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An analysis of total factor productivity of cotton in Tamil Nadu

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ABSTRACT

Cotton, popularly called as "white gold" is a leading commercial crop grown world over for its valuable fibre. India has become the global leading grower and largest producer of cotton. However, the growth rate in area, production and yield in the current decade has registered a reduced growth rate. Hence it necessitates a study to analyse the factors responsible for such changes. The 'Total Factor Productivity' (TFP) approach is considered as suitable tool to examine the growth in agricultural productivity and to separate out the effect of inputs and other factors like technology, infrastructure etc., on productivity growth. The study utilizes Tornqvist – Theil index for calculation of total factor productivity. Time series data from various published sources were collected for the period 1970 to 2017-18. The results have shown a declining trend in growth of Total Input Index, Total Output Index and TFP. Declined growth of TFP indicated the negative impact of technological changes on cotton. The study has suggested for more research and policy measures to impede the declining trend in TFP of cotton in the state.

***Key words**: TFP, Bt Cotton, Cost of cultivation, Tornqvist – Theil index*

Introduction

India has become the largest grower of cotton accounts for 36 % of the global cotton area and contributes to 25 % of the cotton production. In our economy, cotton plays an important role as the textile industries are predominantly cotton based. The textile industries in India shares around 5 per cent to gross domestic product (GDP) and 11 per cent to exports earnings. After agriculture, it is the second-largest employer in the country, by providing employment to over 51 million people directly and 68 million people indirectly. (India Trade Portal, GOI). Furthermore, empirical studies in India have shown that increased cotton production resulted in increased women's labour opportunities, thereby contributing to poverty reduction (Subramanian, 2011).

In India most of the cotton growing area comes under rainfed area and majority of the farmers were resource poor. In order to give more importance to cotton sector and improving the cotton yield on par with world average productivity, Government of India launched Technology Mission on Cotton during 2000. It was initiated mainly to improve the yield and quality of cotton, particularly in respect of staple length, micronaire, strength, etc. through development of better cotton varieties thereby increasing the income of the cotton growers by reducing the cost of cultivation. In the year 2002, Monsanto has introduced Bt cotton in India. Many farmers in

India attracted towards Bt cotton since it was introduced mainly to control pink boll worm which was a great menace in cotton cultivation. Thereby it reduces the expenditure towards pesticides and increases the net returns in cotton cultivation.

From 2002 to 2011, the area under cotton hybrids popularly called as Bt cotton rose from 2% in North India and 40% elsewhere to 96% across the country. But the success of Bt cotton didn't continued after 2011 since the pink boll worm has developed resistance against bt cotton. Production and productivity of bt cotton has also started to fall. This necessitates a study which identifies the factors behind the yield loss of cotton. This study is undertaken with the objective of analyzing the changes in area, production and yield over the years at both the state and country level. Tamil Nadu was purposively selected for the study since the reduction in yield during 2017-18 was comparatively higher when compared to yield level of 2010-11. The study also analyses the changes in cost of cultivation and Total Factor Productivity (TFP) in Tamil Nadu while sorting out the reasons for reduced productivity.

Materials and Methods

Compound Growth Rate

After the introduction of hybrids in 1970's there was lot of changes in cotton area, production and productivity. In order to derive the compound growth rates, the log linear function was applied. Time series data on cotton area, production and productivity from various published sources were collected for the period 1970 to 2017-18 and compound growth rates (CGR) were find out.

The compound growth rate was estimated using log linear model viz.,

$Y = e^{a+bt}$

$\ln Y = \ln a + b \ln t$

Where Y= Area/production/yield of a crop for the year 't'.

(b is a slope of fitted linear curve, a is an intercept and t- time trend, 1, 2……n)

Ordinary Least Square Estimation

In the present study, ordinary least square estimation function was employed to study the influence of various inputs over cotton returns. Various inputs of cotton production were regressed with cotton gross returns for the period 1970 to 2017-18 and the equation is given below

GRC = a + b1 S + b2 FYM + b3 ML +b4 HL + b5 FERT + b6 PPC + IRRI

Where

GRC= Returns from cotton

a=intercept

S = Seeds

FYM = Manures

ML = Machine labour

HL = Human labour

FERT = Fertilisers

PPC = Plant protection chemicals

IRRI = Irrigation charges

Tornqvist-Theil TFP indices

Tornqvist-Theil TFP indices were used to compute Total Factor Productivity of cotton. The Tornqvist-Theil index is a superlative index, which is exact for the linear homogeneous translog production function (Diewert, 1981). It is a superior index for calculation of total factor productivity (TFP) index (Rosegrant and Evenson, 1995). Expressed in logarithmic form, the Tornqvist-Theil index is given by the following equation

Ln (TFPt/ TFPt.1) = In (O/Ot.l) - % D (Cit+ Cn.l) In (Xi/ X n.l)

Where 0t = output of cotton in year't'

Ci = Share of input 'i' in total input cost

Xit = Input 'i' in year 't'

Specifying the index equal to 100 in a particular year and accumulating the measure based on above equation provides the TFP index

Results and Discussion

Decadal changes in cotton area, production and yield in India

In recent years, cotton scenario in India has dramatically changed. As a result of the developmental initiatives in the form of Technology Mission on Cotton (TMC) and the introduction of Bt cotton during 2002 cotton area has increased from 76.05 lakh ha in 1970–71 to 124.29 lakh ha in 2017-18 and production from 56.64 lakh bales in 1970-71 to 370 lakh bales in 2017-18 (Table 1).

