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Estimation of Total Factor Productivity and its Determinants of Maize in Telangana State

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ABSTRACT

Total factor productivity (TFP) growth and its determinants of maize in Telangana state was estimated from 2000-01 to 2012-13 using parametric approach. The data on the quantity and price of the output of rice and various inputs were collected from the published documents of the "Cost of Cultivation of Principle Crops" scheme of Government of India. The data on the variables like government expenditure on agricultural research, extension and education was collected from the office of the Accountant General of the Government of Telangana, Hyderabad. Other required data were collected from various published documents of the Directorate of Economics and Statistics, Hyderabad. The study revealed that there was 51% improvement in the TFP of maize in Telangana state in 2012-13 when compared to the base year (2000-01) with an annual compound growth rate of 3.5%. Average rainfall in the state and percentage irrigated area under the crop were found to be the most important drivers of TFP growth of maize in the state with regression coefficients of 0.606 and 0.034 respectively. Governments' expenditure on agricultural research, extension and education were also found to be positively influencing the TFP growth.

Keywords: Total factor productivity (TFP), Tornqvist indices, parametric approach, maize productivity, Telangana state

Maize is one of the most important crops cultivated in the Telangana state with almost 13% share in the gross cropped area in the year 2014-15 with production of 23.08 lakh tonnes in the same year (32% of the total foodgrains production). The percentage share of maize in gross cropped area in Telangana has significantly increased in the last decade. The state gained significantly in the production of food grains during and post the green revolution period. This achievement was brought out through the faster spread of modern varieties (MVs) and inputs intensification (Suresh, 2013). The high yielding production technologies recommended during the period of green revolution created some serious problems like nutrient imbalances caused by the huge application of nitrogenous fertilisers, depletion of soil micro-nutrients, over-exploitation of groundwater, degradation of land, more frequent emergence of pests and diseases, and the diminishing returns to inputs (Chand *et al.* 2011). Disparities among different regions also have become a concern to the policymakers of the country (Sripoorni and Manonmani, 2014). It was felt that the potential of green revolution technologies has reached its limits and it was not able to sustain the future growth in Indian agriculture (Chand *et al.* 2012). Significant TFP growth in the Indian crops sector was produced by investments, primarily in research but also in extension, markets, and irrigation (Rosegrant and Evenson, 1995). The production of the crop in Telangana has reached a level of near stagnation in the recent past. With this background there was a need to calculate the growth of TFP of maize and its determinants in the state.

MATERIALS AND METHODS

Total factor productivity (TFP) is the portion of

output not explained by the amount of inputs used in production. Growth in TFP is therefore the growth rate in the total output less than the growth rate in the total inputs (Rosegrant and Evenson, 1995). As such, its level is determined by how efficiently and intensely the inputs are utilized in production. The calculation of TFP in a multi-product and multi-input situation raises many conceptual and computational issues (Reddy, 1997). There are many methods documented in literature for the calculation of TFP (Christensen, 1975; Coelli *et al.* 2005). Tornqvist index is a superior index for the calculation of total factor productivity (TFP) index (Rosegrant and Evenson, 1995).

Estimation of the total factor productivity for the state of Telangana was based on the data of thirteen years starting from 2000-01 to 2012-13. The entire state of Telangana was classified into three different sub-divisions each comprising of three districts. The three sub-divisions are as follows, northern Telangana (Adilabad, Nizamabad and Karimnagar), central Telangana (Medak, Rangareddy and Warangal) and southern Telangana (Khammam, Mahaboobnagar and Nalgonda). The total value of the output of maize was derived by summing up the values of the main product and the by-product in rupees. This gross value of the output was then divided by the area under maize to get the price of the product. The selected inputs of production for the present study were family human labour (in hours), paid human labour (in hours), animal labour (in hours), machine hours, seeds (in kg.), nitrogen fertiliser (in kg.), phosphorous fertilizer (in kg.), potassium fertiliser (in kg.), farm yard manure (FYM) (in quintals), insecticide and irrigation machine (in hours). The data were collected for the period of 2000-01 to 2012-13 from the published documents of the Comprehensive Scheme on the Cost of Cultivation of Principal Crops in India. The district as well the state level data were compiled from the unit level data from the Cost of Cultivation Scheme. The time series data from 2000-01 to 2012-13 on the variables like average rainfall in state, crop wise irrigated area in the state and rural literacy rate (%) were collected from various statistical year books published by the Directorate of Economics and Statistics, Government of Telangana, Hyderabad. Data on the government expenditure on agricultural research, education and extension was collected from the office of the Accountants General, Government of Andhra Pradesh and Telangana.

