Analysis of Total Factor Productivity of Chickpea in Major Producing States in India

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ABSTRACT

Present study was taken up with the aim of analyzing the impact of inputs on productivity performance in chickpea crop. By adopting Divisia chain Indices methodology, TFP indices were calculated along with growth rates and determinants of TFP. The findings of the study revealed that the visible positive TFP growth rates in Madhya Pradesh, Rajasthan and Maharashtra are due to area expansion under chickpea crop than technological intervention. Whereas, in undivided Andhra Pradesh, technology and managerial inputs have contributed to meaningful TFP growths. Apart from traditional inputs, road density was found to be an important source of growth in TFP in the study area. The increased inputs cost and quantity used in chickpea crop has resulted in increase in the cost of production in the selected states during the study period 2005-13.

Key words: Chickpea, Cost of production, Growth rates, Total factor productivity, Total input indices, Total output indices.

INTRODUCTION

India is the principal chickpea producing country with 71 percent share in the total global chickpea production. Chickpea is predominant among other pulse crops in India. Out of total pulses acreage and production, the share of chickpea is around 33.66% and 42.01% respectively (2014-16). Average area under chickpea crop was estimated to be around 8.74 million ha and average harvested produce was around 7.90 million tons with a highest average productivity of 973 kg/ha during 2014-16. Before 1960’s, chickpea was mainly cultivated in the northern states. However, with the advent of green revolution technologies, chickpea cultivation extended to marginal and fragile lands in central and southern states of India. At present, the major producing states in India are Madhya Pradesh, Rajasthan, Uttar Pradesh, Maharashtra, Karnataka and Undivided Andhra Pradesh. Among these Madhya Pradesh, Rajasthan and Uttar Pradesh are traditional cultivators of chickpea and remaining chickpea cultivating southern states are non – traditional cultivators.

During the last three decades, a great transition has taken place in terms of acreage under chickpea cultivation and increased productivity levels with the development and adoption of niche specific improved cultivars in major chickpea cultivation states in India (Kumaracharyulu et al. 2014; Suhasini 2009). In fact, the southern states are contributing significantly to the total production with higher productivity levels. In view of the factors discussed above, the present study has been under taken to estimate the total factor productivity growth (TFP) of chickpea in the major chickpea producing states, viz., Madhya Pradesh, Rajasthan, undivided Andhra Pradesh and Maharashtra. This study also examined the sources of productivity growth in chickpea crop in the selected states.

Significance of TFP and its effect on crop performance

The Marxian and neoclassical theories of growth assign the greatest weight to productivity improvements (TFP growth) driven by advances in technology and the organization of production. In general, the TFP approach is considered as appropriate tool to examine and understand the growth in agricultural productivity and to separate out the effect of inputs like land, labour, machinery, fertilizer, seed etc. Other factors like technology, infrastructure and farmer’s knowledge on productivity growth (Ramesh Chand et al., 2011). The changes in TFP growth are the significant determinants of the average cost of production and income (Ramesh Chand et al., 2011; Desai and Namboodiri, 1997). TFP growth also has important implications for the sustainability of the growth process in the crop sector. TFP estimates the effect of technological change on agriculture as a whole or the total crop sector (Evenson and Jha, 1973; Rosegrant and Evenson, 1992) and it works as a useful indicator of changes in the long-term productivity of the crops.

During the early 1970s to the mid-1990s, TFP was constant for many crops in Andhra Pradesh (Jha, 2001). Another study states that, the contribution of total factor productivity to yield growth has been found to be at 31 per...
cent in the pre-reform period and 37 percent during the post-reform period in the crop sector of the state. This absolute decline in total factor productivity seems to be one of the main reasons for the distress of farmers in the state (2005). A study on TFP in different pulse crops during 1975 to 2005 show that the TFP growth was positive for gram. The decade wise contribution of technology to output growth was substantially higher during 1996-2005 against the previous two decades. It was also estimated that the share of TFP growth in output growth was around 26.1 percent for gram through technological change. This TFP growth has been positive coupled with negative growth in input-use in pulses growing states. Bihar, Rajasthan and Andhra Pradesh have witnessed a high growth in TFP in pulses. Technology and managerial inputs have contributed to meaningful TFP growth for gram in Madhya Pradesh. On the other hand, no technological gains were experienced for gram in Rajasthan (Ramesh Chand et al., 2011). The states witnessing a positive growth in TFP, have experienced a decline in per unit real cost of production. The nominal cost per unit of crop output has declined in gram. However, the decline in the real cost of pulses is the result of a decline in input-use due to the shifting of pulses cultivation to marginal lands (Ramesh Chand et al., 2011).

