Journal of Crop and Weed 8(1): 95-97 (2012)

Input use and technological change in cotton cultivation in different states of India

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Received: 04.11.2011, Revised: 25.03.2012, Accepted : 25.05.2012

ABSTRACT

The nature of input use in cotton cultivation saw a change during the transition from traditional to hybrid cotton in the country. The paper attempts to evaluate the extent of technological change in cotton cultivation through the detailed computation of total output indices, total input indices and total factor productivity indices (TFP) along with the major factors determining the change in productivity of cotton over a decade (1996-97 to 2006-07) across the major cotton growing states in India. For computation of total factor productivity (TFP) of cotton, Theil-Tornqvist discrete approximation to the Divisia index: a superlative to linear homogeneous trans-logarithmic production function was used for aggregation of all the factors of production in cotton cultivation for the seven major cotton growing states of India over the period under study. The cost of cultivation data of the respective states have been used for the entire computation and estimation. The paper highlights the fact that fertilizer use in cotton has become the prime contributor over the change in productivity level across most of the states in India. Farm mechanization and water use have become the key factors in Maharashtra, a traditional cotton belt for the overall change in productivity. Variation in input use and its nature explaining the insignificant growth in TFP indices will be important information for the industry in its marketing strategies and for the planners to identify the input support limiting to the cultivators.

Key words: Cost of cultivation, cotton, farm mechanization, total factor productivity

Cotton is an important fibre producing cash crop in India. In terms of acreage and fibre production in our country share of cotton are 89.53% and 54.91%, respectively among fibre producing crops. It covers an area of 8677.1 thousand hectares of land with an annual production of 18499.0 thousand bales cotton and average yield of 362.0 kg ha^{-1} (Anon., 2007a and 2007b). Andhra Pradesh, Gujarat, Haryana, Karnataka, Maharashtra, Madhya Pradesh and Punjab are the seven major cotton growing states taken into consideration, covering around 92.0% of total acreage and 93.0% of total production in India (Anon., 2009). There had been a shift in the cotton cultivation with a switchover to hybrid cotton at the turn of the millennium. There has been a gradual departure of input use pattern across cotton growing states during this period. The package of practices from seed to harvest is largely different in the traditional cotton cultivation and hybrid cotton. The present study tends to capture the input mobilization pattern underlying technological change across the major cotton growing states in India over this transition and justifying the period 1996-97 to 2006-07 for the study.

MATERIALS AND METHODS

Computation of Technological Change in Cotton Cultivation

To evaluate the technological advancement in cotton cultivation across the major cotton growing states in India, Theil-Tornqvist discrete approximation to the Divisia index: a superlative to linear homogeneous trans-logarithmic production function as proposed by Diewert (1976) was used for the aggregation of all factors of production in cotton cultivation for over the period under study (1996-97 to 2006-07). Output data of cotton for different states have been collected from Statistical Abstract India 2009-10 while input data has been gathered from Cost of Cultivation of Principal Crops in India 2007 edition.

The total output, total input and TFP indices are computed as:

Total Output Index (TOI)

$$TOI_{t-1} = \prod_j \left(\frac{Q_{jt}}{Q_{jt-1}} \right)^{\frac{1}{2}\left(S_{jt}+S_{jt-1}\right)}$$

Total Input Index (TII)

$$TII_{t-1} = \prod_i \left(\frac{X_{it}}{X_{it-1}} \right)^{\frac{1}{2}\left(S'_{it}+S'_{it-1}\right)}$$

where, S_{jt} = share of j^{th} crop in t^{th} year

S_{jt-1} = share of j^{th} crop in $t\text{-}1^{th}$ year

S'_{it} = share of i^{th} input in t^{th} year

S'_{it} = share of i^{th} input in $t\text{-}1^{th}$ year

Q_{jt} = Output of j^{th} crop in t^{th} year

Q_{jt-1} = Output of j^{th} crop in $t\text{-}1^{th}$ year

Total Factor Productivity Index (TFPI)