The Divisia-Tornqvist index or translog index was used in this study for computing the total output, total input, and TFP indices. The total output, total input and TFP indices have been calculated as under,

Total Output Index (TOI),

$$\frac{TOI_t}{TOI_{t-I}} = \Pi_j \left(\frac{Q_{jt}}{Q_{jt-1}} \right)^{\left(R_{jt}+R_{jt-1}\right)^{\frac{1}{2}}} = A_t \qquad \ldots 1$$

Or,

$$\ln\left(\frac{TOI_t}{TOI_{t-I}}\right) = 1/2\Sigma_j \left(R_{jt}+R_{jt-1}\right)\ln\left(\frac{Q_{jt}}{W_{jt-1}}\right) \qquad \ldots 2$$

Total Input Index (TII),

$$\frac{TII_t}{TII_{t-2}} = \Pi_i \left(\frac{X_{it}}{X_{it-2}} \right)^{\left(S_{it}+S_{it-1}\right)^{1/2}} = B_t \qquad \ldots 3$$

Or,

$$ln\left(\frac{TII_t}{TII_{t-1}}\right) = 1/2\Sigma_i \left(S_{it}+S_{it-1}\right) ln\left(\frac{X_{it}}{X_{it-1}}\right) \qquad \ldots 4$$

Where,

R_{jt} is the share of jth crop output in total revenue in year t,

Q_{jt} is the output of jth crop in year t,

S_{it} is the share of input ith the total input cost in year t, and

X_{it} is the quantity of input i in year t.

For the productivity measurement over a long period of time, chaining indices for successive time periods is preferable (Kumar *et al.* 2008).

Total Output Index (TOI) and Total Input Index (TII) for the year t computed from Equations (5) and (6) is as follows:

$$\text{TOI (t)} = \text{TOI}_1\ \text{TOI}_2 \ldots\ldots\ldots\ldots \text{TOI}_{\text{t-1}} \qquad \ldots 5$$

$$\text{TII (t)} = \text{TII}_1\ \text{TII}_2 \ldots\ldots\ldots\ldots \text{TII}_{\text{t-1}} \qquad \ldots 6$$

The Total Factor Productivity (TFP) index is given as

$$\text{TFP}_t = \{\text{TOI (t)} / \text{TII (t)}\}$$

$$= 1/2\Sigma_j \left(R_{jt} + R_{jt-1}\right) ln\left(\frac{Q_{jt}}{Q_{jt-1}}\right)$$

$$-1/2\Sigma_j \left(S_{it} + S_{it-1}\right) ln\left(\frac{X_{it}}{X_{it-1}}\right) \quad \ldots 7$$

For constructing TFP index, chain index is preferred to the fixed base index (Coelli *et al*. 2005). Chain index combines the annual changes in productivity to measure changes in productivity over a period of time. In other words, let I (t+1, t) be an index for the period t+1 with the base period t. This index is applied to time series t=0 to T. A comparison between period t and fixed base 0 is made by the following chain index of the successive periods.

$$I(0, t) = I(0, 1) \times I(1, 2) \times I(2, 3) \times \ldots\ldots\ldots\ldots \times I(t-1, t) \quad \ldots 8$$

Multiple regression analysis was carried out in order to detect the main factors that were influencing the total factor productivity (TFP) growth in Telangana agriculture. For this purpose the crop wise indices of TFP in Telangana state was regressed on various identified variables that affect the TFP growth. Natural logarithm of all the variables including the TFP were taken for the regression analysis except those variables which were represented as ratios and percentages. The basic model for this purpose is as follows,

$\ln (TFP_{maize})$ = f {ln (Government expenditure on agricultural research, education and extension per hectare of cultivated land),

ln (Average rainfall in the state in millimetre),

Percent irrigated area under maize

Rural literacy in percentage,

Cropping intensity in percentage}

After running the regression analysis, the tests of regression analysis were applied. The final selection of the variables to be included in the analysis was done based on no multicollinearity assumption, i.e., the variables having high multicollinearity problem were dropped from the model. Then the selected models were tested for the presence of heteroskedasticity and autocorrelation problems. All the analyses for this purpose were carried out in R software package.