**Sources of growth in TFP**

Public investment in transfer of technology (extension), natural resource management and provision of requisite infrastructure have contributed positively towards TFP enhancement in pulses. In the case of chickpea, research, extension, cropping intensity and groundwater are the major sources of TFP growth at all India level. Other important sources are electricity (Fan et al., 1999) and road density as this would induce input-output market interface and create a suitable environment for the adoption of technology as well as attract investments in agriculture. Rao (2005) and Bhatia, (1999) stated that, rural infrastructure has been found to have a major impact on agricultural productivity. Further, non-price factors have been more important in determining TFP than the price-related factors (Desai and Namboodiri, 1997).

Investment in research on TFP growth during 1975-2005, revealed that overall internal rates of return to public agricultural research investment turned out to be 34 percent for gram and share of agricultural research in TFP growth has been estimated as 42.2 percent for gram. However, contribution of research appears to be not so significant to achieve level of self-sufficiency in gram and thus there is a need to increase research investment by 10.7 percent for gram per annum which is likely to increase TFP by one percent (Ramesh Chand et al., 2011). Thus Fuglie and Rada, (2013) concluded that enhanced productivity is correlated with investments in agricultural research, wider adoption of new technologies and policy reforms which will serve as an incentives to farmers. Another set of studies states that the terms of trade for agriculture have a positive relationship with private capital formation, technical change and output (Ahuwalia, 1996 and Gulati, 1998). In line to this, the present study on TFP growth in chickpea in major chickpea producing states in India and determinants of TFP are carried out with the given specific objectives.

(a) To calculate the Total Factor Productivity (TFP) of chickpea crop and its growth in the selected states of Madhya Pradesh, Rajasthan, Maharashtra and Undivided Andhra Pradesh.

(b) To analyse the factors affecting the TFP growth of chickpea in the selected states in India.

**Materials and Methods**

The current study covers four states namely Madhya Pradesh, Rajasthan, Maharashtra and undivided Andhra Pradesh for their positive performance both in terms of a significant increase in acreage and productivity of the chickpea crop in the last decade. For this study, details on chickpea crop output and four critical inputs used for chickpea crop cultivation are considered for the analysis. Secondary data pertaining to acreage, production, productivity were collected from the Directorate of Economics and Statistics and farm harvest prices data from the Ministry of Agriculture in India. The data on per hectare expenditures on seeds, pesticides, hired labour, land revenue and water charges were collected from the Cost of Cultivation Scheme of the Government of India. Cost of cultivation data are available for Madhya Pradesh and Rajasthan from 1996-97, whereas, for Maharashtra, data available from 2002-03 and for Andhra Pradesh the data available only from 2005-06 onwards. So, for easy comparison of the results within the states, data from 2005-06 to 2013-14 were considered for the study.

**Analytical framework**

Total factor productivity is estimated using the secondary data on cost of cultivation over a period of time for the states of Madhya Pradesh, Maharashtra Andhra Pradesh and Rajasthan.

