing 1.65 million jobs. The sector is responsible for approximately 17.5 per cent of the manufacturing industry of the country. There are an estimated 30,000 textile companies (this encompasses cotton yarn, fiber, weaving, knitting and cotton sowing). However, more than 50 per cent of the production is done by three companies (Coteminas, Santista Textile and Vincunha). Historically, Brazil has exported 35 per cent of its textile productions recently, however it has decreased. The decline can be attributed to the current global economic crisis (resulting in a drastic drop in consumption from the United States, which is a major consumer) and unfavorable
exchange rates. In 2007-08, Brazil exported a considerable percentage of its textiles (25 per cent) to its neighbor Argentina (ICAC, 2009).

1.9 Cotton sector in Australia

Cotton has been planted in Australia for over 150 years with the earliest experimental plantings being trialed in the vicinity of what is now Brisbane (Zhao and Tisdell, 2009). Australia is not only the major cotton-producing country in the Southern hemisphere, but is also a major global exporter of cotton. Most cotton growing regions in Australia include the New South Wales and Queensland. In Australia, in a non-drought year, the cotton industry generates in excess of $1 billion per year in export revenue, is one of Australia’s largest rural export earners and helps underpin the viability of many rural communities (Cotton Australia, 2008a). The sector employs 10,000 Australians and directly supports 4,000 businesses that are reliant on cotton (Cotton Australia, 2008b).

Australia did not commence large-scale commercial cotton production until the early 1960s. In earlier decades, Australia was a major net importer of raw cotton but now is a major net exporter. The latter reflects both the increased supply of Australian grown cotton and the decline in the manufacture of textiles and clothing. Australia’s textile and clothing manufacturing has, to a large extent, moved offshore. The Raw Cotton Subsidy Act (1963) stimulated the development of Australia’s cotton production in the 1960s and its cotton production expanded rapidly until the beginning of this decade even after it was no longer subsidized (Zhao and Tisdell, 2009).

Australia’s total production ascended fast before 2000 and then declined rapidly. Except for some rebound in the two years of 2004 and 2005, in 2007 Australia’s total
production hit a historical low. However, the situation has been changing in recent times. With increased area planted to cotton, improved irrigation water supplies and fine, hot weather in most of Australia’s cotton growing regions, Australian cotton production in 2008-09 estimates reached 314,700 tonnes, more than double the severely drought affected harvest of 2007-08 (ABARE, 2009). Consequently both the planted area of cotton and its volume of production declined sharply. Nevertheless, Australian production still remains well below its peak.

Australia’s 2010-11 cotton production was estimated at 4.0 million 480-pound bales, and up 2.25 million or 125 per cent from previous year (USDA, 2010). Area harvested was estimated at 560 thousand hectares, up 360 thousand hectares or 180 percent from previous year. The yield was estimated at 1555 kg/ha, down 20 per cent from previous year. Australia is on track for a record cotton crop. Australia is the one with the highest yield per hectare. However, the overall yields are projected to decline because a majority of dryland plantings are expanding into areas that have moderate to high variability in rainfall. Besides its high yield and the export quantum, the quality of Australian cotton is very high. Australia is regarded as a reliable supplier of high quality cotton (Zhao and Tisdell, 2009).
was the removal of the capped Bt-cotton acreage. Industry embraced this new technology, sowing about 70 per cent of the national acreage to Bollgard®II. Bt transgenic cotton (Ingard® and Bollgard®II) has delivered huge benefits to the Australian Cotton Industry through reducing reliance on conventional insecticides. In its first six years of commercial use, Ingard® reduced total insecticide use by between 45 and 60 per cent compared to conventional cotton. While Ingard® was not profitable compared to conventional in its early years, it became more profitable through time. In 2003-04, when Bollgard®II, Ingard® and conventional cotton were grown, Bollgard®II delivered a 90 per cent reduction in chemical use compared with conventional cotton, while Ingard® reduced chemical use by 56 per cent (Murray, 2007).

1.10 Rational of the study

As discussed earlier, cotton does serve as an engine of economic growth in both industrial and developing countries worldwide. Cotton production induces additional employment and export revenue from textile and clothing manufacturing. The export revenue from textiles and clothing and employment opportunities in the cotton ginning, spinning, weaving, processing, marketing and transporting have very important income and food security implications for the country and households. However, cotton prices were relatively weak during the 1980’s and early 1990’s. This was due to the dramatic turnaround in world agricultural markets which were as the result of several factors. For one, the falling prices had dramatic effects on the production of cotton in the world. Over this period there has been escalating trade tensions as surpluses were dumped onto the world markets. Many of the countries heavily dependent on cotton exports saw the value of their exports shrink. As a result of the loss of price during that period, cotton lost
market share in both industrial and developing countries. Secondly, rapid productivity growth, including the spread of the green revolution led to sharp increases in supply. Both the worldwide recession during the 1980-82, and finally restricted market access and sharply increased government assistance to farmers resulted in enormous excess capacity in agriculture especially in developed countries. As a result of these developments, pressure for reform of domestic agricultural policies had been built up.

The WTO, the multilateral trade system under the Agreement on Agriculture (AoA) came up as a historical opportunity to reform agricultural policies and liberalize agricultural trade. Due to such alterations in economic conditions, 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.

Further, cotton crop is infested by various pests. Among the pests of cotton, cotton bollworms include American bollworm (Helicoverpa armigera), Pink bollworm (Pectinophora gossypiella) and spotted bollworms (Earias vitella) cause significant yield losses. To reduce pesticide usage in cotton, several strategies like use of genetic resistance to insect pests, Integrated Pest Management (IPM), Insecticide Resistance Management (IRM) etc. are advocated. Bt cotton technology was found to be one of the best strategies to manage bollworms, the most important pest of cotton at the early stages of crop growth (upto 90 days) effectively. The Bt transgenic cotton (Bollgard of Monsanto) was thus been developed successfully in USA, which has the ability to control the bollworms at the early stages of crop growth (up to 90 days) effectively (Manickam et al., 2005). Insect-resistant (Bt) cotton has been rapidly commercially
Introduction

adopted since its introduction in mid to late 1990’s and at the beginning of the 21st century. However, in most countries the adoption faced some resistance.

With this background, it is required to know the cotton production and export performance in the world. Specifically, it is 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 period. Furthermore, factors or various components influencing overall output growth and export of cotton are important issues that need scientific understanding.

Keeping these important points in view the present study entitled “Performance of cotton production and export in the major producing countries” was planned with following objectives.

1.11 Objectives of the study

1. To estimate country wise growth rate of production, area, productivity and export.

2. To estimate country wise instability indices in production, area, productivity and export

3. To determine the relative contribution of crop area and yield in the variations in output of cotton changes

4. To examine the relationship among production, export and price.

1.12 Limitations of the study

All limitations and drawbacks of a study based on secondary data can be seen in this study. Output growths are decomposed into its components using the models for 1980 to 2010 periods. The study is restricted to twenty nine years. In each year, an
average absolute value is taken. The major components which are affecting output growth are influenced by exogenous factors. These factors are not taken into the study due to the wide coverage of those factors.

In the analysis, only area, production, productivity, export and price were taken into consideration due to non-availability of data. The study does not attempt to make an effort to probe into those factors which does explain the performance of cotton in those countries, like cost of production, trade issues between countries, trade policies, and varieties of cotton planted.

This study does not consider the cotton sector as a whole. In accordance with the aim of this study, the sole focus was on the production of predominately cotton lint. Thereby the other resultant activities of cotton production such as cotton yawn, cottonseed oil and cake industries are excluded.
Chapter – II

REVIEW OF LITERATURE

For any scientific investigation, it is mandatory on the part of researcher to review the earlier studies. In this chapter, the reviews examined are related to growth rates and instability indices in production, productivity, area and export and prices of cotton, and agriculture in general. Decomposition techniques and correlation estimates as employed by various researchers were also examined. For brevity, the review of literature relevant to the objectives is presented under the following sub-heads.

2.1. Estimation of country-wise growth rate of production, area, productivity and export

2.2 Estimation of country-wise instability indices in production, area, productivity and export.

2.3 The relative contribution of area and yield in cotton output.

2.4 Examine the relationship among production, export and price.

2.5 Summary

2.1. ESTIMATION OF COUNTRY-WISE GROWTH RATE OF PRODUCTION, AREA, PRODUCTIVITY AND EXPORT

Growth rates are widely employed in the field of agriculture as these have important implications on policy formulation. Growth rates are measures of performance of economic variables that describe the trends over time. The simple and exponential growth rate models have frequently been adopted by various researchers to compute compound growth rates of production, area and productivity in different time periods.
Singh *et al.* (1997) estimated growth in area, yield and production using the compound growth rates by fitting log-linear functions in their study on regional variations in Agricultural performance in India. The study revealed that cotton maintained an increasing trend in its production and yield growth rates over the years at national level. In the case of individual level, Haryana, Punjab, Rajasthan, and Karnataka maintained impressive growth rates in production and productivity of cotton.

Nithya and Arunkumar (2007) computed growth rates in area, production and productivity of cotton for a period of 16 years from 1990-91 to 2005-06 i.e. a comparison between pre introduction of Bt cotton and post Bt introduction period, using the growth rate model in Karnataka state of India. The results revealed that during pre-introduction of Bt cotton growth in area and production was negative, while productivity had a positive growth. However, during the post Bt introduction period, all the parameters i.e. area, production and productivity of cotton showed a positive growth rate.

Agarwal (2008) employed the model to estimate compound growth rates of area, production and productivity of cotton in different time periods in important cotton growing districts of India. The Growth analysis indicated that the area, production and productivity of cotton recorded a positive growth in Punjab, Haryana, Gujarat, Maharashtra, Madhya Pradesh and Andhra Pradesh. In Karnataka and Tamil Nadu, growth of cotton area was negative. Cotton production also showed a negative growth in Tamil Nadu.

Ratna (2009) employed the growth analysis on data relating to domestic production of cotton and export of cotton for India and USA. The results revealed that the domestic production of cotton in India had seen a positive growth over 1997 – 2007. The production increased by 138 per cent. During the period 1997 to 2007 the domestic production of cotton in USA saw variation in its production. During the period, their production of cotton saw a growth of only 2.20 per cent.

Reddy (2009) investigated factor productivity and marketed surplus of major crops in India, in context to Orissa state. Exponential trend was employed to calculate the annual growth rates of output index. The results revealed that over the last three decades
(from 1970 to 1990) there has been stagnation in agriculture in Orissa. During the period 1996 to 2003 the growth rate is negative in area, production and yield for all major crops.

Zhao and Tisdell (2009) examined and compared trends in the time-series of cotton production of China and Australia for the period 1980-2007. In doing so, they took into account of changes in the area planted with cotton and its yield. They found out that China’s total production of cotton in the period 1980-2007 had persistently trended upwards mainly due to a rise in its yields from growing cotton. On the other hand, Australia’s production of cotton rose during this period until 2000 but then declined sharply even though it yields from cotton continued to rise. This change was due to the reduction in the area previously planted with cotton in Australia.

Mohamed et al. (2010) conducted a study to estimate the growth rate of area, productivity and production and measure the contribution of different components to the growth rate of the main crops grown in the Gezira scheme in Sudan. The study used secondary data covering the period before adoption of liberalization policy (1970-71 to 1991-92) and the period after the adoption of liberalization policy (1992-92 to 2007-08). The crops concerned in the study were sorghum, wheat, cotton and groundnuts. The results of the study showed that there were variations in growth rates of area and productivity for the crops during the two periods. The growth rate was positive and increasing during the two periods for sorghum, positive and decreasing for cotton and negative and decreasing for groundnuts.

Salam et al. (2011) conducted a study to estimate the growth rates and decomposition analysis of agriculture production in Pakistan during pre and post SAP period. The study was based on secondary data for the 38 years period from 1972 to 2009. The study data period was divided into two periods: period one, 1972 to 1988, represents the pre structural adjustment period, and period two, 1989 to 2009, is the post structural adjustment period. The study was only restricted to the major crops (Wheat, Rice, Sugarcane, and Cotton) of Pakistan. The estimation of growth rate was mostly done by employing two common methods of growth rate including Linear Growth Rate and Compound Growth Rate (CGR). The comparison of production and acreage...
growth rates in both periods revealed that wheat, sugarcane and cotton, but not rice, show better performance in period one. Yield growth rate comparison shows that wheat and cotton have better growth rates in period one while rice and sugarcane performed better in period two.

Furthermore, various researchers have also applied the parametric and non-parametric regression technique for the computation of growth rates in estimating growth rate of production, area and productivity. However, no single review was found to have applied the technique i.e. parametric and non-parametric regression to calculate growth rate on export of agricultural commodities, in general, particularly in cotton.

Goyal et al. (2000) conducted a study on India’s agricultural exports, growth and instability using the log-linear function and the results revealed that the compound growth rate of raw cotton declined in the eighties as compared to the seventies.

Prajneshu and Chadram (2005) highlighted the discrepancies in computation of growth rate and suggested more efficient procedures that may be adopted to achieve the task. They employed the non-parametric regression methodology for the computation of growth rates in agriculture. In their paper, it was established that non-parametric regression approach might be used in estimation of trend to compute growth rate against the usual parametric approach.

Rajarathinum et al. (2007) used the parametric (polynomial and the time series) and non-parametric regression techniques to study the yield trends in the long term fertility experiment. The results indicated that parametric models failed to depict the trend. The trends developed through non-parametric smoothing techniques fitted well for all the treatment. Further the results revealed a decrease in yield during the initial phase up to minima, followed by increase in yield dummy the middle phase up to the maxima and then a decrease in yields moderately at the final stage of the experiment was characteristic of the trend.

Jose et al. (2008) proposed a non-parametric methodology to estimate the trend and relative growth rate of the time series data. The method was based on the local linear
regression smoother. The only assumption about the form of the trend and growth rate was smooth function of time. They also extended the method of handling sudden shifts or changes in the trend or growth rate functions by adding dummy variables for the jumps. Simulation studies were carried out to see the performance of the proposed procedure. The proposed method was applied to the study of trend and growth rate for a data set from 1951 to 2005.

Dhekale and Rajarathinam (2009) made an attempt to fit the parametric and non-parametric regression models to arrive at a methodology that can precisely estimate the trend and growth rates in area, production and productivity of major crops grown in Gujarat state. The attempt was made on a 54 year time series data from 1949-50 to 2003-04. Relative growth rates of production, area, and productivity of all the crops were calculated for the successive years starting from 1949-50 to 2003-04. Also the values for each year for area, production and productivity were computed year-wise for every plan period commencing from 1951-52 to 1955-56 and the average of five year period of each plan had been computed. The results indicated that none of the parametric models was found suitable to fit the trend in area, production and productivity of the crops under the investigation due to either non-significant partial regression coefficients or fulfilling the of assumptions of the residuals. Nonparametric regression model was selected as the best fitted trend function for the area, production and productivity of wheat, sesameum, mustard, groundnut, castor, cotton and tobacco crops.