RESULTS AND DISCUSSION

Tornqvist total factor productivity indices of Maize

The Tornqvist indices of the total output, total input and total factor productivity of maize in Telangana were estimated form 2000-01 to 2012-13 to find out the productivity performance of the crop in the state over a period of 13 years and the results were presented in Table 1. The total factor productivity of maize in the state of Telangana annually increased with a CAGR value of 3.50% (significant at 5% level), where CAGR of TOI and TII were 5.30% (significant at 5% level) and 1.80% over the period of the study. The average values of the TOI, TII and TFP index in Telangana over the period of time were 145.80, 134.70 and 107.90 respectively. The value of the TOI reached its peak in the year 2012-13 (230.00) and its lowest value was in the year 2001-02 when compared to the base year i.e. 2000-01. The value of TII, on the other hand reached its highest in the year 2003-04 (168.70) and the lowest in the year 2004-05 (72.80). The TFP index of maize in the state was the lowest when compared to the base year in 2004-05 due to drought in that year when the average rainfall in the state was 292.60 mm less than the normal rainfall and there was also a decline in the percentage irrigated area under the crop (1.25% lesser than previous year).

The TFP index of maize saw sudden rise in the year 2007-08 when the percentage irrigated area under the crop increased by 5% when compared to 2006-07 coupled with good rainfall (33.4 mm more than the normal rainfall). The year 2009-10 observed a sudden fall in the TFP index of the crop to 81.90 in Telangana state. This was mainly due to the drastic fall in the area under the irrigation of the crop from 38.79% in the year 2008-09 to 30.39% of the total cultivated area. There was huge deficiency in the average rainfall in the year 2009-10 (224 mm less than the normal rainfall) which led to a fall in the TFP in this year. After 2009-10 the TFP was again more than 100 which was mainly due to the release of hybrid varieties namely DHM 117, DHM 121, Karimnagar Makka, Karimnagar Makka 1, and DHM 111 in the state coupled with good rainfall in 2001-11 (193.60 mm above the normal rainfall).

The region wise analysis of the indices of the total factor productivity revealed that southern Telangana has witnessed the highest annual

Table 1: Tornqvist Total factor productivity indices of Maize in Telangana (Indices Relative to First Observation) from 2000-01 to 2012-13

	Northern Telangana			Central Telangana			Southern Telangana			Telangana		
Year	TOI	TII	TFP	TOI	TII	TFP	TOI	TII	TFP	TOI	TII	TFP
2000-01	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2001-02	191.0	85.6	106.4	96.1	82.6	116.4	91.8	98.1	93.6	92.6	89.5	103.5
2002-03	79.7	113.5	70.2	112.7	91.7	122.8	90.3	155.1	58.2	90.8	113.8	79.8
2003-04	133.9	180.0	74.4	167.6	119.4	140.4	226.9	205.2	110.6	154.8	168.7	91.8
2004-05	76.5	135.2	56.6	144.5	120.9	119.6	150.7	211.0	71.4	105.6	145.0	72.8
2005-06	144.3	138.3	104.4	201.0	130.5	154.1	328.0	251.2	130.6	182.8	157.3	116.2
2006-07	104.5	128.2	81.5	127.8	130.8	97.7	238.1	304.7	78.1	127.1	159.5	79.7
2007-08	176.1	135.3	130.1	233.6	114.7	203.7	443.0	292.8	151.3	224.5	154.4	145.4
2008-09	148.6	129.9	114.4	163.6	116.4	140.5	305.1	254.2	120.1	171.4	144.4	118.7
2009-10	89.3	100.7	88.7	97.2	118.4	82.1	218.3	237.2	92.0	106.7	130.3	81.9
2010-11	118.6	100.7	117.8	176.2	112.1	157.3	339.2	184.3	184.0	161.6	119.3	135.4
2011-12	114.5	101.8	112.5	176.8	105.9	167.0	240.0	188.3	127.5	147.9	117.0	126.4
2012-13	153.2	121.6	126.0	311.5	153.0	203.6	404.3	225.8	179.1	230.0	152.3	151.0
Average	117.7	120.8	98.7	162.2	115.1	138.8	244.3	208.3	115.1	145.8	134.7	107.9
CAGR (%)	3.1	-0.20	3.2***	5.7**	2.4**	3.3	11.0*	5.4**	5.6**	5.3**	1.8	3.5**

*TOI = Total output index; TII = Total input index; TFP = Total factor productivity; CAGR = Compound annual growth rate; ** Significant at 5% level; *** Significant at 10% level.*