TFP is an Index of the total output growth relative to the growth in traditionally measured inputs of labour and capital. Total factor productivity index helps us to measure the growth in productivity change that occurred apart from the changes in inputs over a period of time. In general Total factor productivity (TFP) Index is defined as the ratio of the weighted combination of output to a weighted combination of inputs. Estimates of TFP indices are designed to provide an indication of the change in output per unit of total factor input. It is argued that, TFP measures the rate of technical change (Law, 2000; Krugman, 1996; Young, 1992 among others) and measures only effect of technical change, which are mainly associated with externalities and scale effects (Jorgensen and Griliches, 1967). The estimation of TFP growth would be straight-forward when dealing with one input in the production process. But when multiple inputs of a heterogeneous nature are used in the production process for calculation of TFP we need to consider the use of price
Total output index (TOI) is calculated as; \[ \text{TOI} = \frac{Q_t}{Q_o} \times 100 \]

Where, \( Q_t \) = current year’s output per ha, \( Q_o \) = base years output per hectare.

The following formulas are applied for calculating the TOI, TII and TFP.

**Total Input index**

\[ (\text{TII}) \ln Z_t = \frac{\sum_{i=1}^{n} \{ \text{Wit} \times \text{wit}-1 \}}{2} \ln p_{it} \]

Where, \( Z_t = e^{\text{wit}} \), \( L_t = \text{lt}-1 \). \( Z_t \) is the aggregate input measure and \( P_{it} \) is the quantity of \( i^{th} \) input in period ‘\( t \)’,

\( \text{Wit} \) is share of the \( i^{th} \) input in period ‘\( t \)’ in operational cost. This is a quantity chain base index linked to base year. So the TFP is given by

\[ \text{TFP} = \frac{Q_t - Q_o}{Q_o} \times \frac{2}{Z_t + Z_o} \text{ (or) Output index/ Aggregate Input Index} \]

The given indices have been computed with base year 2005-06=100

The nominal cost of production of the crop was computed by deflating the cost of production by input price index. The estimation of input, output and TFP growth rates was done by computing the average annual growth rate for different states for the study period (2005-06 to 2013-14). In addition the factors influencing TFP growth are also analyzed by running a regression function for the TFP against variables such as research cost, literacy, cropping intensity, infrastructure facilities, road density, rainfall etc.

For the present study, three variables have been selected, i.e., the share of irrigated area in percentages in the study area, length of road in km per one lakh ha. and cropping intensity (Ramesh Chand, 2011). Regression analysis was used to analyze the determinants of TFPG.

Model:

\[ \text{TFPG} = a + b_1X_1 + b_2X_2 + b_3X_3 + \ldots \ldots \ldots \ldots u \]

Where

\[ \text{TFP} = \text{Quantity chain of TFP} \]

\[ X_1 = \text{percentage share of net chickpea irrigated area to total chickpea cultivated area} \]

\[ X_2 = \text{Length of the road in km per 1lakh net cropped area} \]

\[ X_3 = \text{Cropping intensity in the state (in percent)} \]

\[ X_4 = \text{Cold storage capacity in lakh MT in the state} \]

\[ X_5 = \text{Maharashtra (Dummy variable1)} \]

\[ X_6 = \text{Rajasthan (Dummy variable 2)} \]

\[ X_7 = \text{Andhra Pradesh (Dummy variable 3)} \]

**RESULTS AND DISCUSSION**

Trends in Productivity growth rates of chickpea crop in selected states

The analysis of productivity trends of chickpea crop in the selected states in the present study reveals that, at the all-India level the average productivity has increased significantly from 642 kg/ha to 960 kg/ha by 49.53 percent during 1971-2015. Among the states, the highest productivity growth is seen in undivided Andhra Pradesh at 3.94 percent followed by Maharashtra (2.42 percent), Madhya Pradesh (1.57 percent) and Rajasthan with 0.4 percent for the same period. The record level of average productivity while aggregation of inputs. This implies that productivity can be affected by both changes in relative prices of inputs and by the input used per unit of output (Kathuria et al., 2011). Among the prominent methodologies such as Solow Index, Divisia Index and Torn Quist index, Malmquist index methodology and DEA, Divisia index has been chosen in the present study for calculating, TII, TFP and TFP as it is designed to incorporate quantity and price changes over time from subcomponents that are measured in different units such as labour hours and equipment investment and materials purchases in a time series that summarizes the changes in quantities and/or prices. The resulting index number series is unitless, like other index numbers.