2.2 ESTIMATION OF COUNTRY-WISE INSTABILITY INDICES IN PRODUCTION, AREA, PRODUCTIVITY AND EXPORT

The issue of instability attracted lot of attention of researchers in the early phase of adoption of green revolution technology. It was found that adoption of new technology had increased instability in agricultural production in the world and specifically in India. (Chand and Raju, 2008).

Various researchers have frequently adopted the instability Index to estimate the level of instability in production, area, and productivity.
Goyal et al. (2000) calculated the instability index for India’s agricultural exports, and revealed that during the nineties, cotton exhibited high volatility in exports. They further, revealed that the share of agricultural exports in world exports, although very low but had been increasing over the years. The prospects for increasing agricultural exports improved after the liberalization.

Chand and Raju (2008) used the instability index in agriculture and compared at the disaggregate level (state level) and at the aggregate level (national level) in India. They analyzed the data of three phases i.e. 1951 to 1965, 1968 to 1988 and 1989 to 2006. The results revealed that there is instability of cotton area and production at both levels. They indicated that the main reason for increase in instability of cotton area and production after 1992-93 seems to be the extension of its cultivation to non-traditional areas where cotton has replaced jowar, pulses and other cereal crops. Cotton cultivation has been extended to red chalka soils, which are considered not quite suitable for cotton cultivation (Raju and Chand, 2008). The district level instability estimates have shown that the range of instability in production narrowed down for cotton. Further, they indicated that variability in agricultural production consists of variability in area and yield and their interactions. Variation in area under a crop occurs mainly in response to distribution, timeliness and variations in rainfall and other climatic factors, expected prices and availability of crop-specific inputs. Instability index for area has shown an increase after 1992-93 for cotton. It increased from 17.5 per cent to 18.8 per cent. Instability was found higher in yield than area. They indicated that despite a lot of concern about susceptibility of cotton to various pests in recent years, its productivity has shown less fluctuation after 1993 than before 1993.

Zhao and Tisdell (2009) estimated year-to-year variation in the quantity of cotton produced, area planted, and yield in China and Australia by measuring the variations in the annual figures for these variables for the whole of the period 1980-2007. However, those variations include the trends in the variables. The results revealed that China’s annual supply of cotton showed much less comparative variation than Australia’s. In China’s case, its coefficient of variation was 27 per cent but in Australia’s case, this was 54 per cent. However, they revealed that absolute variation was greater for China because
of its much larger volume of output. The yearly percentage changes in supply are for
many purposes, a better indicator of the degree of instability in cotton supply. An upward
trend in cotton yield both in Australia and in China was seen, but there were fluctuations
in yield in both countries. Further, the results indicated that these variations were greater
for Australia than China; similarly the average absolute annual percentage change of
yield in Australia was greater than in China. It was also observed that while the standard
deviation of yield was higher for Australia than China, their coefficients of variation
(CV) was slightly lower for Australia than that for China because of larger volume of
output in China. For China, the CV of yield was higher than the coefficient of variation of
its planted area whereas for Australia, the coefficient of variation of planted area was
much higher than the coefficient of variation of yield.

Tarpara et al. (2010) studied the regional disparity in growth and instability in
area, production, and yield of major crops in Gujarat state (1960-61 to 2008-09). They
employed the instability index to estimate the level of instability in area, production and
yield of these major crops of Gujarat. The results of the instability indices indicated that
the instability index for area and production was the lowest in cotton crop for middle
Gujarat. They concluded that there are relatively less fluctuation in crop productivity as
compared to area and production.

2.3 THE RELATIVE CONTRIBUTION OF AREA AND YIELD IN COTTON
OUTPUT

It is indicated that the variations in the total production of cotton can be attributed
to changes in its planted area and its yield. An economic survey report of India also
revealed that growth in the production of agricultural crops depends upon acreage and
yield (Anonymous, 2010). The expansion of cotton production at a growth rate of
12 per cent in last decades was attributed to world cotton area increase by 8 per cent and
the world average yield increase by 4 per cent (ICAC, 2010). A large body of literature
reports that Bt cotton has led to the significant yield gains. These include studies of
(Qaim, Cap, and de Janvry, 2003; Qaim and de Janvry, 2003; Qaim and de Janvry, 2005;
The various researchers have conducted a decomposition analysis to determine the contribution of different components to the growth rate in production. Most of these researchers have employed the decomposition model developed primarily by Minhas and Vaiyanathan (1965) to estimate the decomposition of growth components of agricultural production.

Parikh (1966) carried out an econometric analysis in India for state-wise growth rate in agricultural output. The study revealed that in most cases, area explained most of the growth rate in output and it was also indicated that area explained 1.813 per cent of 2.50 per cent growth in output.

Coleman and Thigpen (1991) employed the model for decomposing the components of agricultural production in his study entitled “An econometric model of the world cotton and non-cellulosic fibers markets”. The results revealed that since 1963, average world yields of cotton had risen from 338 kg/ha to 545 kg/ha in 1988, an increase of over 60 per cent. Over this period the cotton area has remained fairly constant at around 30 million hectares. They concluded that an important feature of world cotton production is that the substantial increase in output since the early 1960’s, has resulted from yield increases and not from an expansion of area. Further, they recommended that yields and area should be modeled separately as important information may be lost if production is estimated directly as the product of these components.

Chaudhry et al. (1996) made an attempt to review the growth performance of Pakistan’s agriculture from 1950 to 1995 and decomposition analysis was also carried out. The results indicated that area increases accounted for nearly 40 per cent of the total increase in crop output and the rest is due to increases in output per acre. However, growth rates of area and productivity have varied from time to time. The growth of per acre value-added by crops was negative during the decade of the fifties and early seventies. They concluded that any growth in crop output was therefore to be attributed to area increases.
Singh *et al.* (1997) conducted a study on regional variations in agricultural performance in India and examined the determinants of production levels by fitting multiple regression equation using time series data for the period 1972-73 to 1992-93. They found out that generally, in most cases increase in cotton production was on account of increase in cotton yields.

Kumar (2000) employed the model for decomposing the components of agricultural production in his study on cropping pattern and agriculture development in West Bengal during 1970-71 to 1994-95. He indicated that the production of a crop depends on the area allocated to it on the one hand and its level of productivity on the other. He concluded that these two factors, i.e. area and productivity determine the fluctuations in production.

Singh (2002) used a decomposition technique to study the contribution of area, yield and its interaction (area and yield) towards an increase in production. The results of his study entitled “An analysis of major oilseed production in Gujarat” revealed that area was the main factor for total growth of production of oilseeds crops.

Zhao and Tisdell (2009) used the decomposition analysis to determine the relative contribution to variations in the total output of cotton of changes in the total area planted with cotton and its yield in Australia and China. The results revealed that relative contributions are found to be quite different for both countries. They indicated that this increase can be decomposed into three components (A) that due to the increase in the plant area; (B) that due to the rising yield; (C) that due to the multiplicative impact of increased area and rising yield. Further, they explained the relation between the total production and the planted area of cotton in Australia by the regression of the linear equation. The scatter plot more clearly reflects the close relationship between the level of production and area planted with cotton in Australia. Regression analysis shows that there is little connection between Australia’s cotton yield and its level of cotton production. Thus, they concluded that the major factor associated with changes in the total volume of cotton supply by Australia alterations have been made in the area planted with cotton. Applying similar regression analysis to China, no close fit was found
between the level of production and the planted area or yield. The results indicated that China’s level of cotton production co-determined by the two factors. It was found that China’s cotton production, between 1980 and 2007, increased area contributed 13.1 per cent of the increase, and the combination of rising area and yield comprised 18.41 per cent of the growth. Thus overall in that period, both rising area and yield were important for the growth of China’s production of cotton, but the higher yield made the greater contribution.

Mohamed et al. (2010) worked on the estimation of growth rates and analysis of its components in the Gezira scheme in Sudan. They analyzed the growth components of agricultural production using a decomposition model. The results of the decomposition analysis revealed that the main components contributing to growth rate were area, productivity and cropping pattern.

Salam et al. (2011) conducted a study to estimate the growth rates and decomposition analysis of agriculture production in Pakistan during pre and post SAP period. To measure the relative contribution of area and yield towards the total output change with respect of individual crop, component analysis model was used. The decomposition analysis of growth indicated that for wheat, rice and cotton, yield effect is the major source of growth in period one (1972 to 1988) except for sugarcane for which area effect was the major source. In period two (1989 to 2009), source of output growth for wheat and cotton was the yield effect; for sugarcane and rice, the growth source was the area effect. The sources of output for the overall study period (1972 to 2009) revealed that in case of individual crops, the main output source was the yield effect for wheat and cotton and the area effect for sugarcane and rice. The aggregate results for major crops showed that in period one, the source of output growth was due to the yield effect; in period two, the output growth was due to the area effect. However, the analysis for the overall study period for aggregate crops revealed that the area and yield effects had almost equal contribution to total change in output growth.
2.4 EXAMINE THE RELATIONSHIP AMONG PRODUCTION, EXPORT AND PRICE

In line with the study, it was observed during the review of literature that most of the empirical studies used Pearson’s correlation coefficient to examine the patterns of the relationships between the variables. However, most researchers have not worked on the relationship among cotton production, export and price except a few.

Ratna (2009) carried out a comparative analysis of India and USA on cotton production, exports and price for the 1997 to 2007 period. The results revealed that there was a direct relationship between production and export. Increase in production resulted in increased export in both USA and India. He reported that during the study period, the domestic production of cotton in USA saw variation in its production. Further, their production of cotton saw a growth of only 2.20 per cent. However, USA’s exports of cotton almost doubled from 1997 to 2007. In 1997 approximately 40 per cent of USA’s total domestic cotton produce was exported, this figure increased to 78 per cent in 2007. On the other hand, the domestic production of cotton in India has seen a positive growth over 1997 – 2007. The production increased by 138 per cent and its exports grew by 72 per cent in 2007 (base year 1997). For India only 8.54 per cent of its total domestic cotton produce was exported in 1997 and it increased to 34.82 per cent in 2007. A comparative chart giving the details of their production, exports and percentage share revealed that the production of cotton in USA had seen a positive growth. He indicated that US has started exporting a largest share of its domestic produce to the world market which has seen a much higher growth.

Sabo et al. (2009) used the Pearson correlation coefficient to analyze the correlation among the variable cost of production in cotton. Association analysis among the variable costs involved in cotton production showed that the cost of land rent correlated negatively with the cost of ploughing and planting.

Zhao and Tisdell (2009) investigated the relationships between total production, planted area and yield using the correlation coefficient from the statistical data in the
period from 1980 to 2007 for Australia and China respectively. The correlation coefficient between total cotton production and the planted area of cotton in Australia was 0.956143, while the correlation coefficient between total production and yield was only 0.387715. This implies that the total production of Australian cotton depended heavily on the planted area and much less so on yield. However, the situation was different for China, the correlation coefficient between China’s total production of cotton and its planted area in China was merely 0.488792 while its correlation coefficient between total production and yield was 0.830259. This implies that the cotton production of China was co-determined by yield and planted area, but that yield was more closely related to China’s total production of cotton. Thus, in Australia’s case variations in the area planted with cotton was the major influence on the level of Australia’s cotton production whereas in the case of China, it was yield.

Dahal and Routray (2011) used Pearson’s correlation to measure the association among the soil variables and between the input variables and crop yields. The correlation analysis revealed that some of the soil variables were highly interrelated however it was not known how important these variables were in explaining the variations in crop yields. The linear correlations among other variables were much weaker.

Supply of each output is a function of all prices of products within the farmers' opportunity set (i.e. the price of the commodity itself plus the prices of all competing and complementary commodities), all input prices and the levels of fixed inputs. Economic theory suggests that, in an open market, at the margin, cotton production is determined by costs. Prices tend to follow the costs of most efficient producers, and it is expected that, over time, those producers with higher costs would eventually reduce production. Yet, the experience of recent years shows that this notion has been highly distorted by government subsidies in the cotton market. There is really no rational reason for a farmer to decrease cotton production or shift into profitable crops, in response to lower cotton prices, if his or her revenues are guaranteed by government aid (Lima-Campos, 2002).

However, various studies have been conducted to examine the relationship between cotton production and prices. Walsh (1944) indicated that among the first studies
of agriculture production responses to price changes was made by Mooro who demonstrated that there was a direct relationship between the percentage change in the acreage of cotton for any given year and the percentage change in the price of the preceding year. He indicated that area planted with cotton at any given year is largely dependent upon what has been the fortune, good or bad, of cotton farmers in the preceding year i.e. falling cotton prices would result in few acres seeded in that particular year.

Hubbard (1926) observed the economic relation between prices for cotton and acreage. He indicated that the price received for the preceding year’s crop is an important factor, since, other things being equal; a high price one year means an increase in acreage in the next. However, he noted that the price of other commodities may offset the high price for cotton and prevent any increase in acreage. For example he indicated that when feed and food are high in price, it may be that the farmer will find it cheaper to raise them than to buy them. Thus in such case the high cotton price will not bring an increase in the cotton acreage.

Temin (1967) made an attempt to describe the market for cotton prices which was centered on the decade of the 1830’ s. He indicated that the rapid rise in cotton prices stimulated the land boom of 1835-1836. The rise in price must have resulted in a change in behaviour of farmers in that most of them ventured into putting their land in production of cotton. He noted that a change in behaviour of the price led to the shifting outward of the supply curve or the curve were very elastic.

Lima-Campos (2002) revealed that while production in most developing countries and Australia declined, production elsewhere had more than offset such declines, despite the severe weakness of prices. Production had increased so many elsewhere in the world, that it reached this season a record 21.2 million tons, after four years of prices below the long-term average. This report suggests that prices are low even with respect to most efficient producers worldwide.

Gillson et al. (2004) revealed that the low prices of cotton in 2001-02 resulted in lower production and higher consumption in the following year. Consumption exceeded
production by 1.9 million tonnes in 2002-03 (the surplus being taken from stocks) and the average price for the year was US$1.23 per kilogram (a one-third increase over the previous year) reaching US$1.65 per kilogram in December 2003. They indicated that unpredictable fluctuations in production caused the instability and downward movements in prices.

2.5 SUMMARY

The simple and exponential growth rate model has frequently been adopted by various researchers namely Agarwal (2008), Ratna (2009), Nithya et al. (2007), Reddy (2009), Mohamed et al (2010), Zhao and Tisdell (2009), Singh et al. (1997) and Goyal et al. (2000) to compute compound growth rates of production, area, productivity and exports in different time periods. The results produced a mixed bag. As some results revealed that growth in area and production was negative (Reddy, 2009, Mohamed et al. 2010), while productivity had a positive growth (Nithya et al., 2007). Other results revealed that cotton maintained an increasing trend in its production and yield growth rates over the years (Zhao and Tisdell, 2009, Mohamed et al. 2010, Singh et al., 1997). As far as exports are concerned, the results revealed that the export of cotton had seen a positive growth over years (Ratna, 2009). On the other hand, results of Goyal et al. (2000) revealed that the compound growth rate of raw cotton declined in the eighties as compared to the seventies.