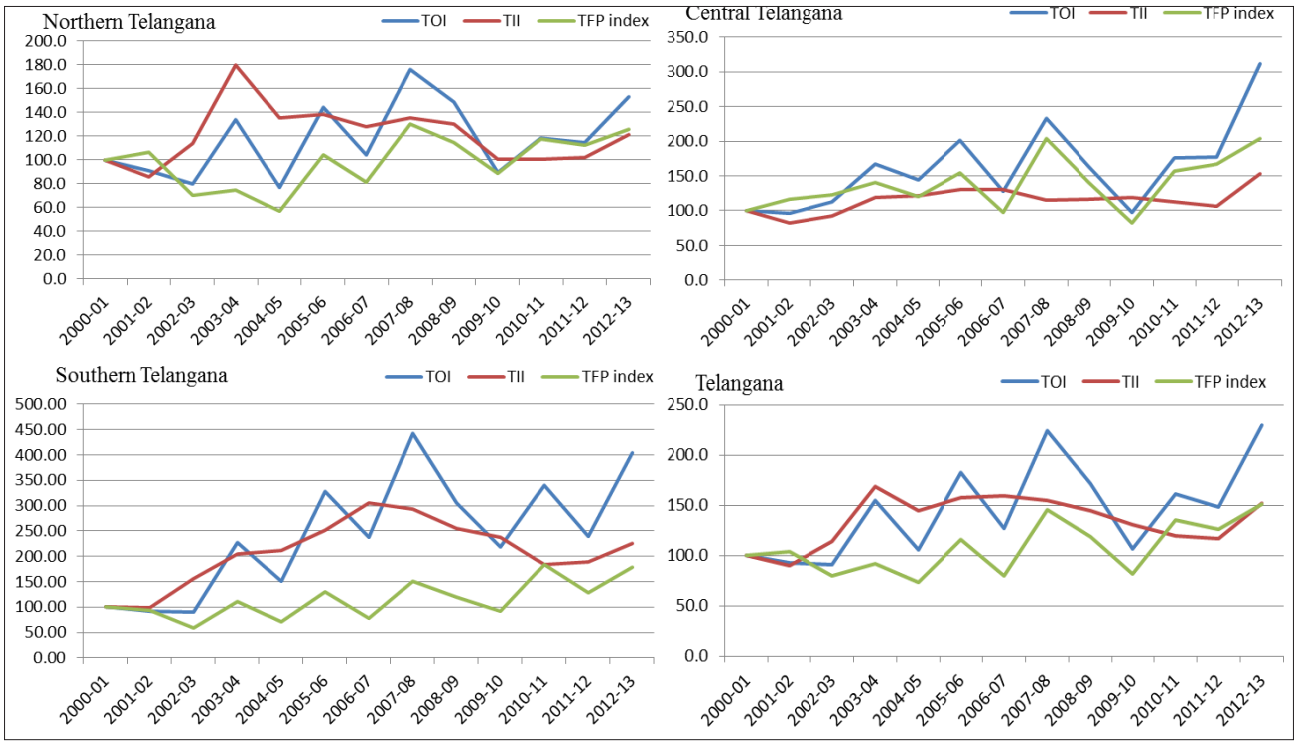

Fig. 1: Tornqvist Total factor productivity indices of Maize in Telangana

compound growth when compared to the other two regions over the period of time where the CAGR of TOI, TII and TFP index were 11.00% (significant at 1% level), 5.40% (significant at 5% level) and 5.60% (significant at 5% level) respectively. The average values of the TOI and TII in this region (244.30 and 208.30 respectively) were the highest among the other regions over the period of the study. The average value of TFP index in southern Telangana was 115.10. The value of TOI was as high as 443.00 in the year 2007-08 and the lowest at 90.30 in the year 2002-03 when compared to the first observation in southern Telangana. Highest TFP index in this region was (179.10) registered in the year 2012-13 and the lowest (58.20) in the year 2002-03. In northern Telangana, the average values of TOI, TII and TFP were 117.70, 120.80 and 98.70 respectively over the period of time. The compound growth rates of the indices were 3.10%, -0.20% and 3.20% (significant at 10% level) respectively in this region. The average value of the TFP index was the lowest in this region when compared to the other two regions. The value of TOI was the highest and the lowest at 191.10 and 76.50 when compared to the base period in the years 2001-02 and 2004-05 respectively. The TII, on the other hand reached the highest and the lowest levels at 180.00 and 85.60during the years 2003-04 and 2001-02. TFP index in this region was the highest when compared to the initial year at 130.10 in the year 2007-08.