Here for estimating the TFP growth for chickpea crop, the output index for chickpea crop and composite input index is calculated as number of inputs are used in its cultivation. This Divisia input index is calculated by aggregating the computed total input price index and quantity index. Here the input price index and input quantity index have been estimated by chain base index. This method is temporal one as it takes in to account changes over time especially in the case of long periods. In this method, a comparison is not made with a fixed base but is made with changing base from year to year. The computation of output and input indices was done taking in to account the current prices.

For calculating the input index, the quantity and prices of four inputs were considered: seed (Rs. Per kg), fertilizer (Rs. per Kg) and human (Rs. Per hour) and animal labour (Rs. Per hour). Organic manure (Rs. per quintal) has been converted and aggregated to cost of fertilizer. Data were not collected on pesticide, interest on working capital and fixed cost due to data constraint faced in the collection of numbers.

Indicators of the total operational cost of the crop in the respective selected inputs cost accounted for approximately 90 percent of the total operational cost of the crop in the respective states.

The share of the various inputs (percentage of input cost to total operational cost) is taken as the weight of the respective inputs and the share of each input is estimated. The growth rate of these inputs is taken by taking the logarithm of different inputs quantities. The growth rate of the inputs aggregate is taken as the weighted average of the growth rate of the input share of the components, multiplied by input quantity and divided by two. The input index is calculated from the aggregated inputs as the exponential of the aggregated weighted inputs. The Divisia index is obtained by aggregating the input index. Total factor productivity index is obtained by dividing total output index by aggregate input index.

The following formulas are applied for calculating the TOI, TII and TFP.

\[ \text{Total output index (TOI)} = \frac{Q_t}{Q_o} \times 100 \]

Where, \( Qt \) = current year’s output per ha, \( Qo \) = base years output per hectare.

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productivity is seen in undivided Andhra Pradesh followed by Madhya Pradesh at 1158 kg/ha and 1132 kg/ha respectively during 2011-13. (Table 1 and Fig 1). On comparing the decadal growth rates in the selected states, in the 1970's, Rajasthan and Maharashtra registered positive growth rates, while, undivided Andhra Pradesh and Madhya Pradesh showed negative growth rates in productivity. The lower growth rate of productivity was attributed to the fact that, this crop has not received much attention for cultivation under rainfed condition. This crop being prone to pest and diseases is also one of the reason for low yield. In the 1980's the growth rate was negative only in Rajasthan. From the 1990's, there has been a significant positive growth rates in productivity in all the selected states due to the development and adoption of the niche specific improved cultivars. Only undivided Andhra Pradesh registered positive growth rate of 3.32 percent in the last five years (2011-2015) due to the adoption of the short duration and wilt resistant improved cultivars by more than 95 percent of the chickpea cultivators. However, the growth rate was negative in the other selected states. At the all-India level, chickpea productivity has increased by 1.01 percent (CAGR) during 1971-2015.

**Cost of production (Rs/quintal) of chickpea in selected states**

The data in Table 2 shows an upward trend in the cost of production of chickpea in all the selected states in India with the highest increase of 225 percent in Andhra Pradesh followed by Maharashtra (149 %), Madhya Pradesh (146.53 %) and Rajasthan (141.34%) during 1996-2013. Among the selected states, the highest cost of production is noticed in the case of Andhra Pradesh followed by Maharashtra, Madhya Pradesh and Rajasthan.

**Changing cost of inputs to total input cost (2005-06 to 2013-14)**

In addition to the above analysis of change in cost of production of chickpea, also calculated change in cost shares of different inputs in total cost of production and the growth rates of inputs cost are calculated based on the secondary data on cost of cultivation data of chickpea in the selected states during 2005-2013. The total input cost of chickpea crop has increased over a period of time in all the selected states in the study period. In general in all the selected states, wages of labour accounted for the major share in total cost of production followed by the rent value of own land, seed, fertilizers cost, interest paid on fixed and working capital, irrigation and pesticide. Except the rental value of owned land, all other inputs such as seed, fertilizer, pesticides and labour wages have shown an increasing trend in the selected states.