Various researchers namely Goyal et al. (2000), Zhao and Tisdell (2009), Raju and Chand (2008), Anonymous (2010), have frequently adopted the instability Index to estimate the level of instability in production, area, productivity, and exports. The results revealed that there was instability of cotton production, area, productivity and export at both local and national levels. Further, the results revealed during the nineties cotton exhibited high volatility in exports (Goyal et al., 2000).

Various researchers namely Singh (2002); Coleman and Thigpen (1991); Kumar (2000); Chaudhry et al. (1996); Mohamed et al. (2010); Zhao and Tisdell (2009); Parikh (1966) have conducted a decomposition analysis to determine the contribution of different components to the growth rate in production. Most of these researchers have
employed the decomposition model developed primarily by Minhas and Vaiyanathan (1965) to estimate the decomposition of growth components of agricultural production. The reviews revealed that relative contributions are found to be quite different from one researcher to another. Some results (Parikh, 1966; Chaudhry et al., 1996 and Singh, 2002) have revealed that the main factor for fluctuations in production was due to area. Others (Coleman and Thigpen, 1991; Zhao and Tisdell, 2009) have shown that it was productivity. Furthermore, the study of Kumar (2000) has indicated that these two factors, i.e. area and productivity determine the fluctuations in production.

Other empirical studies have used Pearson’s correlation coefficient to examine the patterns of the relationships between the variables. The results reveal that there is a direct relationship between the price and production of cotton. Gillson et al. (2004) revealed that lower prices results into lower production. Temin (1967) also revealed that rises in price were found to boost production in that farmers ventured into putting their land in production of cotton. Further, Walsh (1944) revealed that there is a direct relationship between the percentage change in the acreage of cotton for any given year and the percentage change in the price of the preceding year. As far as exports are concerned, Ratna (2009) revealed that there was a direct relationship between production and export. Increase in production resulted in increased export.
Chapter – III

METHODOLOGY

This chapter deals with the description of the nature and sources of data and the various tools and techniques employed in analyzing the data.

The methodology adopted has been presented under the following sub-heads:

3.1 Nature and source of data

3.2 Analytical techniques employed

3.1 Nature and source of data

To achieve the stated objectives, the study was exclusively based on secondary data collected from different published sources for a period of 29 years i.e.1980-81 to 2009-10. The time series data on area, productivity, export, price, and production were collected. The study made use of annual data from Cotton Outlook (Cotlook), United States Department of Agriculture (USDA), UN COMTRADE WITS (United Nations Commodity Trade Statistics Database), FAOSTAT, National Cotton Council of America (NCCA), United Nations Conference on Trade and Development (UNCTAD) and the International Cotton Advisory Committee (ICAC).

Cotton is grown in more than 100 countries in the world. In production, China ranks first, followed by India, USA, Pakistan, Brazil, and Australia. These six countries represent more than 85 per cent of world cotton production and hence all these countries are selected for the present study. This study is restricted to these six countries only considering the global contribution they make. Country wise analysis on cotton production, productivity, area harvested and export was carried out.
The analysis was carried out for the following five periods separately to arrive at the objectives of the study.

<table>
<thead>
<tr>
<th>Period No.</th>
<th>Name of Period</th>
<th>Duration of Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Overall study</td>
<td>1980-81 to 2009-10</td>
</tr>
<tr>
<td>II</td>
<td>Pre-liberalization</td>
<td>1980-81 to 1993-94</td>
</tr>
<tr>
<td>III</td>
<td>Post-liberalization</td>
<td>1995-96 to 2009-10</td>
</tr>
<tr>
<td>IV</td>
<td>Pre-Bt introduction</td>
<td>1995-96 to 2001-02</td>
</tr>
<tr>
<td>V</td>
<td>post-Bt introduction</td>
<td>2002-03 to 2009-10</td>
</tr>
</tbody>
</table>

The overall period (1980-81 to 2009-10) as shown above was sub divided into pre-liberalization and post- liberalization period because the multilateral trade system that was put in place after liberalization brought about alterations in agricultural trade policies in different countries which affected the scenario of cotton trade on the international market which also has an effect on production and export of cotton. Furthermore, the overall study period was also subdivided into pre-Bt introduction and post-Bt introduction period because after the introduction of Bt cotton, productivity improved (Nithya et al., 2009) and that influenced the production and export of cotton.

3.2 Analytical techniques employed

The data collected from different sources as indicated above were statistically analyzed by using the following techniques and the results are presented in tabular forms. Descriptive statistical analyses such as mean, percentage, etc., were also used for examining percentages of export and in other analysis wherever necessary.
3.2.1. Compound growth rate in area, production, productivity and exports

To achieve the objective of country-wise growth rate analysis, the compound growth rates of area, production, productivity, and exports was calculated by fitting the exponential function given.

Exponential growth function \( (Y) = ab^t e \) .................................(1)

Where

\( Y = \) Dependent variable for which the growth rate is estimated i.e., Area, Production, Productivity, and export

\( a = \) Intercept/constant

\( b = \) Regression coefficient

\( t = \) Time variable

\( e = \) Error term

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

\( \ln y = a + t \ln b \) .........................................................................................................................(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).
3.2.2. Instability index

An instability index model was used to estimate the variability in country-wise production, area, productivity and exports. Anonymous (2010), Zhao and Tisdell (2009), Chand and Raju (2008) and Goyal et al. (2000) employed the instability index to estimate the level of instability in agriculture. The simple coefficient of variation (CV) often contains the trend component and thus overestimates 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

\[ I = \text{C.V.} \times \sqrt{1 - R^2} \]

where

\[ I = \text{Instability Index} \]

\[ \text{C.V. \%} = \frac{\text{SD}}{\text{Mean}} \times 100 \]

\[ \text{SD} = \text{Standard Deviation} = \sqrt{\text{variance}} \]

\[ \text{Variance} = \frac{\sum_{i=1}^{n} (Y_i - \bar{Y})^2}{n-1} \]

\( R^2 \) is the coefficient 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.
3.2.3. Decomposition Analysis

To measure the relative contribution of area and yield to the total cotton output change analysis model was 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; 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. In literature 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.

Consider,

\[ P_{io} = A_o C_{io} Y_{io} \] ..........................................................(2.1)

\[ P_{it} = A_t C_{it} Y_{it} \] ..........................................................(2.2)

Where

\( P_{io} \) = production of the \( i \)th crop in the base year \( o \)

\( P_{it} \) = production of the \( i \)th crop in the current year \( t \)

\( A_o \) = gross cropped area in year \( o \)

\( A_t \) = gross cropped area in year \( t \)

\( Y_{io} \) = yield per hectare of crop \( i \) in year \( o \)
Methodology

\( Y_{it} = \text{yield per hectare of crop } i \text{ in year } t \)

\( C_{io} = \text{proportion of area under crop } i \text{ to the total cropped area in year } 0 \)

\( C_{it} = \text{proportion of area under crop } i \text{ to the total cropped area in year } t \)

Differencing over time

\[ P_{it} - P_{io} = A_{it} C_{it} Y_{it} - A_{io} C_{io} Y_{io} \] \hspace{1cm} (2.3)

Each variable in the current period can be expressed as its counterpart in the base year plus the change in the variable between the current and the base year. For example,

\[ A_{it} = A_{io} + \Delta A \]

\[ C_{it} = C_{io} + \Delta C \]

\[ Y_{it} = Y_{io} + \Delta Y \]

Equation (2.3) can, therefore, be written as

\[ P_{it} - P_{io} = (A_{io} + \Delta A)(C_{io} + \Delta C)(Y_{io} + \Delta Y) - A_{io} C_{io} Y_{io} = A_{io} C_{io} Y_{io} + A_{io} Y_{io} \Delta C + C_{io} Y_{io} \Delta A + A_{io} C_{io} \Delta Y + \Delta A \Delta C \Delta Y \] \hspace{1cm} (2.4)

which can be written as:

\[ P_{it} - P_{io} = C_{io} Y_{io} (A_{it} - A_{io}) + A_{io} C_{io} (Y_{it} - Y_{io}) + A_{io} Y_{io} (C_{it} - C_{io}) + Y_{io} (A_{it} - A_{io}) (C_{it} - C_{io}) + C_{io} (A_{it} - A_{io}) (Y_{it} - Y_{io}) + (A_{it} - A_{io}) (C_{it} - C_{io}) (Y_{it} - Y_{io}) \] \hspace{1cm} (2.5)

In this additive scheme of decomposition, the first element on the right hand side is the area effect, i.e., an increase in output of this magnitude could have taken place in the absence of any changes in per hectare yield. The second term is the effect of yield change i.e. yields effect.
The third element is the effect of changes in interaction effect in the absence of any changes in per hectare yields. The remaining four terms measure the effect on production which could be attributed to, (1) interaction between production changes and changes in area (2) interaction between production changes and changes in yield (3) interaction between per hectare yield changed and changes in area, and (4) interaction among production changes, per hectare yield changes and changes in area.

### 3.2.4. To examine the relationship among cotton production, exports and price

A Pearson's correlation coefficient and other regression techniques were used to examine the relationship among production, export and price. Pearson's correlation coefficient between two variables is defined as the covariance of the two variables divided by the product of their standard deviations. The correlation coefficient between two variables X and Y, usually denoted by \( r \) is a numerical measure of linear relationship between them (degree of association ship) and is defined as follows:

\[
\tau = \frac{N \sum xy - (\sum x)(\sum y)}{\sqrt{[N \sum x^2 - (\sum x)^2][N \sum y^2 - (\sum y)^2]}}
\]

Where:

- \( N \) = number of pairs of observations
- \( \sum xy \) = sum of the product of observations
- \( \sum x \) = sum of x observations
- \( \sum y \) = sum of y observations
- \( \sum x^2 \) = sum of squared x observations
- \( \sum y^2 \) = sum of squared y observations

The value of \( r \) lies within the range -1 and +1 and it is units free (Hooda, 2002).
This chapter outlines the findings of the study which was done to assess the performance of cotton production and export in the major cotton producing countries namely, China, India, USA, Pakistan, Brazil and Australia. The data was subjected to both quantitative and qualitative methods to draw meaningful conclusions. Growth rates and instability indices in production, area, productivity and exports were estimated. Further, this study examined two factors, which include area and yield, influencing cotton output. Lastly, correlation coefficients among production, export and price were estimated. The following sub-topics discusses in detail empirical results and the findings of the study.

4.1 Country-wise compound growth rate of production, area, productivity, and export

4.2 Country-wise instability indices of production, area, productivity, and export

4.3. Components of cotton output

4.4. Correlation coefficient estimates among production, export, and price.

4.1 COUNTRY-WISE COMPOUND GROWTH RATE OF PRODUCTION, AREA, PRODUCTIVITY AND EXPORT

The country-wise compound growth rates of production, area, productivity and export of cotton crop during the overall period (1980-81 to 2009-10) and the four sub periods; viz., pre and post liberalization (1980-81 to 1993-94 and 1995-96 to 2009-10 respectively) and pre and post introduction of Bt cotton (1995-96 to 2001-02 and 2002-03 to 2009-10, respectively) were worked out using exponential growth function. The results are presented in the tables onward.

4.1.1 Compound growth rate of production, area, productivity and export in China

The results of the compound growth rate of production, area, productivity and export in China are depicted in Table 4.1.

It can be seen from the table that during the overall study period, area (-0.15 per cent), and export (-4.00 per cent) recorded a negative growth. On the other
hand, productivity (2.45 per cent), and production (2.42 per cent) registered a positive growth. The combined effect of planted cotton area of China and its yield makes the gross cotton production of China the largest globally. However, it can be observed from this study that productivity growth played a big role in positive growth in production. Similarly, these results are in agreement with Zhao and Tidwell (2009), who found out that China’s level of cotton production, has shown an upward trend since 1980 and this upward trend has been fairly regular since 2000. Further, they indicated that this persistent upward trend mainly due to a rise in its yields from growing cotton. This can also be in agreement with the result of this study as it can be observed that productivity growth rates were higher than area growth rates for all the study periods (I to V), indicating changes in cotton yields in China are the principal influence on the supply of cotton. This is probably a result of scientific and technological advances in the cultivation of cotton (Ma et al., 2001).

A negative growth rate (-27.07 per cent) in export during period V (post-Bt introduction) can be explained by the fact that after accession to the WTO in early 21st century, China agreed to eliminate all cotton subsidies which made China less competitive on the world market. It should be noted that Chinese government policies heavily influence the cotton industry. When China was not a member of WTO, to encourage exports, Chinese government used to offer export subsidies, and to discourage imports, it used to impose tariff barriers and non-tariff barriers like quotas. The study conducted by Jin (2003) also confirmed that accession to WTO, led to increased imports and reduced exports. Further, a negative growth rate in exports implied that China did not export much cotton because it had to supply for domestic consumption. According to Macdonald (2007) China’s textile mills reportedly consume more than 40 per cent of the world’s cotton.

It can also be observed that in pre-Bt introduction period exports growth rate (72.82 per cent) was the highest of them all. The reason may be that during that period China was not a member of WTO and it was among the list of cotton producing countries that subsidies their domestic industry, and so these subsidies coupled with low cotton prices during the 21st century meant that subsidized countries found it more easier to compete (ICAC, 2004).
Results and Discussion

Table 4.1: Compound growth rate of production, area, productivity and export in China

<table>
<thead>
<tr>
<th>Period No.</th>
<th>Name of Periods</th>
<th>Area (%)</th>
<th>Productivity (%)</th>
<th>Production (%)</th>
<th>Export (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Overall (1980-81 to 2009-10)</td>
<td>-0.15</td>
<td>2.45</td>
<td>2.42</td>
<td>-4.00</td>
</tr>
<tr>
<td>II</td>
<td>Pre-liberalization (1980-81 to 1993-94)</td>
<td>0.47</td>
<td>1.55</td>
<td>2.04</td>
<td>27.72</td>
</tr>
<tr>
<td>III</td>
<td>Post-liberalization (1995-96 to 2009-10)</td>
<td>1.54</td>
<td>2.52</td>
<td>4.28</td>
<td>-3.53</td>
</tr>
<tr>
<td>IV</td>
<td>Pre-Bt introduction (1995-96 to 2001-02)</td>
<td>-2.97</td>
<td>3.95</td>
<td>0.88</td>
<td>72.82</td>
</tr>
<tr>
<td>V</td>
<td>Post-Bt introduction (2002-03 to 2009-10)</td>
<td>0.44</td>
<td>2.39</td>
<td>3.32</td>
<td>-27.07</td>
</tr>
</tbody>
</table>

4.1.2 Compound growth rate of production, area, productivity and export in India

Table 4.2 shows the results of the compound growth rate of production, area, productivity and export in India. From the table, it can be observed that production (4.59 per cent), area (1.10 per cent), productivity (3.40 per cent) and export (6.01 per cent) had positive growth rate during the entire study period. During all the study periods except in period IV (pre-Bt introduction), productivity growth rates were higher than that of area. This indicates the role of productivity was more than area expansion for cotton production in India.

A negative growth rate in productivity during pre Bt introduction could partly be attributed to the shattered rains and the drought of 2000-2001 in the major drought-prone farming regions of country such as Southern and Eastern Maharashtra, Northern Karnataka, Andhra Pradesh, Orissa, Gujarat, and Rajasthan (Anonymous, 2008).