The CAGR of TOI, TII and TFP index in the central Telangana region were 5.70%, (significant at 5% level), 2.4% (significant at 5% level) and 3.30% respectively. The average values of the indices in this region were 162.20, 115.10 and 138.80 respectively over the period of time. The average value of the TFP index was the highest among the regions. The value of the TOI in this region reached its highest when compared to the first observation in the year 2012-13 (311.50) and the lowest when compared to the first observation in the year 2001-02. TII of maize in central Telangana region was the highest in the year 2007-08 and the lowest in the year 2009-10 when compared to the base period observation. The TFP index in this region remained above 100 throughout the study period except for the years 2006-07 and 2009-10.

Figure 1 represented the graphical presentation of the indices in the state as well as the regions over the period of years. The graphs revealed that the index of the total input has remained mostly below the index of the total output in the state as well as the three regions. In the Telangana state and northern Telangana the TII was above the TOI for a longer period of time when compared to the central and southern Telangana. This implied that the index of TFP has been above hundred for a maximum number of years. The graphs also revealed that the three indices of maize in the state have shown an increasing trend over the period of time.

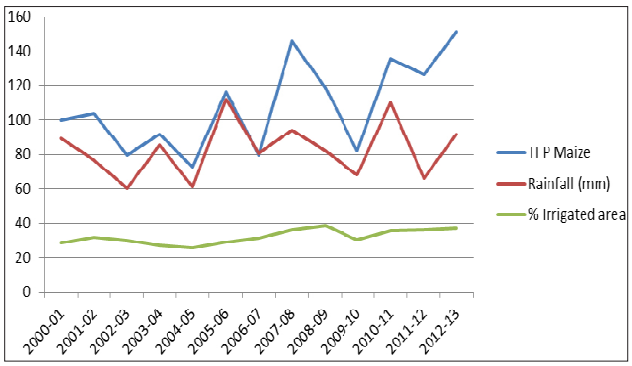

Fig. 2: Graph depicting TFP of Maize in Telangana along with rainfall and per cent irrigated area

It could be clearly seen from the Fig. 2 and Table 2 that the TFP productivity performance of maize in Telangana state has highly been influenced by the average annual rainfall in the state and the percentage irrigated area under maize.

Table 2: Correlation coefficient of TFP of maize with rainfall and percentage irrigated area under maize in Telangana

	TFP maize	
	Correlation coefficient	p-value
Average annual rainfall (mm)	0.613*	0.026
Percentage irrigated area under Maize	0.783**	0.002

** Significant at 5% level; ** Significant at 1% level*

It could be easily seen from the Fig. 2 that these three parameters have moved all together in all the years. The correlation coefficient between TFP maize and annual rainfall was 0.613 (significant at 5% level) and percentage irrigated area was 0.783 (significant at 1% level). So, it can be revealed that rainfall and irrigation facilities have been the major influential factors that determined the performance of maize

Table 3: Determinants of TFP of maize in Telangana state from 2000-01 to 2012-13

Variable	Regression coefficient	Standard error	t- ratio	p-value
Constant	0.278	2.376	0.117	0.910
Government expenditure on Agricultural research, education and extension (per Ha)	0.023	0.177	0.134	0.897
Average rainfall (mm)	0.606***	0.309	1.960	0.0908
Percentage irrigated area	0.034***	0.018	1.927	0.0954
Rural literacy (%)	0.0145	0.023	0.630	0.5484
Cropping intensity (%)	-0.01	0.029	-0.443	0.671
R^2		0.807**		
D-W statistics		3.37^{NS}		

*Dependant variable: TFP index of maize in Telangana state expressed in natural logarithm; All the variables are expressed in natural logarithms expect those calculated as percentages; ** Significant at 5% level; *** Significant at 10% level; NS Non significant.*

in the state. The other variables determining the growth performance of the TFP have been analysed and discussed in the next section of the paper.