In the case of Madhya Pradesh, rental value of owned land accounted for 33 percent of the cost followed by wages paid to human, animal and machinery labour during 2005-06. However, in 2013-14, the highest share in total cost was on account of wages paid to human, animal and machine labour followed by rental value of own land. Share of wages of labour has increased from 28 percent to 44 percent in

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**Table 1: Chickpea crop yield growth Rate (CAGR) in the selected states.**

| Year   | Madhya Pradesh | Rajasthan | Maharashtra | Andhra Pradesh | All India |
|--------|----------------|-----------|-------------|----------------|----------|
| 1971-80| -3.13          | 3.19      | 3.61        | -1.05          | 0.18     |
| 1981-90| 0.74           | -0.77     | 4.83        | 4.22           | 0.85     |
| 1991-00| 1.80           | 1.01      | 0.39        | 3.68           | 0.95     |
| 2001-10| 1.09           | 0.13      | 5.70        | 2.30           | 1.37     |
| 2011-15*| -1.59          | -0.62     | -8.29       | 3.32           | -2.69    |
| 1971-15| 1.56           | 0.40      | 2.42        | 3.94           | 1.00     |

Note: “includes only four year’s data points.

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**Source:** DES, Ministry of Agriculture, India

**Fig 1:** Average yield performance per ha in different time periods in selected states and in India.
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total input cost between 2005-06 and 2013-14. Where as fertilizer and pesticides cost has increased marginally.

In the case of Rajasthan, labour wages and cost of seed and fertilizer have increased significantly whereas the rental value of own land and pesticide cost declined during the study period. Pesticide input cost is more or less zero from 2011 to 2013. In the case of Maharashtra, the share of wages of labour in total input cost was the highest compared to other states at 45 percent and over a period of time the labour cost has remained more or less the same. Proposition of seed and irrigation costs have declined in the study period. The cost of other variables has increased in the same period.

In the case of un divided Andhra Pradesh, seed cost decreased till 2008-09, but thereafter the share of seed cost increased marginally. The major input costs were labour wages and the rental value of land at 39 percent and 28 percent respectively during 2013-14. Irrigation charges are completely absent as chickpea is cultivated as a rain-fed crop in the state of Andhra Pradesh.

Table 3 provides the details on the compound growth rates of quantity and unit cost of the inputs used in chickpea crop in the study period. The quantity of seed used has shown a positive growth rate in all the selected states except in Rajasthan. The unit cost of seed price has registered a positive growth rate of around 6-10 percent in all the states. Fertilizer quantity used registered a 4-5 percent growth rate in all the states except in Maharashtra with 16.98 percent. Prices of inputs also showed a positive growth rate of around 13-14 percent in all the selected states in the study period. Working hours by human labour has showed a negative growth rate in Madhya Pradesh and undivided Andhra Pradesh and a positive growth rate in Maharashtra and Rajasthan. The decline in working hours by human labour indicates the replacement of human labour by farm machinery. The wage rates of human labour have shown 17-18 percent growth rate in all the selected states. Use of animal labour has drastically declined in all the states because of increased use of machine labour as the cost of animal labour was on higher side in the study period. The same is reflected by negative growth rates for animal labour working hours and positive growth rates for the cost of animal labour.

Estimation of Total Input Index, Total Output Index and Total Factor Productivity Index

Madhya Pradesh: In the case of Madhya Pradesh, the total output index shows a mixed trend. The total input index has significantly declined, from 100-91.25 in the study period. Total output index has out-performed the total input index. Total factor productivity increased from 100 to 134 from 2005-06 to 2011-12 and gradually declined thereafter to 124 during 2013-14. The average TFP is registered at 115.67 in the study period. TFP has shown marginal deviation from the trend line.