In general, Total Factor Productivity at t^{th} year is measured by

$TFP_t = (TOI_t / TII_t)$ = Aggregate Output / Aggregate Input

Here, TFPI = Tornqvist Aggregate Output Index / Tornqvist Aggregate Input Index

For the productivity measurement over a long period of time, Output, Input and TFP indices are computed

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on the basis of "Chain Base Index" expressed as percentages. With chain-linking, an index is calculated for two successive periods t and (t-1) over the whole period t_0 to T, (sample from t=0 to t=T) and the separate indexes are then multiplied together:

TOI* (t) = TOI (1). TOI (2).....TOI (t-1)

Similarly, TII* (t) = TII (1). TII (2).....TII (t-1)

Total Factor Productivity Index (TFPI)

$TFP_t = (TOI^*_t / TII^*_t)$

Exponential trend in growth of TOI, TII and TFPI have been attempted with the help of logest estimates with following functional form

The equation for the estimated exponential curve is

$$Y = ae^{bx}$$

where the dependent Y-value is a function of the independent x-values.

Factors affecting change in productivity of cotton over decade

To identify the key factor/s responsible for the overall change in productivity of cotton over the period under study, step-wise multiple linear regression model of Y on X_1, X_2, X_3....X_n has been framed with the following functional form:

$$Y = b_0 + b_1X_1 + b_2X_2 + \ldots\ldots\ldots b_nX_n + e_i$$

Where Y= productivity of cotton, b_0 = constant, X_1.....X_n various factors of production responsible for productivity change in cotton, e_i = error term

RESULTS AND DISCUSSION

Earlier, Agarwal and his co-workers (2007-08) while measuring the TFP of cotton over major cotton growing states of India have came into conclusion that there is a declining feature of TFP cotton in Haryana due to over mechanization, stagnant yield and high input costs while Rajasthan, Maharashtra, Gujarat and Madhya Pradesh have registered higher TFP index which features more or less similar to my present study. Table- 1 views that the state Punjab has recorded the highest significant total output index (TOI) growth rate (14.66%) followed by Madhya Pradesh (13.30%), Andhra Pradesh (8.02%) and Maharashtra (7.58%). Gujarat and Haryana have registered remarkable change in input use of cotton over the year. The technological change in cotton cultivation was robust in the state of Punjab (TFP growth rate 11.64%), Andhra Pradesh (8.68%) and Maharashtra (8.05%). Other states possess insignificant growth rates in TFP.

Table 1: State-wise TOI, TII and TFP growth rates of cotton over 1996-97 to 2006-07

States	TOI	Growth rate (%)	TII	Growth rate (%)	TFPI	Growth rate (%)
Andhra Pradesh	$Y = 88.78e^{0.08x}$ $R^2 = 0.52$	8.02*	$Y = 107.51e^{-0.01x}$ $R^2 = 0.01$	-0.61	$Y = 82.58e^{0.08x}$ $R^2 = 0.59$	8.68*
Gujarat	$Y = 48.02e^{0.13x}$ $R^2 = 0.36$	14.43	$Y = 79.09e^{0.08x}$ $R^2 = 0.70$	8.00*	$Y = 60.72e^{0.06x}$ $R^2 = 0.15$	5.95
Haryana	$Y = 81.29e^{0.05x}$ $R^2 = 0.30$	5.65	$Y = 95.14e^{0.05x}$ $R^2 = 0.62$	4.64*	$Y = 85.44e^{0.01x}$ $R^2 = 0.02$	0.97
Karnataka	$Y = 112.18e^{-0.06x}$ $R^2 = 0.19$	-5.64	$Y = 128.88e^{-0.04x}$ $R^2 = 0.25$	-4.16	$Y = 87.04e^{-0.02x}$ $R^2 = 0.05$	-1.54
Maharashtra	$Y = 105.33e^{0.07x}$ $R^2 = 0.55$	7.58*	$Y = 103.44e^{-0.004x}$ $R^2 = 0.10$	-0.44	$Y = 101.82e^{0.08x}$ $R^2 = 0.62$	8.05*
Madhya Pradesh	$Y = 52.97e^{0.12x}$ $R^2 = 0.48$	13.30*	$Y = 74.36e^{0.06x}$ $R^2 = 0.37$	6.13	$Y = 71.23e^{0.07x}$ $R^2 = 0.25$	6.76
Punjab	$Y = 66.34e^{0.14x}$ $R^2 = 0.84$	14.66*	$Y = 86.34e^{0.03x}$ $R^2 = 0.38$	2.71	$Y = 76.83e^{0.11x}$ $R^2 = 0.81$	11.64*