Furthermore, in period V (post-Bt introduction), production recorded highest magnitude of positive growth rate (9.06 per cent). This could be attributed to increased growth rate in area (5 per cent) and productivity (3.84 per cent) from previous period IV (pre-Bt introduction). This encouraging performance could partly be attributed to use of Bt cotton. These results are in agreement with those of Nithya et al. (2007) who in their
study on cotton production in Karnataka, India, found out that during post Bt introduction period there was a positive growth in area, production, and productivity of cotton. They indicated that a growth in rate of productivity was at least partly attributed to introduction of Bt cotton.

As far as exports are concerned, all periods except period IV (pre-Bt introduction), recorded a positive growth rate. The negative growth rate in period IV (-37.91 per cent) could be explained by the fact that since there was a fall in production government imposed export ban. The ban was imposed to maintain domestic prices at reasonable levels as exports can affect domestic prices by reducing the domestic supply if supply fell short of demand (Goyal et al. 2000). Increased growth in production in period V due to improvement in growth rate of productivity and area, couple with exports subsidies led to increase in growth rate in exports (78.30 per cent). These results were in agreement with Ratna (2009) who in his study found that during the 1997 to 2007, there was a positive growth in production (increased by 138 per cent) and its exports grew by 872 per cent. This tremendous positive growth in export could be due to trade liberalization that saw markets opening up. It was estimated that from 1997 to 2007 the world market size grew by 13.29 per cent, and India's world market share of cotton increased from 2.48 per cent in 1997 to 16.89 per cent in 2007 (Ratna, 2009).

Table 4.2: Compound growth rate of production, area, productivity and export in India

<table>
<thead>
<tr>
<th>Period No.</th>
<th>Name of Periods</th>
<th>Area (%)</th>
<th>Productivity (%)</th>
<th>Production (%)</th>
<th>Export (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Overall (1980-81 to 2009-10)</td>
<td>1.10</td>
<td>3.40</td>
<td>4.59</td>
<td>6.01</td>
</tr>
<tr>
<td>II</td>
<td>Pre-liberalization (1980-81 to 1993-94)</td>
<td>-2.96</td>
<td>4.38</td>
<td>4.14</td>
<td>0.35</td>
</tr>
<tr>
<td>III</td>
<td>Post-liberalization (1995-96 to 2009-10)</td>
<td>1.38</td>
<td>4.32</td>
<td>5.76</td>
<td>31.14</td>
</tr>
<tr>
<td>IV</td>
<td>Pre-Bt introduction (1995-96 to 2001-02)</td>
<td>-0.88</td>
<td>-1.63</td>
<td>-2.54</td>
<td>-37.91</td>
</tr>
<tr>
<td>V</td>
<td>Post-Bt introduction (2002-03 to 2009-10)</td>
<td>5.00</td>
<td>3.84</td>
<td>9.06</td>
<td>78.30</td>
</tr>
</tbody>
</table>
4.1.3 Compound growth rate of production, area, productivity and export in USA

The compound growth rate of production, area, productivity and export in USA are presented in Table 4.3. It is clear from the table that for the entire study period there were positive growth rates for production (1.06 per cent), area (0.13 per cent), and productivity (1.41 per cent). This implies that increased in production was attributed to the positive growth in area and productivity. However, productivity had a larger contribution. This can also be seconded by the fact that for all the periods, productivity recorded higher growth rates than area. Cotton farming in the US has been subject to a myriad of advances in technology (seed varieties, fertilizers, pesticides, and machinery) and production practices (reduced tillage, irrigation, crop rotations, and pest management systems) resulting in consistently high yields (Osakwe, 2009).

Furthermore, period I (overall study period) experienced a highest growth rate in exports (3.45 per cent). The upward trend in exports was also echoed by Ratna (2010) who reported that USA's exports of cotton almost doubled from 1997 to 2007 i.e. from 40 per cent in 1997 to 78 per cent in 2007. US’s cotton exports have experienced a general upward trend due to subsidies that they provide for their domestic industry. In 2005 US taxpayers paid an estimated US$4.2 billion to subsidies their own cotton growers (USDA, 2005). In addition, the US Government, for example, sets a target price for cotton, regardless of world price. These subsidies allow farmers to continue over-producing so that, despite their high cost of cotton production. This leads to an oversupply of cotton on the world market as US growers are not influenced by normal supply and demand factors (ICAC, 2005). It is for this reason that USA continues to be the major exporter of cotton in the world market. On an average 50 per cent of the world market share is captured by USA. It has been the top exporter of cotton in the world since 1997. Due to global demand that was created due to liberalization, USA reported highest growth rate (6.95 per cent) in period III (post-liberalization). Liberalization resulted into openness of agricultural trade which led to increased global market. However, a negative growth rate (-3.55 per cent) was registered in period IV (pre-Bt introduction). This was partly due to a fall in global demand of cotton due to global financial crisis during that period. According to ICAC (2004) the global financial crisis resulted into a reduced
demand coupled with worst cotton prices in 30 years. Between 1997 and 2002, the average world market price for cotton declined by 40 per cent to 42 cents per pound.

In period V (post-Bt introduction), there was a negative growth rate in area (-4.22 per cent) which partly resulted into a negative growth rate (-2.68 per cent) in production. The decline in cotton area can be attributed to farmers switching to more competitive commercial crops such as grains and soybeans. The switch was due to the low prices of cotton on the international markets as a result of global financial crisis (Osakwe, 2009).

**Table 4.3: Compound growth rate of production, area, productivity and export in USA**

<table>
<thead>
<tr>
<th>Period No.</th>
<th>Name of Periods</th>
<th>Area (%)</th>
<th>Productivity (%)</th>
<th>Production (%)</th>
<th>Export (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Overall (1980-81 to 2009-10)</td>
<td>0.13</td>
<td>1.41</td>
<td>1.06</td>
<td>3.45</td>
</tr>
<tr>
<td>II</td>
<td>Pre-liberalization (1980-81 to 1993-94)</td>
<td>0.88</td>
<td>2.37</td>
<td>3.38</td>
<td>0.88</td>
</tr>
<tr>
<td>III</td>
<td>Post-liberalization (1995-96 to 2009-10)</td>
<td>-2.72</td>
<td>2.35</td>
<td>-0.30</td>
<td>6.95</td>
</tr>
<tr>
<td>IV</td>
<td>Pre-Bt introduction (1995-96 to 2001-02)</td>
<td>-0.12</td>
<td>1.63</td>
<td>0.14</td>
<td>-3.55</td>
</tr>
<tr>
<td>V</td>
<td>Post-Bt introduction (2002-03 to 2009-10)</td>
<td>-4.23</td>
<td>1.40</td>
<td>-2.68</td>
<td>2.59</td>
</tr>
</tbody>
</table>

4.1.4. Compound growth rate of production, area, productivity and export in Pakistan

Table 4.4 depicts compound growth rate of production, productivity and export in Pakistan. The results show that during the entire study period (period I) production (3.18 per cent), area (1.11 per cent) and productivity (2.00 per cent) had a positive growth rate. This indicates that the growth in production was due to positive growth rates in area
and productivity. However, productivity is found to have contributed more than that area. These results agreed with the results of Salam et al. (2011) who found out that growth in cotton output in Pakistan was due to improvement in yield. Cotton yields have been increasing due to improved practices, greater experience with biotech varieties, and availability of higher quality input (ICAC, 2009).

During that period I (overall study period), export (-8.44 per cent) witnessed a negative growth rate. Hussain (2010) gave the reason for poor performance of exports during 1989 to 1994 in the second phase may partly be attributed to economic sanctions following the atomic detonation while low exports growth during 2005 to 2009 largely reflects phasing out of textile quota and global economic recession. However, positive growth rates were recorded in period III (4.25 per cent) and Period V (7.01 per cent) in export. The reason could partly be that for period III (post-liberalization), opening of global cotton market due to liberalization. Liberalization leads to world trade expansions indicating that demand factors play an important role in cotton exports from Pakistan (Hussain et al., 2010). As for period V, the reasons could partly be because of favorable changes in export prices after the recovery from the global recession.

Surprisingly, during post Bt introduction period, against expectations that after Bt cotton introduction yield was to improve and increase, growth in productivity was of lowest magnitude (0.73 per cent) after Bt introduction. This indicates that Bt cotton introduction did not play a major role in productivity of cotton in Pakistan. This was due to the fact that commercial cultivation of Bt cotton was not officially approved and unregulated in Pakistan until recently (Abdullah, 2006). Nazli et al. (2010) explained the non-adoption due to close geographical proximity and similarities in production and cultural practices, the Indian experiences created controversies and apprehensions about the Bt cotton adoption in Pakistan. However, there might be many possible reasons for low growth rate in cotton productivity in Pakistan like lack of irrigation was increasingly becoming a major cause for concern and noticeably affected 2007-08 cotton production (Osakwe, 2009).
Table 4.4: Compound growth rate of production, area, productivity and export in Pakistan

<table>
<thead>
<tr>
<th>Period No.</th>
<th>Name of Periods</th>
<th>Area (%)</th>
<th>Productivity (%)</th>
<th>Production (%)</th>
<th>Export (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Overall (1980-81 to 2009-10)</td>
<td>1.11</td>
<td>2.00</td>
<td>3.18</td>
<td>-8.44</td>
</tr>
<tr>
<td>II</td>
<td>Pre-liberalization (1980-81 to 1993-94)</td>
<td>1.99</td>
<td>4.84</td>
<td>7.05</td>
<td>-0.17</td>
</tr>
<tr>
<td>III</td>
<td>Post-liberalization (1995-96 to 2009-10)</td>
<td>0.10</td>
<td>1.55</td>
<td>1.67</td>
<td>4.25</td>
</tr>
<tr>
<td>IV</td>
<td>Pre-Bt introduction (1995-96 to 2001-02)</td>
<td>-0.08</td>
<td>1.81</td>
<td>1.08</td>
<td>-7.68</td>
</tr>
<tr>
<td>V</td>
<td>Post-Bt introduction (2002-03 to 2009-10)</td>
<td>0.25</td>
<td>0.73</td>
<td>0.99</td>
<td>7.01</td>
</tr>
</tbody>
</table>

4.1.5 Compound growth rate of production, area, productivity and export in Brazil

The results of compound growth rate of production, area, productivity and export in Brazil are presented in Table 4.5.

It is clear from the table that during the entire period of the study (period-I), productivity (6.48 per cent), production (2.94 per cent) and export (6.34 per cent) recorded positive growth rate. Whereas, area (-3.25 per cent) registered negative growth. This negative growth in area was partly due low cotton prices. Lower prices and consequently lower profitability cause a negative growth in land allocated to cotton. Osse (2006) concurred with this statement, and reported that the dip in international cotton prices was the biggest reason behind Brazilian cotton acreage shrinking by 35 per cent during that growing season. Due to the low prices many cotton growers shifted to sugarcane, corn or soybeans.

During post liberalization period, Brazil experienced a positive growth in area (2.76 per cent), productivity (7.81 per cent), production (10.77 per cent) and exports (56.16 per cent). Exports recorded highest growth rate after liberalizing the market. Opening of the market benefited cotton producing countries (like Brazil) that subsidise
their domestic industry (ICAC, 2005). Export growth rate sharply reduced from 51.31 per cent in period IV (pre-Bt introduction) to 21.99 per cent in period V (post-Bt introduction). This might be due to the low global cotton prices. This decline is also apparent in production growth figures even though there was an increase in area allocated for farming.

Productivity had positive growth rate during all periods (period I to period V). However, there was a tremendous fall in growth rate of productivity in period V (Post-Bt introduction) i.e. from 21.66 per cent in period IV to 2.90 per cent in period V, indicating that Bt cotton introduction did not play much big role in productivity increase. During the time when Bt cotton was being introduced, Brazil prevented and resisted to GM in the country. The small group of underfunded Brazilian environmentalists and consumers had succeeded against all the odds in keeping a GM ban in place for four years. These groups believed that the usage of Bt seed as it would not only could damage the crops but the environment as well (Branford, 2002). Further, it was observed that during post-Bt introduction period, the growth in production was largely due to growth in area as productivity rate (2.90 per cent) being lower than that of area rate (3.54 per cent).

**Table 4.5: Compound growth rate of production, area, productivity and export in Brazil**

<table>
<thead>
<tr>
<th>Period No.</th>
<th>Name of Periods</th>
<th>Area (%)</th>
<th>Productivity (%)</th>
<th>Production (%)</th>
<th>Export (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Overall (1980-81 to 2009-10)</td>
<td>-3.25</td>
<td>6.48</td>
<td>2.94</td>
<td>6.34</td>
</tr>
<tr>
<td>II</td>
<td>Pre-liberalization (1980-81 to 1993-94)</td>
<td>-3.60</td>
<td>1.58</td>
<td>-1.98</td>
<td>-6.29</td>
</tr>
<tr>
<td>III</td>
<td>Post-liberalization (1995-96 to 2009-10)</td>
<td>2.76</td>
<td>7.81</td>
<td>10.77</td>
<td>56.16</td>
</tr>
<tr>
<td>IV</td>
<td>Pre-Bt introduction (1995-96 to 2001-02)</td>
<td>-2.97</td>
<td>21.66</td>
<td>18.06</td>
<td>51.31</td>
</tr>
<tr>
<td>V</td>
<td>Post-Bt introduction (2002-03 to 2009-10)</td>
<td>3.54</td>
<td>2.90</td>
<td>6.56</td>
<td>21.99</td>
</tr>
</tbody>
</table>
4.1.6. Compound growth rate of production, area, productivity and export in Australia

Table 4.6 presents the compound growth rate of production, area, productivity and export in Australia. The results revealed that during the overall study period (Period I), a positive growth was observed in area (2.65 per cent), productivity (1.70 per cent), production (4.39 per cent) and exports (6.75 per cent). Therefore, it may be inferred that the increase in exports was as result of positive growth in production, due to positive growth in area and productivity.

Surprisingly, observations from the table also indicate that productivity had a negative growth (-1.56 per cent) during the post Bt introduction period. Productivity was to increase over the years with a significant growth because of improved varieties (Bt cotton). But the results of this study are on the contrary in post-Bt introduction period. A major factor contributing to the decline in Australian cotton productivity has been the decline in Australia’s availability of water as a result of reduced rainfall (Zhao and Tisdell, 2009). Australian production of cotton is largely dependent on local rainfall. Even when Australian cotton growers do not depend on local catchment dams on their properties for irrigation water, access to other water sources, for example, in rivers and streams, is limited. Furthermore, during the same period of Post-Bt, production (7.82 per cent) and area (9.42 per cent) had positive growth. This indicates that the increase in production was due to the increase in area and not due to productivity.