Rajasthan: The total output index declined initially and increased sharply after that during the study period. TII also declined continuously except during 2009-10. Here also the TOI out-performed the TII, while, TFP had a mixed trend. On the whole it increased significantly to 155 in 2013-14 from the lowest level of 98 in 2009-10. Like the TOI, the TFP also increased gradually during the study period. The overall average TFP was around 127.34 during the study period. In the case of Rajasthan, the TFP had initially increased in 2006-07 and declined to 98.97 in 2009-10. Thereafter, it increased to 158.

Table 2: Chickpea crop average cost of production per quintal (TE) in the selected states in different time periods (in Rs./quintal).

| Year (TE) | Madhya Pradesh | Rajasthan | Maharashtra | Undivided Andhra Pradesh |
|----------|----------------|-----------|-------------|-------------------------|
| 1996-98  | 848.94         | 774.36    | NA          | NA                      |
| 2001-03  | 1101.4         | 1444.36   | NA          | NA                      |
| 2006-08  | 1572.14        | 1585.17   | 1928.86     | 1449.94                 |
| 2011-13  | 2692.12        | 2376.99   | 2878.01     | 3262.06                 |
| CAGR (%) | 146.53         | 141.34    | 149.23      | 225.06                  |

Source: Cost of cultivation data, Ministry of Agriculture. India.

Table 3: Growth rate (percentage) of quantity of inputs and prices of inputs used in chickpea crop during study period (2005-06 to 2013-14).

| Particulars             | Madhya Pradesh | Rajasthan | Maharashtra | Undivided Andhra Pradesh |
|------------------------|----------------|-----------|-------------|-------------------------|
| Quantity of inputs CAGR| 0.88           | -1.4      | 1.89        | 2.92                    |
| Fertilizer(Qtls)       | 3.97           | 5.29      | 16.98       | 2.97                    |
| Human labour(in hrs)   | -0.03          | 0.92      | 1.5         | -0.18                   |
| Animal labour(in hrs)  | -19.6          | -33.86    | -10.98      | -22.27                  |
| Unit cost of inputs CAGR|              |           |             |                         |
| Seed                   | 9.95           | 8.16      | 9.19        | 5.84                    |
| Fertilizer             | 14.11          | 13.32     | 13.91       | 8.39                    |
| Human labour           | 17.57          | 18.16     | 19.19       | 19.53                   |
| Animal labour          | 16.12          | 23.47     | 9.29        | 13.5                    |
**Maharashtra:** In the case of Maharashtra, the TOI has been increasing continuously during study period. The TII has been more or less at the same level with a marginal increase between 2005-06 and 2013-14. On the whole, the TFP increased with increased TOI and TII but showed a mixed trend during few years with a higher fluctuation. The average TFP was registered at 121.3.

**Undivided Andhra Pradesh:** In the case of undivided Andhra Pradesh, TOI increased initially but declined sharply in 2011-12 and 2012-13 and again recovered in the next year. The same trend is seen in TII also. But the TFP has shown more fluctuations irrespective of the trend of TOI and TII. From this we can infer that the TFP is influenced by the other factors which are not included in the analysis. The average TFP index is 94.17 which is much below than the average TFP of the other states. Andhra Pradesh had the highest TII at 203.82 in 2013-14. Higher TII than the TOI, resulted in lower TFP of 56.6 in 2013-2014. This is the lowest TFP compared to all the other states in the study period. The TFP graph illustrates the high degree of fluctuation from 2005-06 to 2013-14.

From the above analysis (Table 4) it is clear that, TOI is not in tandem with the TII all the time i.e., TOI is not always increasing with rising TII and sometimes it shows a declining trend. So there is a need to look into factors other than the inputs used in the above analysis to examine the sources of total factor productivity growth. The other factors identified to study the source of TFP are, percentage share of chickpea irrigated area, cropping pattern, road density and, storage capacity for the harvested produce.