Similarly, the productivity of cotton in India has been increasing despite the major cotton growing areas remaining still under rainfed conditions. As against world average of 647 kg lint/ha, India's productivity was only 186 kg lint/ha during 2001-02.

Table 1. Area, Production and Yield of Cotton in India

Year	Area (lakh ha)	Production (in lakh bales of 170 kgs)	Yield (Kg/ha)
1970-71	76.05	56.64	127
1980-81	78.23	78.00	169
1990-91	74.39	117.00	267
2000-01	85.76	140.00	278
2009-10	103.10	305.00	503
2017-18	124.29	370.00	506

Source: Cotton Corporation of India

But from the year 2005-06 the productivity increased substantially. Thereafter the gap between world and India in productivity is reducing. The gap which was 461 kg lint per ha during 2001-02 reduced to 97 kg lint per ha during 2017-18 (Table 2).

Table 2. Productivity Gap (Kg/ha)

Year	India	World	Gap
2001-02	186	647	(-) 461
2005-06	362	734	(-) 372
2009-10	502	768	(-) 266
2017-18	506	603	(-) 97

Source: Cotton Corporation of India

Productivity in several cotton growing states in India is well above the world average. The average yield of Gujarat, Tamil Nadu, and Andhra Pradesh are equal with world average, ranging from 600 to 800 kg lint per ha (Cotton Corporation of India, GOI).

All India compound growth rate for area, production and yield of cotton from 1971-80 to 1991-2000 are indicative of the fact that during past decades, production and yield have increased by more than 2% per annum (Table 3) with a comparatively less growth in area. At early stages, the improvement in production and productivity seems to be the result of dissemination and adoption of improved technologies as there was practically very little increase in the cotton area. During 1991 to 2000 there was a significant increase in area at the rate of 2.21 % with growth rate of 4.63% in production and with decrease in yield. The TMC period i.e 2001-2010 revealed 2.9 % growth rate in cotton area but the growth in production and yield increased tremendously to 10.78 % and 7.54 % respectively. But the growth rate has not sustained in recent years. The negative growth rate in production and yield of cotton despite increase in area necessitates an analysis on factors inducing such changes.

Table 3. Decadal Growth rate in India (% per annum)

Year	Area	Production	Yield
1971-80	0.53	2.42	1.92
1981-90	-0.96	3.15	4.15
1991-2000	2.21	4.63	2.37
2001-2010	2.94	10.78	7.54
2011-18	0.39	-0.06	-0.44

Source: Own estimation from secondary data

State wise cotton scenario

The states of Gujarat, Maharashtra, Andhra Pradesh, Telengana, Haryana, Punjab, Madhya Pradesh, Rajasthan, Karnataka and Tamil Nadu are the major cotton producing states in India (Table 4).

With the growing exception of Punjab, Karnataka, Madhya Pradesh and Tamil Nadu, the area under cotton has increased in all the states with the significant increase in Gujarat, Andhra Pradesh and Maharashtra.

From the Table 5 it could be seen that the cotton production has increased to larger extent in Gujarat, Maharashtra and Andhra Pradesh.

State wise Productivity of cotton is given in (Table 6). It has shown a sharp increase in Gujarat, Andhra Pradesh and Tamil Nadu. The average productivity of cotton in Tamil Nadu during 2000-01 and 2010-11 was the highest of all the cotton growing states in India.

But during the current decade, although area has shown a tremendous increase, production and yield has recorded a negative rate of growth (Table 7).

