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Indian Journal of Economics and Development (2018) 14(1), 182-186
DOI: 1.10.5958/2322-0.430.2018.00024.0

NAAS Score: 4.82
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Total Factor Productivity Growth of Soybean in Madhya Pradesh

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Received: October 02, 2017 *Manuscript Number: MS-17196* *Revision Accepted: January 19, 2018*

ABSTRACT

The study was analyzed Total Factor Productivity growth using log of aggregated values of each year was taken to construct output index by Tornqvist-Theil (T-T) approximation to the Divisia Index of soybean and growth in the area, production and productivity of wheat crop in Madhya Pradesh. Time series secondary have been collected for the study. These data have been classified into three periods, viz. Period-I (1986 to 1995), Period-II (1996 to 2005) and Period-III (2006 to 2015) along with overall period (1986 to 2015). The annual overall compound growth rate in the area was positive and significant (5.20percent), while the production (11.98percent) and productivity (1.49percent) of soybean were observed negative and non-significant.Atanoverall level growth rate of TFP in Madhya Pradesh was found to be positive and non-significant, output index was highest during 1986 to 1995 (4.99). The overall growth of TFP and output index wasapositive while, the growth of input index shown negative response during the study period of 2006 to 2015. The overall analysis shows that input as a source of growth for soybean crop was found declined in case of manure, human labour, and animal labour revealing that the ratio of output to input decline over the period of time but still fertilizer and seed are the principal sources of growth for the soybean crop in Madhya Pradesh.

Keywords
Growth, input and output index, TFP, Wheat.

JEL Codes
C43, C81, C51, C52, O13, Q56.

INTRODUCTION

Productivity growth in agriculture is of paramount importance as higher yields are associated with declining rural poverty, suggesting that impact of growth in agricultural production on poverty remains high (Himanshu *et al*., 2010). The agricultural productivity continues to be an important driver of rural poverty reduction; especially it helps in rising agricultural wages. The slow agricultural growth could be due to reduced demand for food, slow technological change in agriculture, lack of employment opportunities for part-time smallholders, limited technology adoption by full-time farmers (Sharma *et al.,* 2016). The oilseed crops play an important role in the agricultural development of India, sharing 14 percent of the country's gross cropped area and accounting for about 3 percent of the gross domestic product and nearly 6 percent of the value of all agricultural products (ICAR-IIOR, 2015). Soybean, introduced for commercial cultivation in India in 1970-71, has established itself as a leading oilseed crop in the rainfed agro-ecosystem of central and peninsular India (Bhatia *et al.,* 2008). The crop has gained tremendous strides in terms of growth in area and production in the country. The area under soybean has increased at an annual growth rate of 13.74 percent and production by 15.1 percent during 1970-71 to 2013-14 (based on five-year moving average data), whereas the growth in productivity has been merely at 1.19 percent only. The government policies and research support from National Agricultural Research System (NARS) paved the way for more than trebling the average productivity of soybean in the country, from 436 kg/ha in 1970-71 to 1353 kg/ha in 2012-13 (Government of India, 2015).

The growth in production and productivity, however, has not been uniform across crops, regions and time periods. It is felt that the potential of green revolution

technologies has reached its limits and it is not able to sustain the future growth in Indian agriculture. The debate is stretched to question the efficacy and contribution of research to the agricultural growth process. Again, a sound empirical analysis of the sources of growth and contribution of factors like research, education, extension, infrastructure, etc. in raising the crop productivity in recent years is missing (Chand *et al*., 2012). This paper makes an attempt to address these issues focusing on the following queries: (1) to study the growth of Agriculture in Madhya Pradesh during the study period, (2) to find out an estimate of Total Factor Productivity of Agriculture in the Madhya Pradesh, and (3) to analyze factor affecting TFP.