**Annual growth rate in input use, output, TFP and real cost of production for chickpea in different states of India (2005 to 2013)**

The calculated annual growth rates of input, output and TFP indices for chickpea crop grown in major producing states of India are illustrated in Table 5. From the analysis it is clear that performance of technological change in chickpea crop was significant in all the selected states which is indicated by the positive TFP growth rates. The highest TFP growth was registered in Rajasthan and Maharashtra. Andhra Pradesh experienced a moderate growth of 4.71 percent and low growth is seen in the major chickpea producing state Madhya Pradesh. These results are slightly in contrast from the findings of Ramesh Chand et al., (2011).

In the traditionally chickpea cultivating states viz., Madhya Pradesh and Rajasthan, the input used index has registered a negative growth with a positive growth in the output index. In the case of Maharashtra, the rise in input use at the marginal rate of 0.11 percent has raised the output index significantly by 7.29 percent, which has resulted in positive TFP growth. However, the TFP growth is outperforming the output growth in these three chickpea growing states. These types of positive TFP growth may be due to spatial shift in area under crops (Ramesh Chand et al., 2011) in the recent times and this positive growth is not due to technological change. So the share of TFP growth in output growth in such cases has not been reported in the study. In undivided Andhra Pradesh, the input index has increased by 23.71 percent and the output index increased moderately by 5.557 percent with TFP of 4.71 percent. The share of technology in output growth of chickpea was estimated at 84.5 percent for undivided Andhra Pradesh.

**Table 4:** Divisia chain Indices (TOI, TII and TFP) for the selected states from 2005-06 to 2013-14.

| Year   | Madhya Pradesh | Rajasthan | Maharashtra | Andhra Pradesh |
|--------|----------------|-----------|-------------|----------------|
| 2005-06| 100.00         | 100.00    | 100.00      | 100.00         |
| 2006-07| 98.95          | 94.74     | 104.44      | 114.24         |
| 2007-08| 95.48          | 94.45     | 101.09      | 107.59         |
| 2008-09| 108.09         | 89.84     | 120.31      | 115.72         |
| 2009-10| 119.85         | 92.49     | 129.59      | 107.53         |
| 2010-11| 107.04         | 88.02     | 121.61      | 107.12         |
| 2011-12| 124.26         | 92.34     | 134.57      | 115.66         |
| 2012-13| 117.02         | 93.69     | 124.90      | 107.12         |
| 2013-14| 95.38          | 91.25     | 104.52      | 107.12         |

**Table 5:** The average annual growth rates of input and output and TFP indices for chickpea crop.

| States       | Input growth | Output growth | TFP growth | Nominal cost of production | TFGP share in output growth |
|--------------|--------------|---------------|------------|---------------------------|-----------------------------|
| Madhya Pradesh | -1.07        | 0.08          | 1.12       | 10.28                      | -                           |
| Rajasthan    | -0.39        | 6.81          | 9.83       | 8.23                       | -                           |
| Maharashtra  | 0.11         | 7.29          | 7.79       | 9.33                       | -                           |
| Andhra Pradesh | 23.71        | 5.57          | 4.71       | 14.93                      | 84.56                       |
Technology and managerial inputs have contributed to meaningful TFP growths for gram in undivided Andhra Pradesh. Technological change has resulted in achieving historically high productivity levels i.e. 1250kg/ha in Andhra Pradesh state and led to a silent revolution in chickpea production in Andhra Pradesh. No gains were experienced for chickpea in Rajasthan, Maharashtra and Madhya Pradesh in the study period.

The states witnessing a positive growth in TFP have experienced an increase in per unit nominal cost of production which was justified in the above analysis. The TFP growth analysis indicates that, the positive TFP growth rates particularly in Madhya Pradesh, Rajasthan and Maharashtra are due to the area expansion under chickpea crop than technological intervention. Therefore, priority must be given in these states for adopting the developed technologies for achieving the potential yield levels and self-sustained chickpea production in India.