In case of exports, in post liberalization period, against all odds Australia registered a negative growth (-2.94 per cent). In 2002, the combined level of world subsidies reached almost US$6 billion, more than a quarter of the global value of production. This coincided with the worst cotton prices in 30 years, and meant unsubsidized countries (like Australia) found it even more difficult to compete (ICAC, 2004). According ICAC (2005), 53 per cent of cotton produced in the world is subsidized. However, Australia’s cotton growers receive no direct government subsidies and are unfairly disadvantaged against overseas growers from subsidized countries (WTO, 2005).
As far as export growth rate is concerned, the highest growth rate (17.12 per cent) was seen in period IV (pre-Bt introduction). This could be partly attributed to the effects of liberalization which created new export opportunities as a result of wider opening of markets. Further, liberalization benefited significantly the Australian cotton industry since trade barriers was lifted.

**Table 4.6: Compound growth rate of production, area, productivity and export in Australia**

<table>
<thead>
<tr>
<th>Period No.</th>
<th>Name of Periods</th>
<th>Area (%)</th>
<th>Productivity (%)</th>
<th>Production (%)</th>
<th>Export (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Overall (1980-81 to 2009-10)</td>
<td>2.65</td>
<td>1.70</td>
<td>4.39</td>
<td>6.75</td>
</tr>
<tr>
<td>II</td>
<td>Pre-liberalization (1980-81 to 1993-94)</td>
<td>8.11</td>
<td>2.02</td>
<td>10.46</td>
<td>16.57</td>
</tr>
<tr>
<td>III</td>
<td>Post-liberalization (1995-96 to 2009-10)</td>
<td>-3.38</td>
<td>1.82</td>
<td>-1.63</td>
<td>-2.94</td>
</tr>
<tr>
<td>IV</td>
<td>Pre-Bt introduction (1995-96 to 2001-02)</td>
<td>5.13</td>
<td>3.01</td>
<td>8.31</td>
<td>17.12</td>
</tr>
<tr>
<td>V</td>
<td>Post-Bt introduction (2002-03 to 2009-10)</td>
<td>9.42</td>
<td>-1.56</td>
<td>7.82</td>
<td>-10.41</td>
</tr>
</tbody>
</table>

**4.1.7. Comparison among the major cotton producing countries’ growth rates of production, area, productivity and export**

The pattern of yearly country wise growth rates in production, area, productivity and exports are shown in Figures 4.1, 4.2, 4.3 and 4.4, respectively.

**4.1.7.1 Production growth rates comparison**

Several features can be seen from the Figure 4.1 regarding growth rates of production. The figure shows that in production, India recorded the highest growth during period I (overall study period) followed by Australia, Pakistan, Brazil, China and USA. This suggests that cotton production in India was the fastest growing in the world during
accumulated debts to buy expensive Bt cotton when the crop failed due to the non-availability of irrigation in some areas (Nazli et al., 2010).

A negative growth rate in the pre-liberalization was observed in Brazil. According to Filho (1994), Brazil’s cotton production collapsed in the early 1990’s as local textile mills switched to imported fiber.

Period III (post Liberalization) and IV (Pre Bt introduction) saw Brazil recording highest positive growth rate by far from the rest of other countries in production i.e. above 10 per cent. This could partly be due to the fact that trade liberalization did help Brazil to boost cotton production in the long run. The removal of non-tariff barriers for agricultural inputs like pesticides and machinery crucial to modern cotton production was particularly important for production in new, tropical States of Brazil like Mato Grossow (Kiawu et al., 2011). Furthermore, cotton farming in Brazil is highly mechanized; pesticides, fertilizers and machines are all integrated into the production process. In addition, according to Lissdaniels and Madsen (2011), the relocation of production to the Cerrado and the resultant increase in production in the 1997-1998 season led to a trend break. As a result of research, new varieties were developed, which for the first time enabled a larger production in the Cerrado of Brazil. Production was from this point onwards mechanized and carried out in large scale where new technologies had been adopted. These factors increased productivity significantly hence led to growth in production in Brazil.

A negative growth rate in period III (Post-Liberalization) was observed in Australia, which was due to the decline in Australia’s availability of water as a result of reduced rainfall. Australian production of cotton is largely dependent on local rainfall. Even when Australian cotton growers do not depend on local catchment dams on their properties for irrigation water, access to other water sources, for example, in rivers and streams, is limited (Zhao and Tisdell, 2009).

India saw negative production growth rate in period IV (pre-Bt introduction) owing to the shattered rains in the major cotton farming regions of country (Anonymous, 2008).
As stated above in periods I, II, IV, and V, Australia ranked first in growth rate of area allocated to cotton. However, there was a fall in land allocated to cotton during period III (post-liberalization). This could be as a result of falling cotton prices in the world and less water availability in Australia. According to Zhao and Tisdell (2009) grain prices were quite favorable for grain crops compared to cotton prices, and may have encouraged some farmers to switch to grain crops in place of cotton. This was in agreement with Carpio and Ramirez (2002), who using a 1979-99 model, found that cotton acreage in Australia was affected by changes in the returns from competing crops, but the magnitude of their competing crops’ effect seems to have diminished.

4.1.7.3 Productivity growth rates comparison

It can be seen through the examination of Fig 4.3 that during the entire study period (period I), as far as productivity is concerned, all countries registered a positive growth rate. Brazil recorded the highest rate of growth followed by India, China, Pakistan, Australia and USA. The highest positive growth rate in Brazil was observed because of the fact that the cotton farming has been highly mechanized in Brazil and pesticides, fertilizers and machines have been integrated into the production process. In addition, Brazil has experienced ideal climatic conditions (Anonymous, 2006). Due to this Brazilian producers have emerged as the highest rain fed cotton yields in the world (ICAC, 2009).

In period II (pre-liberalization), Pakistan recorded the highest rate of growth in productivity followed by India, USA, Australia, Brazil and China. In period III (Post-liberalization), Brazil showed the highest rate of growth followed by India, China, USA, Australia and Pakistan.

In period IV (pre-Bt introduction), Brazil showed the highest rate of growth in productivity followed by China, Australia, Pakistan and USA whereas a negative growth was observed in India.

As far as Period V (post-Bt introduction) is concerned, India recorded the highest rate of growth followed by Brazil, China, USA, and Pakistan, whereas in Australia a
a response to growing demand for an expanding textile and apparel sector Elbehri (2004).

In period II (Pre-liberalization), China recorded the highest growth rate followed by Australia, USA, and India whereas a negative growth was observed in Brazil and Pakistan.

With regard to Period III (Post-liberalization), Brazil registered the highest growth followed by India, USA, Pakistan, whereas Australia and China were under negative growth. According to Kiawu et al. (2011), Brazil has become world’s leading cotton producers and an important competitor of the United States in Asian and European cotton markets. This situation has come about as a result of trade liberalization. Furthermore, they indicated that exchange rates were a significant factor in the year to year shifts in Brazilian cotton trade. During the latter half of the 1990’s, Brazil fought inflationary expectations by pegging its currency to the U.S. dollar. As a result, the value of the Brazilian real on foreign exchange markets was high relative to earlier years, and by some measures the currency was overvalued. After the Asian financial crisis of 1997-98, Brazil relinquished the peg with the dollar in January 1999, and the real per dollar exchange rate depreciated significantly. The U.S. dollar strengthened against a number of other currencies during this time as well, and Brazil’s net exports rose. The newly favorable exchange rate helped Brazil reap the benefits of the policy reforms of the previous 15 years and increase cotton exports significantly.

Surprisingly, China which had highest growth rate in period of pre-liberalization (period II) recorded negative growth rate in period III (post-liberalization) and turned highest again in period IV (pre-Bt introduction) after that in period V (post-Bt introduction), again negative growth rate was seen in China. This gradual rebound was driven by the global revival in the consumption. In addition, China granted export subsidies on cotton from Xinjiang autonomous Region and offering foreign textile mills in China export tax rebates for using Xinjiang cotton. Furthermore, China’s Ministry of Foreign Trade and Economic Co-operation had also allowed the local Xinjiang government and state farms to sell cotton directly on international markets (USDA, 1999).
4.2 COUNTRY-WISE INSTABILITY INDICES OF PRODUCTION, AREA, PRODUCTIVITY AND EXPORT OF COTTON

An instability index model was used to estimate the variability in country-wise production, area, productivity and exports. Agricultural growth with stability has been a matter of concern in the strategy of agricultural development in the world, especially in developing countries. This study used the Instability index as used by Cuddy and Della (1978). The results for the period 1980-81 to 2009-10 are presented in the tables in the sub-sections below.

The country-wise picture is composite in area, productivity, production and exports. Some countries witnessed higher instability while others experienced a relatively low instability. The country wise instability rates, for all the study period, for export ranged from 7.94 per cent to 137.92 per cent, for area, it ranged from 2.01 per cent to 46.99 per cent, for production it ranged from 5.15 per cent to 51.64 per cent, for productivity, it ranged from 3.03 per cent to 23.86 per cent.

4.2.1 Instability indices of production, area, productivity and export in China

The instability indices of production, area, productivity and export in China are shown in Table 4.7.

It is clear from the table that exports recorded highest degree of instability in all the periods, with highest recorded in period III (post-liberalization) i.e.133.64 per cent. These fluctuations could partly be explained by the export controls (export taxes, export licensing and export quotas) to maintain the domestic prices at reasonable levels as the export can affect domestic prices by reducing supply to domestic market. In addition, international trade policies and violent ups and downs of cotton prices were also some of the factors for the instability in exports (Morrison, 2005).

As far as productivity is concerned, it can be observed that the magnitude of instability is lower than that of production, area, and exports in all the periods. It ranged from 3.03 per cent (Pre-Bt introduction period) to 13.19 per cent (Pre-liberalization period). Better selection of cotton varieties and cultivation methods for its varied
ecological zones and geographical changes in the location of China’s cotton production have helped to dampen fluctuations. In addition, the research on development and application of transgenic pest-resistant cotton varieties has resulted in a steady improvement in cotton yield in China (Zhao and Tidwell, 2009). As said above the instability in productivity recorded a lower magnitude than the instability in production in all the periods. This implies the importance of instability of area.

Instability in exports had highest magnitude in all the periods as compared to instability in area, production and productivity. This was partly due to the fluctuations in world demand coupled with volatility of cotton prices on the international market. It is important to note that during post liberalization, China experienced a highest degree of fluctuations in exports, suggesting that export competitiveness and increase in trade openness due to liberalization might have caused this magnitude of fluctuations, due to increased supply.

### Table 4.7: Instability indices of production, area, productivity and export in China

<table>
<thead>
<tr>
<th>Period No.</th>
<th>Name of Periods</th>
<th>Area (%)</th>
<th>Productivity (%)</th>
<th>Production (%)</th>
<th>Export (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Overall (1980-81 to 2009-10)</td>
<td>14.24</td>
<td>9.59</td>
<td>17.95</td>
<td>112.92</td>
</tr>
<tr>
<td>II</td>
<td>Pre-liberalization (1980-81 to 1993-94)</td>
<td>13.45</td>
<td>13.19</td>
<td>20.57</td>
<td>91.01</td>
</tr>
<tr>
<td>III</td>
<td>Post-liberalization (1995-96 to 2009-10)</td>
<td>11.76</td>
<td>5.58</td>
<td>12.06</td>
<td>133.64</td>
</tr>
<tr>
<td>IV</td>
<td>Pre-Bt introduction (1995-96 to 2001-02)</td>
<td>10.09</td>
<td>3.03</td>
<td>9.98</td>
<td>101.43</td>
</tr>
<tr>
<td>V</td>
<td>Post-Bt introduction (2002-03 to 2009-10)</td>
<td>9.69</td>
<td>6.34</td>
<td>11.41</td>
<td>88.46</td>
</tr>
</tbody>
</table>

### 4.2.2. Instability indices of production, area, productivity and export in India

Table 4.8 shows the instability indices of production, area, productivity and export in India. It can be noted from the table that in all the periods among the four
Results and Discussion

variables, exports recorded highest degree of instability and lowest degree of instability, was observed in area.

Instability in exports ranged from 59.57 per cent (Post Bt introduction period) to 136.55 per cent (the entire study period). These findings of high instability in exports are in agreement with results of Goyal et al. (2000). They reported that during the nineties cotton witnessed high volatility in exports as indicated by instability indices. The sources of instability in export were due to changes in export polices. Adoption of liberalization policies by Government of India had paved a way for agricultural exports promotion policies. In addition, other factors were such as, government export controls (these were done to control domestic prices and also maintain supply for the domestic market), world economic scenario, prices of cotton exports relative to world prices, exchange rate and inflation rate in the countries competing with India for the world market, and taxes and subsidies on exports. Furthermore, Mahadevaiah et al. (2005) indicated that the export of cotton from 1988-89 to 2003-04 have been fluctuating. They indicated that the several factors that have contributed to the variability in exports 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.

In productivity, the period I (overall study period) recorded highest magnitude of instability (14.47 per cent) followed by post-liberalization period (12.93 per cent), and post-Bt introduction period (11.66 per cent). These fluctuations could partly be caused by adoption of new technology (i.e. Bt cotton), expansion of irrigation, and variability of rainfall. Against all odds most studies which covered 10 to 20 years for increasing production since the adoption of new technology concluded that instability in agricultural production had increased with the adoption of new technology. However, the findings of the inference on increase in instability due to adoption of new technology were refuted by Chand and Raju (2008). They indicated that when a little longer period was taken into consideration when the spread of improved technology to large area, improved technology brought stability in productivity. It can also be noted that from period I (overall study period) to Period IV (pre-Bt introduction), the instability in
Results and Discussion

productivity were lower than those of production. This suggested the importance of instability of area on production. However, in period V (post-Bt introduction), instability in productivity was higher than that of production. This suggested the importance of instability of productivity in post-Bt introduction period.

Table 4.8: Instability indices of production, area, productivity and export in India

<table>
<thead>
<tr>
<th>Period No.</th>
<th>Name of Periods</th>
<th>Area (%)</th>
<th>Productivity (%)</th>
<th>Production (%)</th>
<th>Export (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Overall (1980-81 to 2009-10)</td>
<td>9.8</td>
<td>14.47</td>
<td>20.02</td>
<td>136.59</td>
</tr>
<tr>
<td>II</td>
<td>Pre-liberalization (1980-81 to 1993-94)</td>
<td>4.99</td>
<td>9.35</td>
<td>9.97</td>
<td>86.69</td>
</tr>
<tr>
<td>III</td>
<td>Post-liberalization (1995-96 to 2009-10)</td>
<td>10.2</td>
<td>12.93</td>
<td>15.42</td>
<td>95.31</td>
</tr>
<tr>
<td>IV</td>
<td>Pre-Bt introduction (1995-96 to 2001-02)</td>
<td>2.01</td>
<td>4.11</td>
<td>5.15</td>
<td>113.89</td>
</tr>
<tr>
<td>V</td>
<td>Post-Bt introduction (2002-03 to 2009-10)</td>
<td>5</td>
<td>11.66</td>
<td>9.03</td>
<td>59.57</td>
</tr>
</tbody>
</table>

4.2.3. Instability indices of production, area, productivity and export in USA

The results of instability indices of production, area, productivity and exports in USA are shown in Table 4.9.

The picture from the table reveals that instability of exports ranged from 14.68 per cent (Post-Bt introduction) to 28.65 per cent (overall study period). The United States is one of the largest exporters of cotton. Availability of cotton is crucial to maintain this position. Therefore instability in exports is mainly and partly caused by the instability in production of cotton.