METHODOLOGY

Time series secondary data have been collected for the study. These data have been classified into three periods, viz. Period-I (1986-1995), Period-II (1996-2005) and Period-II (2006-2015) along with overall period (1982-2015) for the analysis of growth in the area, production, and productivity and TFP growth. An attempt has been made in the present study to analyze TFP growth in Madhya Pradesh using secondary data collected from different sources. The state has a diversified cropping pattern in different regions depending upon agro-climatic conditions and hence all the important cereals, pulses and oilseeds were selected for the present study.

To calculate input and output index, Tornqvist-Theil index was used for data on output and inputs of the soybean crop. The Tornqvist-index of TFP is the frequently used index to compute TFP growth. It does not require the assumption of neutral technical change and allows for the variable elasticity of substitution (Evenson *et al.,* 1999). Another advantage of this index is that it accounts for the change in the quality of inputs because current factor prices are used in constructing the weights. The quality improvements in inputs are incorporated to the extent that these are reflected in higher wages and rental value (Capalbo & Vo, 1988). The output and input indexes were calculated for the soybean crop in major states and at all-India level using TFPIP program developed by Coelli *et al.* (1998; 2005).

Total Output Index (TOI)

For the construction of output index, principal crops of the State were taken into account. The minimum support Price (MSP) was considered for converting physical values into monetary values. The physical quantities of production of all the crops for all the years were collected and multiplied by the respective Minimum Support Price (MSP) to get the value of the production. All these added to get the total value of production. The log of aggregated values of each year was taken to construct output index using Tornqvist-Theil (T-T) approximation to the Divisia index.

$$TOI_t / TOI_{t-1} = \prod_j (Q_{jt} / Q_{jt-1})^{(R_{jt} + R_{jt-1})/2} = A_t \quad \ldots\ldots(1)$$

Where,

R_{jt} is the share of j^{th} crop output in total revenue in the year t, Q_{jt} is the output of j^{th} crop in year t,

Total Inputs Index (TII)

For the construction of Input Index, following inputs human labour, animal power, seed, fertilizers (NPK)and manures have been taken. The per hectare expenditure on seeds, fertilizers (NPK), manures, human labour, animal power was used from the cost of cultivation data for principal crops in State. Tornqvist index has been used in the proposed study for computing the TFP for the crop sector.

$$TII_t / TII_{t-1} = \prod_i (X_{it} / X_{it-1})^{(S_{it} + S_{it-1})/2} = B_t \quad \ldots\ldots(2)$$

S_{it} is the share of input i in total input cost in year t, X_{it} is the quantity of input i and p_{it} is the price of input i in year t. In the case of TFP for a single crop, revenue share refers to the share of main product and by-product in total revenue from the crop, while output includes main product and by-product. Total output index (TOI) and Total input index (TII) for the year "t" were computed from equations (1) and (2) as follows:

$$TOI(t) = A_1 A_2 \ldots A_t \quad \ldots\ldots(3)$$

$$TII(t) = B_1 B_2 \ldots B_t \quad \ldots\ldots(4)$$

This way, streams of total output index (TOI) and Total input index (TII) for different years (t) were computed from equations (1) and (2) respectively

Total Factor Productivity (TFP)

TFP is defined as the ratio of aggregate outputs to aggregate inputs used in the agricultural production process. As TFP index is a measure of growth the choice of index is important, as it will affect growth rates if the wrong procedure is chosen. Estimates of TFP indices have designed to provide an indication of the change in output per unit of total factor input. This index was computed as the ratio of an index of aggregate outputs to an index of aggregate inputs. Specifying the index equal to 100 in a particular year (1979-80 in the present study) and accumulating the measure based on above equation provides the TFP index. This index was calculated for the crop sector as a whole. The total factor productivity (TFP) index was computed from TOI and TII as under TFPt = {TOI(t)/TII(t)}.

The TFP defined by above equations can be used as an approximation of technological progress, assuming that producers behave competitively, that the production technology is input-output separable, and that there is no technical inefficiency (Antle & Capalbo, 1988).

RESULTS AND DISCUSSION

Trend and Growth

The growth of the area, production, and productivity of soybean in Madhya Pradesh was analyzed during the study (Table 1). The data were divided into three periods, Period-I (1986 to 1995), Period-II (1996 to 2005) and Period-III (2006 to 2015) along with overall period (1986 to 2015).