Changes in cost of cultivation of Cotton in Tamil Nadu

Cost of cultivation is considered to be an important factor in deciding the changes in area, production and productivity of a crop. Inorder to analyse the factors responsible for such changes in Tamil Nadu, cost of cultivation of cotton is taken for the years 1980-81 to 2016-17. It has been seen from the Table 8 that of all the factors the share of human labour in the total cost of cultivation has increased tremendously whereas the share of plant protection chemicals has reduced from 4.44 per cent in 1981-90 to 2.73 per cent in 2011-18. The share of variable cost in total cost has increased from 70.71 per cent in 1981-

Table 4. State wise cotton area (lakh ha) from 1970-71 to 2017-18

State	1970-71	1980-81	1990-91	2000-01	2010-11	2017-18*
Punjab	3.97	6.48	7.01	5.5	5.30	2.91
Haryana	1.93	3.17	4.9	5.8	4.92	6.69
Rajasthan	2.25	3.57	4.55	4.82	3.35	5.84
Gujarat	15.82	15.72	9.21	15.78	26.33	26.23
Maharashtra	28.12	26.67	27.3	27.93	39.32	42.07
M.Pradesh	6.92	5.95	6.08	5.57	6.50	6.03
Telengana						18.97
A.Pradesh	3.16	4.19	6.55	8.87	17.84	6.44
Karnataka	9.95	9.56	5.96	5.35	5.45	5.46
Tamil Nadu	3.11	2.23	2.39	1.33	1.22	1.85
Others	0.83	0.7	0.44	0.53	1.09	1.95
Total	76.05	78.23	74.39	81.48	111.42	124.44

*Estimate Source: Cotton Corporation of India

Table 5. State wise cotton production (lakh bales) from 1970-71 to 2017-18

State	1970-71	1980-81	1990-91	2000-01	2010-11	2017-18*
Punjab	8.19	11.78	17.25	9.5	18.50	11.50
Haryana	3.53	6.5	11.5	10	17.00	22.50
Rajasthan	2.29	3.88	9.5	10.8	10.10	22.00
Gujarat	15.71	17.14	15	23.8	106.20	104.00
Maharashtra	4.82	12.69	15	18.3	87.75	85.00
M.Pradesh	2.1	2.68	16	19.3	17.70	20.50
A.Pradesh	0.78	7.5	18.75	25.3	59.50	20.50
Telengana						55.00
Karnataka	3.43	4.69	8	7.75	11.10	18.00
Tamil Nadu	3.45	2.65	5	5.5	7.20	5.50
Others	0.68	0.6	1	1	4.05	5.50
Total	44.99	70.1	117	131.25	339.10	370.00

*Estimate Source: Cotton Corporation of India

Table 6. State wise cotton productivity (kg/ha) from 1970-71 to 2017-18

State	1970-71	1980-81	1990-91	2000-01	2010-11	2017-18*
Punjab	371	309	611	355	593	672
Haryana	329	349	470	337	587	572
Rajasthan	184	185	366	406	513	640
Gujarat	179	185	227	290	686	674
Maharashtra	31	81	78	145	379	343
Madhya Pradesh	55	77	255	534	463	578
Andhra Pradesh	45	304	456	498	538	541
Telengana						493
Karnataka	62	83	258	286	346	560
Tamil Nadu	199	202	370	703	1003	505
Others	106	152	263	319	1030	680
Average	127	169	267	278	517	506

*Estimate, Source: Cotton Corporation of India

Table 7. Decadal growth rate in Tamil Nadu (% per annum)

Year	Area	Production	Yield
1971-80	-0.45	3.49	3.28
1981-90	1.63	7.36	5.62
1991-2000	-2.84	0.04	2.63
2001-2010	-4.95	0.88	6.17
2011-18	4.58	-3.38	-7.75

90 to 76.29 per cent in 2011-18. Over the years, gross returns from cotton cultivation has increased from Rs 7180/ha to Rs. 78928 / ha. But the net return in cotton cultivation has reduced from Rs 1106/ ha in 1981-90 to only Rs 263/ha in 2011-18. Increase in cost of cultivation of cotton over the years leads to decline in net returns.

The results presented in the Table 9 showed an R square value of 0.97, which meant that 97 per cent of the variation in the dependent variable (Cotton output value) was explained by the given independent variables (inputs). The variables such as human labour and fertilisers are statistically significant at one- percent level and had the positive influence over the gross returns. Whereas .irrigation charges which was statistically significant at one- percent level have negative influence over returns since dry land cotton cultivation is predominant in India. The variable machine labour has positive influence over cotton returns and it was significant at five per cent level. The inputs seed and manure application doesn't have significant influence over cotton returns. The influence of other factors over cotton cultivation was studied by analyzing the TFP.