As far as production is concerned, instability ranged from 11.77 per cent to 19.64 per cent. Instability in production is mainly due to the instability in cotton area and instability in productivity. Instability of productivity was found to be less than that of production. This suggests the importance of area instability. Instability in productivity is partly due to water shortages, and changes in cost of operations (the cultivation,
fertilization and picking of cotton are all costly). This is arguably coupled with the high input intensive aspect of cotton farming (ICAC, 2009).

The results also reveal that during post-Bt introduction period, the instability in productivity was the lowest. This may be as a result of advance technology. This was in agreement with the observations made by Chand and Raju (2008) who indicated that improved technology spread brings about stability in productivity.

Table 4.9: Instability indices of production, area, productivity and export in USA

<table>
<thead>
<tr>
<th>Period No.</th>
<th>Name of Periods</th>
<th>Area (%)</th>
<th>Productivity (%)</th>
<th>Production (%)</th>
<th>Export (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Overall (1980-81 to 2009-10)</td>
<td>17.09</td>
<td>9.322</td>
<td>18.6</td>
<td>28.65</td>
</tr>
<tr>
<td>II</td>
<td>Pre-liberalization (1980-81 to 1993-94)</td>
<td>15.64</td>
<td>9.05</td>
<td>16.77</td>
<td>22.75</td>
</tr>
<tr>
<td>III</td>
<td>Post-liberalization (1995-96 to 2009-10)</td>
<td>10.98</td>
<td>7.84</td>
<td>17.66</td>
<td>23.11</td>
</tr>
<tr>
<td>IV</td>
<td>Pre-Bt introduction (1995-96 to 2001-02)</td>
<td>8.29</td>
<td>8.77</td>
<td>11.77</td>
<td>26.46</td>
</tr>
<tr>
<td>V</td>
<td>Post-Bt introduction (2002-03 to 2009-10)</td>
<td>12.24</td>
<td>6.99</td>
<td>19.64</td>
<td>14.68</td>
</tr>
</tbody>
</table>

4.2.4. Instability indices of production, area, productivity and export in Pakistan

Visual inspection of Table 4.10 indicates that exports have highest magnitude in instability for the entire study period. It ranges from 41.82 per cent (post Bt introduction period) to 124.2 per cent (pre Bt introduction period). These fluctuations are partly due to the volatility of global cotton prices and global financial crisis that lead to fluctuations in global demand. It implies the important role of global demand in determination of Pakistan’s exports (Hussain et al., 2010). Furthermore, Pakistan has been a net importer of cotton since the mid 1990’s. This is due to expansion in domestic demand for cotton. There has been increasing competition for cotton between local and international market. Based on prices on the international and local market, farmers prefer taking their commodities to markets where they are attractive. Cotton trading in Pakistan is facilitated
by the fact that the government has no quantitative restrictions or duties on imports and exports of cotton (Osakwe, 2009).

In productivity, the highest magnitude of instability was recorded during period II (pre-liberalization) and it was 19.61 per cent. According to Ahmad (2001) the sources of instability of productivity of cotton in Pakistan include vulnerability of the crop to disease and insect attack, consistently rising production cost, incapacity of the farming communities to deal with the dynamism of technology in cotton production, and increasing waterlogging and salinity problem.

The instability in productivity was lower than that of production in all periods except period IV (pre-Bt introduction). In this period productivity and production recorded almost similar instability, i.e. productivity and production recorded 8.86 per cent and 8.54 per cent respectively.

It can further be observed from the table that as far as area is concerned, in all the periods, area recorded the lowest degree of instability in all the variables. This implies that there was more stability in area allocated to cotton in Pakistan as compared to productivity, production and exports. This is in line with global world cotton area which in most years it has no apparent tendency to rise or fall (ICAC, 1997). This could be due to the factors that land’s growth potential (the acreage effect) is limited due to the scarce supply of water resources (Salam et al., 2011). However, generally, the slight rise and fall in cotton area could partly be attributed to low cotton prices which depress the cotton area, and high cotton prices results in increase area.
Table 4.10: Instability indices of production, area, productivity and export in Pakistan

<table>
<thead>
<tr>
<th>Period No.</th>
<th>Name of Periods</th>
<th>Area (%)</th>
<th>Productivity (%)</th>
<th>Production (%)</th>
<th>Export (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Overall (1980-81 to 2009-10)</td>
<td>5.57</td>
<td>14.59</td>
<td>15.82</td>
<td>81.78</td>
</tr>
<tr>
<td>II</td>
<td>Pre-liberalization (1980-81 to 1993-94)</td>
<td>3.36</td>
<td>19.61</td>
<td>21.56</td>
<td>59.91</td>
</tr>
<tr>
<td>III</td>
<td>Post-liberalization (1995-96 to 2009-10)</td>
<td>4.11</td>
<td>8.04</td>
<td>9.96</td>
<td>102.06</td>
</tr>
<tr>
<td>IV</td>
<td>Pre-Bt introduction (1995-96 to 2001-02)</td>
<td>2.97</td>
<td>8.86</td>
<td>8.54</td>
<td>124.2</td>
</tr>
<tr>
<td>V</td>
<td>Post-Bt introduction (2002-03 to 2009-10)</td>
<td>4.88</td>
<td>7.53</td>
<td>10.72</td>
<td>41.82</td>
</tr>
</tbody>
</table>

4.2.5. Instability indices of production, area, productivity and export in Brazil

The instability indices of area, production, productivity and export in Brazil are presented in Table 4.11.

It may be observed from the table that in all the periods, productivity recorded lowest degree of instability as compared to production, area and exports. It ranged from 6.42 per cent to 23.86 per cent. The fluctuations were higher in area and production because of the volatility of cotton price, which, in combination with higher production costs, changes in fertilizer prices, and the advancement of boll weevil (Lissdaniels and Madsen, 2011).

As far Production indices are concerned, they ranged from 18.4 per cent to 36.21 per cent. The overall study period recorded the highest fluctuations (36.21 per cent). This could partly be due to the magnitude of instability in area and productivity in this period.
For all the study periods, export instability indices ranged from 16.06 per cent to 137.92 per cent. Highest degree of instability was recorded during period IV (pre-Bt introduction) i.e. it was 137.92 per cent. These fluctuations were primarily caused by the fluctuations in demand of cotton in the world due to global economic crisis (resulting in a drastic drop and rise in consumption from the United States, which is a major consumer), and unfavorable exchange rates (Osakwe, 2009). In addition, the instabilities can be attributed to import substitution policies aimed at nurturing industrial agriculture in Brazil (Kiawu et al., 2011).

Table 4.11: Instability indices of production, area, productivity and export in Brazil

<table>
<thead>
<tr>
<th>Period No.</th>
<th>Name of Periods</th>
<th>Area (%)</th>
<th>Productivity (%)</th>
<th>Production (%)</th>
<th>Export (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Overall (1980-81 to 2009-10)</td>
<td>27.13</td>
<td>23.86</td>
<td>36.21</td>
<td>88.62</td>
</tr>
<tr>
<td>II</td>
<td>Pre-liberalization (1980-81 to 1993-94)</td>
<td>14.93</td>
<td>13.72</td>
<td>19.41</td>
<td>88.97</td>
</tr>
<tr>
<td>III</td>
<td>Post-liberalization (1995-96 to 2009-10)</td>
<td>20.28</td>
<td>12.5</td>
<td>19.24</td>
<td>34.67</td>
</tr>
<tr>
<td>IV</td>
<td>Pre-Bt introduction (1995-96 to 2001-02)</td>
<td>17.39</td>
<td>10.57</td>
<td>18.52</td>
<td>137.92</td>
</tr>
<tr>
<td>V</td>
<td>Post-Bt introduction (2002-03 to 2009-10)</td>
<td>19.3</td>
<td>6.42</td>
<td>18.4</td>
<td>16.06</td>
</tr>
</tbody>
</table>

4.2.6 Instability indices for production, area, productivity and export in Australia

Table 4.12 shows the instability indices for area, productivity, production and export in Australia. If we examine the pattern of variations shown in the table, several features are evident.

In production, the instability ranged from 10.12 per cent (period IV) to 51.64 per cent (period V). Highest instability was recorded during post Bt introduction. This could be partly attributed to the instability in area (56.38 per cent) as a result of Bt introduction, free market forces and water availability. According to Zhao and Tisdell (2009) the level of Australian cotton production was shown to be much
more volatile than other countries principally because the area planted with cotton in Australia was so variable. Further, it can be observed that the instability of productivity was lower than instability in production in all the periods. This also implies the importance of instability in area. Surprisingly, pre-Bt introduction period had lower instability in productivity (6.44 per cent) than the post Bt-introduction period (8.35 per cent). These results are in contradiction to the results of Zhao and Tisdell (2009), who found out that development and application of transgenic pest-resistant cotton varieties reduce fluctuations in yields. Further, they indicated that the change from a system heavily reliant on persistent pesticides and on exploitive soil and water practices to integrated crop management has substantially improved stability in Australia yields.

Instability indices for area ranged from 14.99 per cent to 56.38 per cent. Area had the highest degree of instability in period V (Post-Bt introduction) and it was 56.38 per cent. The source of this instability was changes in allocation of land to cotton due to free market forces and water availability (Zhao and Tisdell, 2009). It is believed that in Australia, farmers’ land-use decisions are driven primarily by free market forces and water availability. When the export market can be fully guaranteed, the land used for planting cotton is increased quickly and vice versa. This explains the importance of reduced demand on international market, due to financial crisis, as one factor that caused on fluctuations in area in Australia.

As far as exports are concerned, the range was from 7.94 per cent (during pre Bt-introduction) to 42.95 per cent (entire study period). Lowest instability during period IV (pre-Bt introduction) could be explained by the stability in production, area and productivity which recorded lowest magnitude of instability in that period. This could partly be due to stable water availability and the scientific progress and technological improvements, in cotton production, the ability of responding to natural disasters and controlling cotton diseases and insect pests which had been strengthened (ICAC, 2007).

In post-liberalization period (period III), the instability in exports was 32.89 per cent and it could partly be explained as global financial crisis that kept hitting the global cotton market during that period. This kept on affecting the changes in the
global demand of cotton, and reduced cotton global market prices which resulted into reduced profits, and hence shifting of land allocation to more profitable (ICAC, 2009).

Table 4.12: Instability indices of production, area, productivity and export in Australia

<table>
<thead>
<tr>
<th>Period No.</th>
<th>Name of Periods</th>
<th>Area (%)</th>
<th>Productivity (%)</th>
<th>Production (%)</th>
<th>Export (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Overall (1980-81 to 2009-10)</td>
<td>46.99</td>
<td>10.72</td>
<td>47.07</td>
<td>42.95</td>
</tr>
<tr>
<td>II</td>
<td>Pre-liberalization (1980-81 to 1993-94)</td>
<td>16</td>
<td>11.59</td>
<td>22.82</td>
<td>19.59</td>
</tr>
<tr>
<td>III</td>
<td>Post-liberalization (1995-96 to 2009-10)</td>
<td>46.81</td>
<td>10.26</td>
<td>43.06</td>
<td>32.89</td>
</tr>
<tr>
<td>V</td>
<td>Post-Bt introduction (2002-03 to 2009-10)</td>
<td>56.38</td>
<td>8.35</td>
<td>51.64</td>
<td>25.57</td>
</tr>
</tbody>
</table>

4.2.7. Comparison among the major cotton producing countries’ instability indices of production, area, productivity and export

The percentage variations in production, area, productivity and exports are graphed in Figures 4.5, 4.6, 4.7, and 4.8, respectively. A picture of the figures reveals that the instability indices of production, area, productivity and exports range from 2.01 to 137.92 per cent. The highest magnitude was recorded in exports (see Table 4.11) and lowest magnitude was recorded for area (see Table 4.8). This suggests that exports experienced more instability than other variables i.e. area, production and productivity.

4.2.7.1. Production instability comparison

It is clear from Fig 4.5 that in all the study periods except period IV (Pre-Bt introduction), Australia recorded the highest degree of instability in production indicating that Australia was the most unstable comparatively in cotton production.
came from area; it was about 61.68 per cent, 41.22 per cent, 86.56 per cent and 106.39 per cent, respectively.

In case of post-Bt introduction period (Period V), it was found that growth in production of cotton was largely due to interaction effect. It was 39.54 per cent. The contribution of yield was 19.22 per cent whereas the contribution of area was 35.78 per cent. This indicates how the driving force of area and yield equally contributed in cotton production during post-Bt introduction.

**Table 4.13: Components of growth in cotton production in China**

<table>
<thead>
<tr>
<th>Period No.</th>
<th>Name of Periods</th>
<th>Area (%)</th>
<th>Yield (%)</th>
<th>Interaction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Overall (1980-81 to 2009-10)</td>
<td>61.68</td>
<td>27.89</td>
<td>1.21</td>
</tr>
<tr>
<td>II</td>
<td>Pre-liberalization (1980-81 to 1993-94)</td>
<td>41.22</td>
<td>39.63</td>
<td>7.44</td>
</tr>
<tr>
<td>III</td>
<td>Post-liberalization (1995-96 to 2009-10)</td>
<td>86.56</td>
<td>19.25</td>
<td>-7.49</td>
</tr>
<tr>
<td>V</td>
<td>Post-Bt introduction (2002-03 to 2009-10)</td>
<td>35.78</td>
<td>19.22</td>
<td>39.54</td>
</tr>
</tbody>
</table>

**4.3.2. Components of growth in cotton production in India**

The results of decomposition analysis of the growth in output for cotton crop in India are presented in Table 4.14.

It can be seen that during the all the five periods the major contribution to the growth of cotton output came from yield ranging from 65.41 per cent to 113.02 per cent. This implies that even though India occupies first place among cotton growing countries of the world in respect of area (USDA, 2010), yield did played a major role in growth of cotton output.
It is worth noting that during post Bt cotton introduction, yield effect recorded the highest magnitude (113.02 per cent) as compared to the rest of the study periods. This may be partly due to introduction and expansion of biotech cotton and improved hybrid cotton varieties.

These findings were in line with Nithya and Arunkumar (2007), who in their study found out that productivity has been playing a big role in production of cotton in India. They also indicated that increase in yield effect being the major driving force for cotton output growth may be at least partly attributed to introduction of Bt cotton.

Table 4.14: Components of growth in cotton production in India

<table>
<thead>
<tr>
<th>Period No.</th>
<th>Name of Periods</th>
<th>Area (%)</th>
<th>Yield (%)</th>
<th>Interaction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Overall (1980-81 to 2009-10)</td>
<td>33.94</td>
<td>71.01</td>
<td>3.06</td>
</tr>
<tr>
<td>II</td>
<td>Pre-liberalization (1980-81 to 1993-94)</td>
<td>26.07</td>
<td>88.62</td>
<td>-12.41</td>
</tr>
<tr>
<td>III</td>
<td>Post-liberalization (1995-96 to 2009-10)</td>
<td>44.05</td>
<td>71.27</td>
<td>-7.43</td>
</tr>
<tr>
<td>IV</td>
<td>Pre-Bt introduction (1995-96 to 2001-02)</td>
<td>15.62</td>
<td>65.41</td>
<td>17.35</td>
</tr>
<tr>
<td>V</td>
<td>Post-Bt introduction (2002-03 to 2009-10)</td>
<td>44.17</td>
<td>113.02</td>
<td>-48.79</td>
</tr>
</tbody>
</table>

4.3.3. Components of growth in cotton production in USA

The relative contribution of area, yield and their interaction to change in production of cotton in USA is presented in Table 4.15.