Determinants of TFP of maize in Telangana state from 2000-01 to 2012-13

The growth of the TFP of any sector is crucial for the development of the sector in the long run. It is therefore important to find out the key determinants of TFP growth that the policy makers should focus on (Isaksson, 2007). The total factor productivity (TFP) index of maize was regressed on various variables in order to identify the major determinants. These determinants of the TFP growth suggest areas for policymaking and the policy discussions should be indicative rather than directive (Isaksson, 2007). Government expenditure on Agricultural research, education and extension per ha, average rainfall in mm, percentage of irrigated rice area, and rural literacy percentage and cropping intensity were identified as the determinants of the TFP of maize in the state. The R^2 value of the regression model was 80.7% (significant at 5% level) implying that 81% variation in the TFP growth was explained by the included independent variables. There were no problem of multicollinearity, heteroskedasticity and autocorrelation in the model.

The results of the regression analysis were presented in the Table 3. A quick look in to thetable revealed that except for the cropping intensity in the state all the other variables had a positive influence on the TFP of maize. Only average rainfall and the percent irrigated area of maize had significant influence on the productivity. The coefficient of average rainfall was 0.606 (significant at 10% level) and for percent irrigated area it was 0.034 (significant at 10% level). Similar results were reported by Kannan, 2011 in his study of determinants of TFP growth of Karnataka agriculture. The other coefficients were not significant. Since the production of maize requires enough water, the effect of rainfall and irrigation were positive for the productivity of the crop. To capture the positive effect of rainfall on the production of the crop, enough provision of rain water harvesting should be created in the state. The excess rainfall should be harvested for the purpose of use in the lean rainfall years.

TFP index of maize was below 100 in the initial years of the study period and from 2005-06 it remained mostly over 100. The average value of TFP index in Telangana during the study period was 107.9, and was the highest in the year 2012-13. The CAGR of TFP was 3.5% in Telangana. The highest average value of TFP was observed in central Telangana (138.8). The CAGR of TFP index was the highest in southern Telangana region. The regression analysis revealed that the average rainfall and percentage irrigated area under maize were significantly affecting the TFP of the crop in Telangana over the years with regression coefficients 0.606 and 0.034 respectively. Other variables that were identified to affect the TFP were government expenditure on agricultural research, education and extension (per Ha) and rural literacy. The R^2 value of the selected model was 80.7%. Various policy measures that could be taken up for the enhancement of the TFP growth of maize in the state are significant government investment in agricultural research and

education, creation of water harvesting technologies and by bringing more area of maize under irrigation facilities.

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REFERENCES

Chand, R., Kumar, P. and Kumar, S. 2012. Total Factor Productivity and Returns to Public Investment on Agricultural Research in India. *Agricultural Economics Research Review,* **25**(2), 181-194.

Chand, R., Kumar, P. and Kumar, S. 2011. Total Factor Productivity and Contribution of Research Investment to Agricultural Growth in India. *Policy Paper 25*, National Centre for Agricultural Economics and Policy Research, New Delhi.

Christensen, Laurtis R. 1975. Concepts and measurement of agricultural productivity, *American Journal of Agricultural Economics,* **57** (5).

Coelli, T.J., Rao, D.S.P., O'Donnell, C.J. and Battese, G.E. 2005. An Introduction to Efficiency and productivity Analysis. Springer, New York.

Isaksson, A. 2007. Determinants of total factor productivity: a literature review. Staff Working Paper 02/2007, Research and Statistics Branch, United Nations Industrial Development Organization (UNIDO).

Kannan, E. 2011. Total factor productivity growth and its determinants in Karnataka agriculture. Working paper 265. The Institute for Social and Economic Change. Bangalore.

Kumar, P., Mittal, S. and Hossain, M. 2008. Agricultural Growth Accounting and Total Factor Productivity in South Asia: A Review and Policy Implications. *Agricultural Economics Research Review,* 21 (July-December), 145-172.

Reddy, P.P. 1997. Economic Analysis of Paddy Cultivation in Andhra Pradesh. PhD Thesis, submitted to Dr B.R. Ambedkar Open University, Hyderabad through Centre for Economic and Social Studies, Hyderabad.

Rosegrant, M.W. and Evenson, R.E. 1995. Total factor productivity and sources of long-term growth in Indian agriculture. EPTD Discussion Paper No. 7, Environment and Production Technology Division, International Food Policy Research Institute, Washington.

Sripoorni, R.S. and Manonmani, M. 2014. Factors influencing total factor productivity across the southern states of India- an application of discriminant function. *International Journal of Commerce, Business and Management,* **3**(4): 623- 625.

Suresh, A. 2013. Technical Change and Efficiency of Rice Production in India: A Malmquist Total Factor Productivity Approach. *Agricultural Economics Research Review,* **26**(Conference): 109-118.