The area of soybean increased from 1096.50 thousand hectares in (1985-86) to 5578.00 thousand hectares in (2014-2015), that shows a relative change of

392.87 percent with the fluctuation of 37.83 percent during this period. The overall annual compound growth rate (5.20 percent) of soybean was observed positively significant. The growth was found to positively significant during the 1996-2005 (0.64 percent). The growth of an area of soybean was found positive and non-significant during 1986 to 1995 and 2006-2015 (17.94 and 3.49 percent). The higher relative change 166.65 percent during the 1986 to 1995 period as compared to 2006 to 2015 (27.66 percent) and 1996 to 2005 period (3.23 percent) with the fluctuation were also higher in 1986 to 1995 (41.11 percent) period as compared to 2006 to 2015 (11.26 percent) and 1996 to 2005 (5.16 percent) period.

The production of soybean increased from 829.00 thousand tonnes in (1985-86) to 6353.00 thousand tonnes in (2014-2015), that shows a relative change of 753.11 percent with the fluctuation of 48.49 percent during this study. Overall annual compound growth rate (11.98 percent) of soybean was observed positive and non-significant. The growth of production of soybean was found positive and non-significant (20.48 percent) in 1986 to 1995 and positive and significant in the case of 2006 to 2015 (3.55 percent), while during the period (1996 to 2005) was found negative growth rate (1.88 percent). The higher relative change 298.89 percent during 1986 to 1995 as compared to 2006 to 2015 period (13.35) and 1996 to 2005 (-12.68 percent) with the fluctuation was higher in 1986 to 1995 (53.76 percent) as compared to 1996 to 2005 (17.17 percent) and 2006 to 2015 (16.47 percent) during the study. Similar findings were reported by Narayanamoorthy (2007).

The productivity of soybean increased from 756.04 kg/ha in (1985-86) to 1138.94 kg/ha in (2014-2015), that shows a relative change of 72.37 percent with the fluctuation of 19.67 percent during this period. Overall annual compound growth rate (1.49 percent) of soybean was observed positive and non-significant. The growth of productivity was found positive and significant (4.79 percent) in 1986 to 1995 and 2006 to 2015 (0.06 percent), while the growth of productivity in 1996 to 2005 (2.50 percent) was found to be negative and significant. The higher relative change 47.64 percent during1986 to 1995 as compared to 1996 to 2005 (-15.25) and 2006 to 2015 period (3.45) percent with the fluctuation was higher in 1986 to 1995 (19.80 percent) as compared to 1996 to 2005 (16.62 percent) and 2006 to 2015 (11.38 percent) during the study.

Growth rate of Input and Output Index and TFP

Total Factor Productivity of soybean and input-output Index for the different period of time given in Table 2. The data shows that output index was highest during 1986-1995 (4.99). TFP growth was positive during all the period and highest with highly significant during 1986-1995. The overall growth of TFP and output index was a positive while, the growth of input index shown negative response during the study period of 1986 to 2015.

Table 2. Growth rate of input and output index and TFP of soybean in M.P.

Period	Output	Input	TFP
1986 to 1995	4.99	0.34	4.63***
1996 to 2005	0.57	0.39	0.18**
2006 to 2015	1.71	-3.52	3.59**
1986 to 2015	1.64	-1.41	3.09**

**** and ** Significant at 1and 5 percent level.*

Source of Growth in TFP

The source of growth rate in Total Factor Productivity

Table 1. Growth rate of soybean crop in Madhya Pradesh (1982-2015)