*Note: * Significant at 5% level of probability*

Table-2 highlights the major factors contributing the overall changes in productivity of cotton across different cotton growing states of India. It has been registered that the fertilizer use in cotton has become the major contributor for the overall change in productivity in the states of Gujarat, Karnataka and Madhya Pradesh. Optimum use of irrigation as well as farm mechanization over the last decade in Maharashtra was largely instrumental in the massive improvement of total factor productivity (8.05%) over the year studied. Use of improved seed replacing older cultivars variety has been viewed to raise the productivity level prominently in Haryana. The growth in cotton has happened despite human labour being the predominant form in Haryana, while in Punjab the regression analysis shows that a change is in process from human labour towards mechanization. Largely speaking, across the states, the fertilizer use has been the single most important contributor heralding the growth in cotton cultivation. FYM has been recorded as a major contributor to productivity in Andhra Pradesh with the farmers favouring a shift towards organic use in cotton cultivation in many places.

Table 2: Step-wise regression model on productivity of cotton with various input use

States	Regression equation	Included Variables	Excluded Variables
Andhra Pradesh	$Y = 776.712-6.505 X_1+5.055 X_2$	Bullock labour (X_1), Organic manure (X_2)	Seed quantity, Fertilizer quantity, Irrigation charges, Machine labour, Human labour
Gujarat	$Y = -306.692+7.193 X_1$	Fertilizer quantity (X_1)	Seed quantity, Organic manure, Irrigation charges, Machine labour, Bullock labour, Human labour
Haryana	$Y = 529.928+0.503 X_1 - 41.381 X_2$	Human labour (X_1), Seed quantity (X_2)	Fertilizer quantity, Organic manure, Irrigation charges, Machine labour, Bullock labour
Karnataka	$Y = 82.001+1.901 X_1$	Fertilizer quantity (X_1)	Seed quantity, Organic manure, Irrigation charges, Machine labour, Bullock labour, Human labour
Maharashtra	$Y = 91.143-0.389 X_1+0.367 X_2$	Irrigation charges (X_1), Machine labour (X_2)	Seed quantity, Fertilizer quantity, Organic manure, Bullock labour, Human labour
Madhya Pradesh	$Y = 22.986+1.837 X_1$	Fertilizer quantity (X_1)	Seed quantity, Organic manure, Irrigation charges, Machine labour, Human labour
Punjab	$Y = -478.424+3.826X_1+0.646 X_2+0.044 X_3$	Fertilizer quantity (X_1), Human labour (X_2), Machine labour (X_3)	Seed quantity, Organic manure, Irrigation charges, Bullock labour

The study clearly indicates the states of deficit use of certain inputs which needs to be addressed by the Industry and the Government. Seed use and the choice of varieties have been reportedly undergoing a strong change favouring BT use and here the increased yield calls for more input investment and more so as to the organics in the era of sustainable agriculture. There had been notable changes underlying the growth and technological change with respective states giving more stress to fertilizer use, improved seeds and irrigation in this transition period. Farm mechanization shifts will be further necessary to cut down operational costs. The study also, in effect, helps to understand the limiting factors in the respective states which will planners to identify their priorities.

ACKNOWLEDGEMENT

For preparing the entire research study and manuscript on the economics of cotton cultivation, The DES, Ministry of Agriculture, Govt. of India is duly acknowledged.

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