Sources of TFP in chickpea crop in the study area

From the above analysis it is clear that TFP registered a positive growth rates irrespective of the growth rates in TII and TOI. This may be due to factors other than the inputs used in crop production. Thus the TFP growth rate can be affected by various factors such as, cropping intensity, literacy, research investment, extension services, human capital, balanced application of plant nutrients, Infrastructural development and climatic factors (Ramesh Chand et al., 2011). It is important to understand the relative importance of these productivity enhancing factors in determining productivity growth. In order to assess the determinants of TFP, the total factor productivity index of the selected states Madhya Pradesh, Rajasthan, Maharashtra and Andhra Pradesh is regressed against the variables such as percentage share of net chickpea irrigated area, road density, cropping intensity and cold storage capacity in the respective states. Maharashtra, Rajasthan and Andhra Pradesh states are taken as a dummy variable in the model to see the variation across these selected states. Here the state of Madhya Pradesh which is a traditional chickpea growing state was suppressed in the model to see the variation across the selected states in comparison to Madhya Pradesh state as it is the largest chickpea growing state.

The results furnished in Table 6 shows that only road density which is considered an infrastructure variable (i.e., length of the total surface road length in km standardized for one lakh cropped area) was found to be important source of growth in TFP in all the selected states. This implies that, with one unit change in road density (Length of the road in km per one lakh net cropped area), the TFP increases by 0.05 percent in the selected states in the study. The other selected variables, such as, percentage share of net cropped irrigated area, cold storage capacity and cropping intensity are not found statistically significant in the study area. TFP growth in undivided Andhra Pradesh is comparatively better than in MP which turned out to be statistically significant at 5 percent level. The calculated R2 value is only 47.18 percent which implies that the selected variable explains only 47.18 percent of the variation in TFPG. So there are other variables such as research and extension expenditure for chickpea crop improvement, rainfall distribution, literacy rate and financial institutions may have impact on the growth of TFP of the crop. But due to lack of data availability in specific to chickpea crop these variables are not included in the above model.

CONCLUSION

In India, despite the higher instability in area and production, chickpea crop productivity witnessed positive growth rate from the 1990’s onwards due development and adoption of niche specific improved cultivars. At all-India level, the average productivity has increased significantly from 642 kg/ha to 960 at 1.01 percent (CAGR) during 1971-2015. Among the states, the highest productivity growth was seen in the case of undivided Andhra Pradesh followed by Maharashtra, Madhya Pradesh and Rajasthan for the same period. All the selected chickpea growing states registered a positive TFP growth during 2005-2013. It is revealed that in the case of Madhya Pradesh, Rajasthan and Maharashtra states, positive TFP growth rates are due to area expansion under chickpea crop than technological intervention. On the contrary, in undivided Andhra Pradesh, technology and managerial inputs have contributed to positive TFP growth. The regression analysis revealed that in addition to the traditional inputs and technology, variable road density was found to be an important source of growth in TFP in all the

| Source | Coefficient | Standard error | P>|t| |
|--------|-------------|----------------|-----|
| Constant | 66.62 | 118.91 | 0.580 |
| Percent share of net chickpea irrigated | -1.27 | 0.86 | 0.151 |
| Road density | 0.05 | 0.02 | 0.054* |
| Cropping intensity | 0.77 | 0.84 | 0.363 |
| Cold storage capacity in lakh MT | -2.00 | 2.76 | 0.474 |
| Maharashtra (Dummy variable 1) | -36.92 | 29.75 | 0.225 |
| Rajasthan (Dummy variable 2) | -6.54 | 20.16 | 0.748 |
| Andhra Pradesh (Dummy variable3) | -110.51 | 53.17 | 0.047* |

Note: N=36; R² =47.18; F Value 3.47; * significant at 5percent
selected states. While, other factors such as percentage share of net chickpea irrigated area, cropping intensity and cold storage capacity did not have any influence on chickpea crop productivity performance. Another interesting observation made from the study is that, the input cost and quantity of inputs used in chickpea crop have increased significantly which resulted in increase in the cost of production in all the selected states. Hence, it is concluded that on the lines of findings from Andhra Pradesh, there is a need to give emphasis on leveraging technology and other infrastructures for increasing yield of chickpea in other selected states. There is also a need to reduce increasing cost of cultivation by adopting INM and IPM technologies.

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