It can be observed that the growth of cotton production during period I (overall study period), period II (pre-liberalization) period III (post-liberalization) and period V (post Bt-introduction) was largely due to area effect ranging from 63.17 per cent to 110.17 per cent. The reason behind area being a major driving force during these periods could partly be, according to ICAC (2005), US Government domestic cotton programs set a target price for cotton, regardless of world price and also it provided subsidies which...
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provided direct payments to compensate farmers for low market prices. These subsidies encouraged farmers to allocate land to cotton despite high cost of cotton production. This led to an oversupply of cotton on the world market as US growers were not influenced by normal supply and demand factors.

The increase in cotton output growth during period IV (pre-Bt introduction) was largely due to yield effect, it was about 95.67 per cent. This implies that yield played a major role in cotton growth in USA during this period. According to ICAC (2009), there was a decline in cotton area in the 1990’s because most cotton farmers switched to more competitive crops such as grains and soybeans. The global financial crisis (GFC) in the 1990’s (World Bank, 1998) led to reduced global demand for cotton, and secondly, the GFC led to falling prices of cotton on the international market and for that reason grain prices in USA have been quite favorable for grain crops compared to cotton prices, and may have encouraged some farmers to switch to grain crops in place of cotton. In addition, there was a declining demand for cotton due to increased competition from synthetic fibers and slow world economic growth.

Table 4.15: Components of growth in cotton production in USA

<table>
<thead>
<tr>
<th>Period No.</th>
<th>Name of Periods</th>
<th>Area (%)</th>
<th>Yield (%)</th>
<th>Interaction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Overall (1980-81 to 2009-10)</td>
<td>110.17</td>
<td>32.74</td>
<td>-38.96</td>
</tr>
<tr>
<td>II</td>
<td>Pre-liberalization (1980-81 to 1993-94)</td>
<td>98.81</td>
<td>32.43</td>
<td>-22.63</td>
</tr>
<tr>
<td>III</td>
<td>Post-liberalization (1995-96 to 2009-10)</td>
<td>63.17</td>
<td>32.28</td>
<td>2.58</td>
</tr>
<tr>
<td>IV</td>
<td>Pre-Bt introduction (1995-96 to 2001-02)</td>
<td>85.55</td>
<td>95.67</td>
<td>-67.66</td>
</tr>
<tr>
<td>V</td>
<td>Post-Bt introduction (2002-03 to 2009-10)</td>
<td>77.50</td>
<td>12.24</td>
<td>11.07</td>
</tr>
</tbody>
</table>
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4.3.4. Components of growth in cotton production in Pakistan

The relative contribution of area, yield and their interaction to change in production of cotton in Pakistan is presented in Table 4.16.

It can be observed that during the all the five periods the major contribution to the growth of cotton output came from yield ranging from 56.96 per cent to 108.15 per cent. During overall study period (Period I), pre-liberalization (period II), post-liberalization (period III), pre-Bt introduction (period IV) and post-Bt introduction it was about 69.68 per cent, 81.71 per cent, 65.81 per cent, 108.15 per cent and 56.96, respectively. This implies that yield effect was the major driving force for cotton output growth in Pakistan. The findings of this study were in agreement with the findings of Salam et al. (2011), who found out that in Pakistan cotton, for their study period of 1972 to 2009, the sources of output growth was yield effect.

Table 4.16: Components of growth in cotton production in Pakistan

<table>
<thead>
<tr>
<th>Period No.</th>
<th>Name of Periods</th>
<th>Area (%)</th>
<th>Yield (%)</th>
<th>Interaction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Overall (1980-81 to 2009-10)</td>
<td>10.04</td>
<td>69.68</td>
<td>18.54</td>
</tr>
<tr>
<td>II</td>
<td>Pre-liberalization (1980-81 to 1993-94)</td>
<td>2.30</td>
<td>81.71</td>
<td>14.93</td>
</tr>
<tr>
<td>III</td>
<td>Post-liberalization (1995-96 to 2009-10)</td>
<td>17.24</td>
<td>65.81</td>
<td>13.09</td>
</tr>
<tr>
<td>V</td>
<td>Post-Bt introduction (2002-03 to 2009-10)</td>
<td>16.52</td>
<td>56.96</td>
<td>23.42</td>
</tr>
</tbody>
</table>

4.3.5. Components of growth in cotton production in Brazil

The relative contribution of area, yield and their interaction to change in production of cotton in Brazil is presented in Table 4.17.

The decomposition analysis of the growth of cotton crop shows that the area effect was the major driving force for cotton output growth in Brazil. This is evident from
the table that during the overall study period (period I) area and yield contributed 52.15 per cent and 39.82 per cent, respectively. Likewise observations from other periods also indicated that growth in cotton production was mainly due to area effect i.e. pre-liberalization (64.15 per cent), post-liberalization (121.99 per cent), pre-Bt introduction (57.68 per cent) and post-Bt introduction (116.11 per cent). Area was found to be the major driving force for cotton production in Brazil because of the shifting of place of cotton cultivation from south and southeast to Mato Grosso and Bahia (Osakwe, 2009). Mato Grosso and Bahia area accounts for 96 per cent of total farming area under cotton occupying about 197 million hectares, or about 23 per cent of Brazil’s land.

Table 4.17: Components of growth in cotton production in Brazil

<table>
<thead>
<tr>
<th>Period No.</th>
<th>Name of Periods</th>
<th>Area (%)</th>
<th>Yield (%)</th>
<th>Interaction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Overall (1980-81 to 2009-10)</td>
<td>52.15</td>
<td>39.82</td>
<td>24.07</td>
</tr>
<tr>
<td>II</td>
<td>Pre-liberalization (1980-81 to 1993-94)</td>
<td>64.15</td>
<td>54.27</td>
<td>-20.79</td>
</tr>
<tr>
<td>III</td>
<td>Post-liberalization (1995-96 to 2009-10)</td>
<td>121.99</td>
<td>46.54</td>
<td>-56.70</td>
</tr>
<tr>
<td>IV</td>
<td>Pre-Bt introduction (1995-96 to 2001-02)</td>
<td>57.68</td>
<td>18.93</td>
<td>17.05</td>
</tr>
<tr>
<td>V</td>
<td>Post-Bt introduction (2002-03 to 2009-10)</td>
<td>116.11</td>
<td>14.35</td>
<td>-25.39</td>
</tr>
</tbody>
</table>

4.3.1. Components of growth in cotton production in Australia

The decomposition analysis of the growth in output for cotton crop in Australia is presented in Table 4.18.

It can be observed that the growth in production of cotton in Australia was largely due to area effect ranging from 50.74 to 192.54 per cent. It can be seen that in all the five periods [Overall (122.16 per cent), pre-liberalization (50.74 per cent), post-liberalization (149.10 per cent), pre-Bt introduction (192.54 per cent) and post-Bt introduction
the area effect was the major driving force for cotton output growth. These results were in agreement with the results of Zhao and Tisdell (2009), who found that even though Australian cotton yields are among the highest in the world in most seasons, increased area accounts for the largest proportion of the increase (72.79 per cent) in Australia cotton production and during the similar period, yields contributed only 4.32 per cent of the increase.

### Table 4.18: Components of growth in cotton production in Australia

<table>
<thead>
<tr>
<th>Period No.</th>
<th>Name of Periods</th>
<th>Area (%)</th>
<th>Yield (%)</th>
<th>Interaction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Overall (1980-81 to 2009-10)</td>
<td>122.16</td>
<td>6.37</td>
<td>-28.92</td>
</tr>
<tr>
<td>II</td>
<td>Pre-liberalization (1980-81 to 1993-94)</td>
<td>50.74</td>
<td>26.68</td>
<td>18.23</td>
</tr>
<tr>
<td>III</td>
<td>Post-liberalization (1995-96 to 2009-10)</td>
<td>149.10</td>
<td>7.19</td>
<td>-46.39</td>
</tr>
<tr>
<td>IV</td>
<td>Pre-Bt introduction (1995-96 to 2001-02)</td>
<td>192.54</td>
<td>35.55</td>
<td>-109.41</td>
</tr>
<tr>
<td>V</td>
<td>Post-Bt introduction (2002-03 to 2009-10)</td>
<td>119.50</td>
<td>2.62</td>
<td>-23.61</td>
</tr>
</tbody>
</table>

### 4.3.7. Components of growth comparison among the countries during different periods

#### 4.3.7.1 Overall study period (period I)

The relative contribution of area, yield and their interaction to change in production of cotton as presented in the tables above revealed that during period I (overall period), Australia (122.16 per cent) recorded the highest magnitude in area effect followed by USA (110.17 per cent), China (61.68 per cent), Brazil (52.15 per cent), India (33.94 per cent) and Pakistan (10.04 per cent).

Yield contribution was the highest in India (71.01 per cent), followed by Pakistan (69.68 per cent), Brazil (39.82 per cent), USA (32.74 per cent),
China (27.89 per cent), and Australia (6.37 per cent). Thus, it was observed that the yield effects have nearly equal contribution to total change in output growth in India (71.01 per cent) and Pakistan (69.68 per cent). The yield effect was lower than the area effect in Brazil, Australia, USA, and China. However, in Pakistan and India, it was the opposite, i.e. yield effect was higher than the area effect.

Area and yield interaction contribution was highest in Brazil (24.07 per cent), followed by Pakistan (18.54 per cent), India (3.06 per cent) and China (1.21 per cent). The contribution of area and yield interaction was positive in Brazil, India, Pakistan and China, whereas it was negative in Australia and USA.

4.3.7.2 Pre-liberalization (period II)

During the pre-liberalization period, results show that among the six countries, USA registered the highest in area as a major source of growth output of cotton; it was about 98.81 per cent. This was followed by Brazil (64.15 per cent), Australia (50.74 per cent), China (41.22 per cent), India (26.07 per cent) and Pakistan (2.30 per cent).

It is further observed that India recorded the highest magnitude (88.62 per cent) in yield effect as the major contribution to the growth of output during pre-liberalization period. This was followed by Pakistan (81.71 per cent), Brazil (54.27 per cent), China (39.63 per cent), USA (32.43 per cent) and Australia (26.68 per cent). There was a difference of about 7 per cent between India (88.62 per cent) and Pakistan (81.71 per cent) which was nearly the same in the first period. Yield contribution was higher than area in India, and Pakistan. On the other hand, area contribution was higher than yield in Brazil, Australia, USA and China.

As far as interaction effect is concerned, Australia recorded the highest (18.23 per cent), followed by Pakistan (14.93 per cent) and China (7.44 per cent). Yield-area interaction was positive in Australia, Pakistan and China but it was negative in Brazil, India and USA.

4.3.7.3 Post liberalization (period III)

In post-liberalization, the main source of output growth of cotton due to area effect was highest in Australia (149.10 per cent), followed by Brazil (121.99 per cent), China (86.56 per cent), USA (63.17 per cent), India (44.05 per cent) and
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Pakistan (17.24 per cent), while the increase in output growth due to yield effect was highest in India (71.27 per cent) was followed by Pakistan (65.81 per cent), Brazil (46.54 per cent), USA (32.28 per cent), China (19.25 per cent), and then the lowest was observed in Australia (7.19 per cent). The yield effect was lower than the area effect in Brazil, Australia, USA, and China. However, in Pakistan and India, it was the opposite, i.e. yield effect was higher than the area effect.

It can be seen that in case of yield-area interaction effect, Pakistan recorded the highest (13.09 per cent) followed by USA (2.58 per cent). The contribution of area and yield interaction was positive in USA and Pakistan, whereas it was negative in Brazil, India, China and Australia.

4.3.7.4 Pre-Bt introduction (period IV)

During Period IV, the results indicate that as far as area effect is concerned, Australia registered a highest magnitude (192.54 per cent). This was followed by China (106 per cent), USA (85.55 per cent), Brazil (57.68 per cent), India (12.19 per cent) and Pakistan (12.19 per cent).

It is further observed that Pakistan recorded the highest magnitude (108.15 per cent) of yield effect as the major contribution to the growth of cotton output. This was followed by USA (95.67 per cent), India (65.41 per cent), Australia (35.55 per cent), Brazil (18.93 per cent) and China (9.37 per cent). Yield contribution was higher than area in India, USA and Pakistan. On the other hand, area contribution was higher than yield in Brazil, Australia and China.

The contributions of yield–area interaction was highest in India (17.35 per cent), followed by Brazil (17.05 per cent). The contributions of yield–area interaction were negative in the Australia, USA, Pakistan and China, whereas in India and Brazil they were positive.

4.3.7.5 Post Bt introduction (period V)

In the last period, the major source of output growth of cotton due to area effect was highest in Australia (119.50 per cent), followed by Brazil (119.50 per cent), USA (77.50 per cent), India (44.17 per cent), China (35.78 per cent) and Pakistan (16.52 per cent).
Results and Discussion

The increase in output growth due to yield effect was highest in India (113.02 per cent). This was followed by Pakistan (56.96 per cent), then China (19.22 per cent), Brazil (14.35 per cent), USA (12.24 per cent) and lastly, Australia (2.62 per cent). The yield effect was lower than the area effect in Brazil, Australia, USA and China. However, as it was observed in the previous periods, in Pakistan and India, it was the opposite i.e. yield effect was higher than the area effect.

In case of yield-area interaction effect, it can be seen that, China recorded the highest, (39.54 per cent) followed by Pakistan (23.42 per cent) and USA (11.07 per cent). The contribution of area and yield interaction was positive in China, Pakistan and USA, whereas in Brazil (-25.39 per cent), India (-48.79 per cent) and Australia (-23.61 per cent) experienced a negative interaction.

4.4 Correlation among Production, Export and Price in the Major Producing Countries

Country wise correlation estimates of production, export and price are presented in Table 4.19.

It can be observed from the table that among the countries the correlation between production and export, production and price, and export and price ranged from -0.339 to 0.822, -0.267 to 0.033, and -0.26 to 0.322, respectively.

Further, it was found that there was a positive and significant relationship at 1 per cent level between production and export in Australia (0.822), Brazil (0.775), India (0.7710) and USA (0.688). This implies that total export of cotton in these countries depend on their production. These results are in line with the observations made by earlier studies of Jin (2003), Goyal et al. (2000) and Ratna (2009). In China and Pakistan, the negative and non-significant relationship was observed between production and export. This can be explained by the fact the share in global export on the international market of these two countries is less as compared to the other major producing countries.