Particulars	Average	SD	Base year	Current year	Relative change	CV (Percent)	CGR (Percent)
Area							
1986 to 1995	2148.10	883.09	1096.50	3225.20	166.65	41.11	14.97
1996 to 2005	4332.60	223.45	3849.20	4485.30	3.23	5.16	0.64**
2006 to 2015	5365.70	604.30	4255.30	5578.00	27.66	11.26	3.49
1986 to 2015	3948.80	1494.00	1096.50	5578.00	392.87	37.83	5.20**
Production							
1986 to 1995	1842.80	990.80	829.00	2870.40	298.89	53.76	20.48
1996 to 2005	4030.30	692.06	3891.50	3747.10	-12.68	17.17	-1.88**
2006 to 2015	5936.80	977.99	4500.70	6353.00	31.35	16.47	3.55**
1986 to 2015	3936.70	1909.00	829.00	6353.00	753.11	48.49	11.98
Productivity							
1986 to 1995	818.10	161.95	756.04	889.99	47.64	19.80	4.79***
1996 to 2005	930.53	154.65	1010.99	835.42	-15.25	16.62	-2.50**
2006 to 2015	1106.40	125.94	1057.67	1138.94	3.45	11.38	0.06**
1986 to 2015	951.68	187.21	756.04	1138.94	72.37	19.67	1.49

**** and ** Significant at 1and 5 percent level.*

Table 3. Source of growth in TFP of Soybean in Madhya Pradesh

Period	Seed (kg)	Fertilizer (kg)	Manure (q)	Human labour (hr)	Animal labour (Pair hr)
1986 to 1995	2.59	11.17	-12.63	1.18	-7.27
1996 to 2005	-0.94	-2.60	-0.94	-3.00	-3.30
2006 to 2015	-0.12	1.40	1.99	-4.00	-16.26
1986 to 2015	0.14	1.09	-1.01	-1.10	-6.13

during the different time period is worked out and presented in Table 3. The data presented in table depict that seed as a source of growth during 1986 to 1995 in soybean crop was highest (2.59), while during 1996 to 2005 and 2006 to 2015 it was lowest and negative (0.94 & 0.12), this revealed that the quality seed distribution and seed replacement of soybean by new varieties over old varieties was higher during 1986 to 1995.

While from1996 to 2005, and 2006 to 2015 there was a setback due to drought *in use of inputs* because maximum input as a source of growth depicts negative figure. In case of fertilizers, the growth was highest during 1986 to 1995 because during this period yellow seeded High Yielding Varieties of soybean were introduced and adopted by the farmers of the Madhya Pradesh. The overall response of fertilizers as a source of growth was highest among all the inputs considered in the study for the soybean crop.

Manure as a source of growth shown positive response in soybean crop during 1986 to 1995. The growth of labour resources was positive during 1986 to 1995 (1.18) but remaining periods were negative as well as overall level in the study because substitution of human labour by mechanical power especially in the land preparation and threshing of the soybean crop, it was converted to negative impact as a source of growth. While in the case of animal labour it also showed negative growth during all the periods which was found increasing over the period of time reflecting that rate of substitution of animal labour by machinery power increased over the period of time at a faster rate.

The overall analysis shows that input as a source of growth for soybean crop was found declined in case of manure, human labour, and animal labour revealing that the ratio of output to input decline over the period of time but still fertilizer and seed are the principal sources of growth for the soybean crop in Madhya Pradesh. This indicates that in future more fertilizer responsive and development of varieties resistance to abiotic and biotic stress will lead to positive growth in soybean in Madhya Pradesh.

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CONCLUSIONS

At overall level growth rate of TFP in Madhya Pradesh was found to be positive, The data shows that output index was highest during 19986-1995 due to favourable government policies and effective implementation of various programmes helped in enhancing productivity of principal crops in the state, along with promotion of thefirst programme on oilseeds production which was started as Technology Mission on Oilseeds (TMO), and later on oilseed, pulses, oil palm, and maize were brought in as its ambit in the 1990sIntegrated Scheme of Oilseeds, Pulses, Oil Palm and Maize (ISOPOM, w.e.f. 1st April 2004) which ultimately resulted in enhancing purchase of inputs like improved seed, fertilizer, etc., for soybean production, despite of negative input growth during 2006-2015 reveals that over the period of time response of input is declined due to various reasons such as increasing price, deterioration in quality of input and other managerial factors.

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