Total Factor Productivity of cotton

In order to measure the technological interventions on cotton production in India, Total factor produc-

Table 8. Decadal Changes in cost of cultivation of Cotton in Tamil Nadu (Rs/hectare)

Year Variable cost	1981-90	1991-2000	2001-2010	2011-18	Overall
Human labour	1860.11(29.13)	7882.41(40.39)	13969.41(39.58)	38909.22(49.41)	13769.83(38.83)
Animal Labour	252.69(4.56)	358.75(1.87)	778.36(2.37)	470.45(0.56)	464.62(2.48)
Machine labour	181.31(3.05)	666.87(3.30)	1851.92(5.08)	4078.60(5.32)	1501.38(4.09)
Fertiliser	504.67(8.39)	1432.45(7.44)	3109.01(8.72)	6701.15(8.59)	2631.61(8.26)
Organic manure	66.34(1.09)	263.92(1.29)	1051.13(2.80)	2412.79(2.97)	829.82(1.96)
Seeds	143.32(2.50)	361.34(1.82)	1504.20(4.31)	3063.85(3.87)	1122.58(3.06)
Irrigation	507.08(8.65)	633.17(3.50)	885.49(2.62)	969.30(1.26)	730.88(4.23)
Plant protection chemicals	264.90(4.44)	985.55(4.87)	1255.86(3.64)	2175.24(2.73)	1088.92(4.02)
Interest on working capital	529.13(8.90)	802.78(5.07)	522.66(1.47)	1239.67(1.57)	735.77(4.47)
Fixed cost	1764.45(29.29)	6108.75(30.44)	10134.29(29.41)	18644.92(23.71)	8394.31(28.58)
Variable cost	4309.56(70.71)	13387.24(69.56)	24928.04(70.59)	60020.27(76.29)	22875.41(71.48)
Total cost	6074.00	19495.99	35062.33	78665.19	31269.72
Gross returns	7180.29	19905.82	35401.44	78928.71	31820.99
Net returns	1106.29	409.83	339.11	263.52	551.27

Note: Figures in parenthesis indicates percentage to the total

Table 9: Determinants of Gross Returns in Cotton

Particulars	Coefficients	Standard Error	t Stat	P-value
Intercept	9002.93	2272.64	3.96	0.000
Seeds	-0.14	2.38	-0.06	0.952
Manures	-2.19	1.97	-1.11	0.277
Machine labour	3.93*	1.78	2.21	0.035
Human labour	0.70**	0.25	2.78	0.009
Fertilisers	6.89**	1.87	3.68	0.001
Plant protection	-1.58	2.19	-0.72	0.476
Irrigation Charges	-9.76**	2.98	-3.28	0.003

R Square: 0.97

**- Significant at one per cent level/ *- Significant at five per cent level

tivity (TFP) analysis is used. TFP analysis is an attempt to measure the amount of increase in the total output, which is not accounted for by increase in total inputs. There is a large residual, measured by total factor productivity, which is the contribution of improvement of technology, infrastructural developments, human capital improvement and policy interventions. Total factor productivity relates output to all inputs simultaneously. The changes in total factor productivity indices over a substantially long period of time indicate the role of technology in increasing resource use efficiency.

To measure TFP, the farm level data relating to input costs (Rs/ha) and returns were collected from the Reports of Commission for Agricultural Costs and Prices (CACP) published by Ministry of Agriculture, New Delhi. Total input, output and productivity indices were worked out using Tornquist-Theil indexing procedure.

TFP in Tamil Nadu

The Total factor productivity (TFP) of cotton in Tamil Nadu is presented in Table 10. The result revealed that the Total Input Index (TII) of cotton in Tamil Nadu has been stagnating and ranges from 1.79 in 1981-90 to -1.57 in 2011-18. As far as the Total Output Index (TOI) of cotton is concerned, the average index was 2.04 during 1981-90 but it turns to a positive value of 1.53 in the decade 2001-2010. Higher output growth than input growth in the decade 2001-10 to 2017-18 led to positive TFP. After the year 2010-11, the average value of TOI has shown a negative value (-2.43). Total Output Index (TOI) was not increasing appreciably because of lower productivity. Although TFP index was positive during the period 1981-90 and 2001-2010 and thereafter the Index has shown negative growth owing to higher cost of input resulting in a decrease to - 0.88 in 2011-18. This analysis indicated the inefficiency in the usage of resources, especially in the period 2010 -11 to 2017-18.

Table 10. Growth rate of TFP Indices of Cotton in Tamil Nadu

Year	TII	TOI	TFP
1981-90	1.79	2.04	0.24
1991-2000	-0.77	-1.49	-0.73
2001-2010	0.80	1.53	0.72
2011-18	-1.57	-2.43	-0.88
Overall	-0.06	-0.10	-0.03

Source: own estimation from secondary data

Conclusion

In India, small land holdings, high level of pest incidence especially pink boll worm resistance, indiscriminate use of pesticides, high cost of cultivation due to higher hybrid seed cost and lack of Integrated Pest Management (IPM) are considered to be important reasons which hinders farmers in cotton cultivation. The results of the study indicated declined growth of TFP in the recent years which announced the negative impact of technological changes on cotton production. Besides, higher input growth (TII) than output growth (TOI) resulted into negative TFP growth thus indicates the resource use inefficiency in cotton. The study has suggested for more research and policy measures to impede the declining trend in TFP of cotton in the state. A technology that can reduce cost of cultivation and give returns to the farmers are in need of the hour.

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