As far as production and world price relationship is concerned, it was observed that a negative correlation was found in all the major producing countries except in USA. According to Besanko and Braeutigam (2005) the negative relationship indicates that as production rises, the world prices falls. The positive relationship between production and world price observed in USA suggest that even though world prices of cotton fall, USA
still produce and exports large quantities. This could partly be due to the USA government cotton programs (refer to section 4.3.3).

As far as the relationship between export quantity and world price is concerned, though all the result were found to be non-significant, it was worth mentioning the signs and meaning of correlation coefficients in the six countries. A positive correlation was observed in India (0.137) and Australia (0.322). This indicates that as world prices rise, the export in these two countries also increases. A negative correlation was observed in Brazil (-0.132), China (-0.122), Pakistan (-0.26) and USA (-0.05). It is worth noting that even though USA and Brazil had a negative relationship, they are ranked first and third respectively in global export of cotton. This implies that even though world cotton prices fall, these two countries export is not affected by the price and so it does not fall. This may partly be due to their competitiveness in cotton export because of heavy domestic support (subsidies) given to their cotton farmers (ICAC, 2005).
Table 4.19: Correlation among production, export and price in the major producing countries

<table>
<thead>
<tr>
<th></th>
<th>Production</th>
<th>Export</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Export</td>
<td>-0.32</td>
<td></td>
</tr>
<tr>
<td>Price</td>
<td>-0.11</td>
<td>-0.122</td>
</tr>
<tr>
<td>India</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Export</td>
<td>0.771**</td>
<td>0.137</td>
</tr>
<tr>
<td>Price</td>
<td>-0.073</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Export</td>
<td>0.688**</td>
<td></td>
</tr>
<tr>
<td>Price</td>
<td>0.033</td>
<td>-0.05</td>
</tr>
<tr>
<td>Pakistan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Export</td>
<td>-0.339</td>
<td></td>
</tr>
<tr>
<td>Price</td>
<td>-0.208</td>
<td>-0.26</td>
</tr>
<tr>
<td>Brazil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Export</td>
<td>0.775**</td>
<td></td>
</tr>
<tr>
<td>Price</td>
<td>-0.267</td>
<td>-0.132</td>
</tr>
<tr>
<td>Australia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Export</td>
<td>0.822**</td>
<td></td>
</tr>
<tr>
<td>Price</td>
<td>-0.267</td>
<td>0.322</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level
Chapter – V

SUMMARY AND CONCLUSION

This final chapter provides a nutshell description of the study including the major findings, conclusions and policy implications drawn from the study.

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 contributes 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 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 period. Furthermore, factors or various components influencing overall output growth and export of cotton are important issues that need scientific understanding.

With this background, the present study entitled “Performance of cotton production and export in the major producing countries” was planned with following objectives.
5.1 OBJECTIVES

1. To estimate country wise growth rate of production, area, productivity and export.

2. To estimate country wise instability indices in production, area, productivity and export

3. To determine the relative contribution of crop area and yield in the variations in output of cotton changes

4. To examine the relationship among production, export and price.

5.2 METHODOLOGY

To achieve the above stated objectives, the secondary data related to area, production, productivity and export of the major cotton producing countries (China, India, USA, Pakistan, Brazil and Australia) were collected from different published sources 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 various statistical techniques were applied in the analyses. Descriptive statistical analyses such as mean, percentage, etc., were used for examining percentages of production, area, productivity and export and in other analysis wherever necessary. To achieve the objective of country-wise growth rate analysis, the compound growth rates of area, production, productivity and exports were calculated by fitting the exponential function. An instability index model was used to estimate the variability in country-wise production, area, productivity and exports. A decomposition analysis was employed to measure the relative contribution of area and yield to the total cotton output change. Lastly, a Pearson's correlation coefficient and other regression techniques were used to examine the relationship among production, export and price.
5.3 MAJOR FINDINGS

The major findings from the research are summarized below.

5.3.1 Compound growth rate in production, area, productivity and exports

5.3.1.1 Production growth rates in the major cotton producing countries

India recorded the highest growth (4.59 per cent) in production followed by Australia (4.39 per cent), Pakistan (3.18 per cent), Brazil (2.94 per cent), China (2.42 per cent) and USA (1.06 per cent) during the overall study period (1980-81 to 2009-10). This suggests that cotton production in India was the fastest growing in the world during 1980-81 to 2009-10. The growth rate of production during the overall study period ranged from 1.06 per cent to 4.59 per cent in the major cotton producing countries.

5.3.1.2 Area growth rates in the major cotton producing countries

During the overall study period (1980-81 to 2009-10), Australia recorded the highest rate of growth (2.65 per cent) in area followed by Pakistan (1.11 per cent), India (1.10 per cent) and USA (0.13 per cent), whereas a negative growth was also observed in China (-0.15 per cent) and Brazil (-3.25 per cent). In periods II (pre-liberalization), IV (pre-Bt introduction), and V (post-Bt introduction) also, Australia ranked first in growth rate of area allocated to cotton. This suggests area allocated to cotton in Australia was the fastest growing in the world. The growth rate of area for the overall study period (period I) ranged from -3.25 per cent to 2.65 per cent in the major cotton producing countries.

5.3.1.3 Productivity growth rates in the major cotton producing countries

As far as Productivity is concerned, 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 per cent) in productivity followed by India (3.40 per cent), China (2.45 per cent), Pakistan (2.00 per cent), Australia (1.70 per cent) and USA (1.41 per cent). This suggests that productivity of cotton in Brazil was the fastest growing
in the world during 1980-81 to 2009-10. In the major cotton producing countries, the growth rate of productivity for the overall study period (period I) ranged from 1.41 per cent to 6.48 per cent.

### 5.3.1.4 Export growth rates in the major cotton producing countries

During the overall study period (1980 to 2009), Australia witnessed the highest growth (6.75 per cent) in export followed by Brazil (6.34 per cent), India (6.01 per cent) and USA (3.45 per cent), whereas in China (-4.00 per cent) and Pakistan (-8.44 per cent), a negative growth was observed. This suggests export of cotton from Australia was the fastest growing in the world during 1980-81 to 2009-10. In the major cotton producing countries, the growth rate of exports ranged from -8.44 per cent to 6.34 per cent during overall study period.

Surprisingly, China which had highest growth rate (27.72 per cent) in export among the major producing countries in period of pre-liberalization, recorded negative growth rate (-3.53 per cent) in post-liberalization period, and again turned highest growth rate (72.82 per cent) in pre-Bt introduction period. However, in post-Bt introduction period, negative growth rate (-27.07 per cent) was observed. This gradual rebound in China, might be partly driven by the global revival in the consumption of cotton.

India which had second position (31.14 per cent) in export growth during post-liberalization period, recorded a negative growth rate (-37.91 per cent) in pre-Bt introduction period. This fall could be because of government involvement in the export of cotton. Government implemented a cotton ban in export. However, in post-Bt introduction period, India registered the highest growth rate (78.30 per cent) in export and this growth rate was far more than that of the other major cotton producing countries. Increase in production as a result of improvement in yield due to Bt cotton adoption could partly be the contributing factor to this higher growth rate of export in India.

### 5.3.2 Instability indices of production, area, productivity and export

The country-wise picture is composite in area, productivity, production and exports instability. Some countries witnessed higher instability while others experienced
a relatively low instability. The country wise instability rates, for all the study period, for export ranged from 7.94 per cent to 137.92 per cent, for area, it ranged from 2.01 per cent to 46.99 per cent, for production it ranged from 5.15 per cent to 51.64 per cent and for productivity, it ranged from 3.03 per cent to 23.86 per cent.

### 5.3.2.1 Production instability in the major cotton producing countries

During the overall study period (1980-81 to 2009-10), Australia recorded the highest degree of instability (47.07 per cent) in production followed by Brazil (36.21 per cent), India (20.02 per cent), USA (18.6 per cent), China (17.95 per cent) and Pakistan (15.82 per cent). In all the study periods except period IV (Pre-Bt introduction), Australia recorded the highest degree of instability in production indicating that Australia was the most unstable comparatively in cotton production.

In India, cotton production was comparatively stable among the major producing countries as instability in production was observed lowest in pre-liberalization period (1980-81 to 1993-94), pre-Bt introduction period (1995-96 to 2001-02), and post-Bt introduction (2002-03 to 2009-10), and it ranked third in overall study period (1980-81 to 2009-10) and fourth in post-liberalization period (1995-96 to 2009-10).

In overall study period (1980-81 to 2009-10), the lowest instability was observed in Pakistan followed by China, USA, India, Brazil and Australia.

### 5.3.2.2 Area instability in the major cotton producing countries

Australia recorded the highest degree of instability in area in all the study periods except period IV (pre-Bt introduction) in which it ranked second. This indicates among the major cotton producing countries, Australia was comparatively the most unstable country in allocation of area of cotton.

In area allocation, Brazil was also comparatively very much unstable as it ranked second in period I (overall study period), period II (pre-liberalization) and period V (post-Bt introduction), and first in period IV (pre Bt introduction).
Comparatively, the lowest instability in area was observed in Pakistan during all the periods except period IV (pre-Bt introduction), in which it was second lowest. This indicates that the allocation of land under cotton in Pakistan was comparatively stable over the periods.

It was also observed that the land allocation for cotton was comparatively more stable in India than that of the other major cotton producing countries except Pakistan as it ranked second lowest in all the period except period IV (pre-Bt introduction) in which it was first lowest.

During the overall study period (1980 to 2009), Australia recorded the highest degree of instability (46.99 per cent) in area followed by Brazil (27.13 per cent), USA (17.09 per cent), China (14.24 per cent), India (9.8 per cent) and Pakistan (5.57 per cent).

5.3.2.3 Productivity instability in the major cotton producing countries

During overall study period (1980-81 to 2009-10), Brazil recorded the highest degree of instability (23.86 per cent) in productivity followed by Pakistan (14.59 per cent), India (14.47 per cent), Australia (10.72 per cent), China (9.59 per cent) and USA (9.32 per cent). As Brazil was ranked first in instability in productivity in period I (overall study period) and IV (pre-Bt introduction), and it was also ranked second in period II (pre-liberalization) and III (post-liberalization), it can be concluded that Brazil was comparatively more unstable in productivity than the other major producing countries.

5.3.2.4 Exports instability in the major cotton producing countries

In overall study period (1980-81 to 2009-10), India recorded the highest degree of instability (136.59 per cent) in exports followed by China (112.92 per cent), Brazil (88.62 per cent), Pakistan (81.78 per cent), Australia (42.95 per cent) and USA (28.65 per cent). These results indicate that comparatively India is more unstable when it comes to export of cotton in the world.
China recorded highest degree of instability in export during period II (pre liberalization), III (post-liberalization) and IV (pre-Bt introduction) and during period I (overall study period), it was ranked second. This also indicates that there is unstable situation in export in China.

It was also observed that instability of export was lowest in USA during period I (overall study period), III (post-liberalization period) and V (post-Bt introduction) and it was also second lowest in period II (pre-liberalization) and IV (pre-Bt introduction). This implies that comparatively export of cotton from USA is more stable than that of the other major producing countries.

5.3.3 Decomposition analysis to measure the relative contribution of area and yield to the total cotton output change

During the overall study period (1980-81 to 2009-10), Australia (122.16 per cent) recorded the highest magnitude in area effect followed by USA (110.17 per cent), China (61.68 per cent), Brazil (52.15 per cent), India (33.94 per cent) and Pakistan (10.04 per cent). Whereas, in the same period (1980-2009), yield contribution was highest in India (71.01 per cent) followed by Pakistan (69.68 per cent), Brazil (39.82 per cent), USA (32.74 per cent), China (27.89 per cent), and Australia (6.37 per cent). Thus, during over all study period (1980-81 to 2009-10); the yield effect was lower than the area effect in Brazil, Australia, USA, and China. However, in Pakistan and India, it was the opposite, i.e. yield effect was higher than the area effect.

Similar results were found in all the study periods except in USA where yield effect was more than area effect during pre-Bt introduction period (1995-96 to 2001-02) and in China where area-yield interaction effect was higher as compared to other effects during post-Bt introduction period (2002-03 to 2009-10).

In all the study period, area effect, yield effect and area-yield interaction effect ranged from 2.30 per cent to 192.54 per cent, from 2.62 to 113.02 per cent and from -109.41 per cent to 39.54 per cent, respectively.
5.3.4 Correlation among production, export and price of cotton in the major cotton producing countries.

Among the major cotton producing countries, the correlation between production and export, production and price, and export and price ranged from -0.339 to 0.822, -0.267 to 0.033 and -0.26 to 0.322, respectively.

A positive and highly significant relationship between production and export was found in Australia (0.822), Brazil (0.775), India (0.7710) and USA (0.688). This implies that total export of cotton is determined by the production of cotton in Australia, Brazil, India and USA.

As far as production and world price relationship is concerned, though all the results were non-significant, a negative correlation was found in all the major producing countries except in USA. The negative relationship indicates that as production rises, the world prices falls. The positive relationship between production and world prices observed in USA suggests that even though world prices of cotton fell, USA still produced and exported large quantities. This could partly be due to the USA government cotton programs.

As far as the relationship between export quantity and world price is concerned, though all the result were found to be non-significant, a positive correlation was observed in India (0.137) and Australia (0.322). This indicates that as world prices rise, the export in these two countries also increases. A negative correlation was observed in Brazil (-0.132), China (-0.122), Pakistan (-0.26) and USA (-0.05). It is worth noting that even though USA and Brazil had a negative relationship between export quantity and world price, they are ranked first and third respectively in global export of cotton. This implies that even though world cotton prices fell, these two countries export was not affected by the price and so it did not fall. This may partly be due to their competitiveness in cotton export because of heavy domestic support (subsidies) given to their cotton farmers.
5.4 CONCLUSION AND POLICY IMPLICATIONS

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. In this study, an analysis on performance of cotton production and export in the major producing countries was done through comparison of compound growth rates and instability indices of production, yield, area and export. It can be seen from the results that growth rates and instability indices are different for each period from country to country. It is clear from the results that growth rate and instability performance was better in pre-liberalization period than under post liberalization period in some countries and vice versa in other countries. The main focus of liberalization was to enhance openness of agricultural trade (Free and fair trade) and competitiveness (by reducing subsidies). Further, the results clearly show that the growth rate and instability performance was better in pre-Bt cotton introduction than that of under post-Bt cotton introduction period in some countries and vice versa in other countries. In some other countries growth rate was almost similar in those two periods.

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 likely have a negative effect on per capita
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 programs using new efficient technologies. Further, developing and establishing the bio-technology programs should be intensified to develop high yield varieties of the crops suitable to the ever changing agro-climate conditions due to global warming.

Generally, it was found that production and export have a positive and significantly relationship. This implies that exports from the major cotton producing countries are dependent on production.

It was also found that production and price had inverse relationship. Though the results were non-significant, it is said supply decides price. Therefore, for taking proper export decisions, it is imperative for the governments and the market institutions to provide well timed information about production projections of the competitive countries to the stakeholders of cotton industry.

As far as further research is concerned, it could include the demand side (consumption) of cotton in the world as this study only focused on the supply side (production). Further research could also extend to other cotton resultant activities of cotton production such as cotton yawn, cotton seed oil and cake industries.
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