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Total factor productivity growth and trend in production of gram in Central India

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Abstract
The study was carried out using data from various sources for growth rate and TFP estimated. The output variable used in the study was yield (kg/ha) and input variables used in the research study viz.: fertilizer (kg/ha), animal power (pair hrs/ha), manure (q/ha), human labour (hrs/ha). These data have been classified into three period's viz. Period-I (1982-1991), Period-II (1992-2001) and Period-II (2002-2011) along with overall period (1982-2011). An overall compound growth rate (CGR) of area (1.02%/year) was observed positively and non-significant. The growth of production of gram was found positive and significant 1.7, 2.02 & 2.96 per cent per year in all the Period while at overall CGR was observed positively & non-significant 2.37 per cent per year in gram. The overall growth of input- output index and TFP was positive during the study period of 1992-2011. Shows that input as a source of growth for gram crop was found decline in case of manure, human labour & animal labour revealing that the ratio of output to input declined over the period of time but still fertilizer and seed are the principal source of growth for gram crop in Madhya Pradesh.

Keywords: Gram, TFP Growth, Trend, Productivity

Introduction
India ranked first in area and production in the world, followed by Pakistan, Australia and Iran. The most important pulse crop in India is gram. It comprised 35.03 per cent of total pulses area and 42.75 per cent of total pulses production, as well as per capita per day (grams) for Rural (2.60) and Urban (1.43) consumption of gram in 2011-12. It is cultivated mainly in the states of Madhya Pradesh, Rajasthan, Maharashtra and Uttar Pradesh. Madhya Pradesh show yields of 1039 kg/ha as compared to the country average of 889kg/ha. The total area and production of gram in the country were 82.5 lakh hectares and 73.3 lakh tonnes respectively. Madhya Pradesh position in area and production of gram 34.58% and 40.42% of the total area and production of the country (DES 2014-15) [3]. Madhya Pradesh is the largest producer accounting for around a third of both area and production. It is mainly consumed as 'Dal' (split cotyledons) and chhole. Many attractive dishes viz – sweets, snacks and namkeen are also prepared from its floor called besan. Also eaten as whole fried or boiled and salted. Fresh green leaves (sag) are used as vegetables and green grains as hare chhole or chholia. Straw of gram is an excellent fodder while both husk and bits of 'Dal' are valuable cattle feed. The daily protein requirement of an average person is 56 g, and 100 g of pulses contain around 25 g of protein. At least half of the daily requirement of protein can be met by including two servings of pulses in the daily diet. Food security stands on the three pillars of availability, access and absorption (nutrition) (UNICEF, 2016) [6]. Encouraging the production and consumption of pulses is in line with the second Sustainable Development Goal's three-fold objective to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture (FAO, 2016b) [7] The major source of the TFP growth has been the public sector investment, notably in research, development and extension (Singh and Pal, 2010) [8]. 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) [10]. 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 at*. 2012) [5]. This paper makes an attempt to address these issues focusing on the following queries: (1) To study the growth of gram, to estimate of Total Factor Productivity of gram in the Madhya Pradesh.

Methodology

The study has been carried out using data from various sources for growth rate and TFP estimation were collected from the published reports of "Comprehensive Scheme for Cost of Cultivation of Principal Crops", by the Directorate of Economics and Statistics, Ministry of Agriculture, Govt. of India, New Delhi. The output variable used in the study was yield (kg/ha) and six input variables used in the research study viz.: fertilizer (kg/ha), animal power (pair hrs/ha), manure (q/ha), human labour (hrs/ha). These data have been classified into three period's viz. Period-I (1982-1991), Period-II (1992-2001) and Period-II (2002-2011) along with overall period (1982-2011). 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 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 variable elasticity of substitution (Evanson *et al.*, 1999) [11].

Analytical Tools

Compound growth rate

The growth rate of area, production, productivity, input and output of gram crop was estimated by using semi log trend equation. Y = abt

Compound growth rate = (b – 1) x 100

Total Output Index (TOI)

The physical quantities of production of all the crops for all the years were collected and multiplied with 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.

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

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 (TIT)

The per hectare expenditure on seeds, fertilizers, manures, human labour, animal power were used. Tornqvist index have been used in the proposed study for computing the TFP for the crop sector.

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

S_{it} is the share of input i in total input cost in year t, X_{it} is quantity of input i and p_{it} is 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 in total revenue from the crop, while output includes main product.

Total output index (TOI) and Total input index (TII) for the year "t" were computed from equations (1) and (2) as follows:

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

$TII\ (t) = B_1\ B_2 \ldots\ldots B_t$ .....(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)

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 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 and Capalbo, 1988) [9].

Results and Discussion

Trend and Growth

The area of gram increased from 2174.27 thousand hectare in (1981-82) to 3012.7 thousand hectare in (2010-11), that shows a relative change of 38.56 per cent with fluctuation of 12.21 per cent during this period. Overall compound growth rate (1.02%/year) of gram was observed positively and non-significant. The growth of area of gram was found positive and significant (0.76 & 0.22%/year) in Period I & II, while the growth rate in Period III (1.85%/year) was found to be positive & highly significant. The higher relative change 15.64 per cent during the period III as compared to period II (5.72) and period-I period (5.11) per cent with the fluctuation were found higher in P II period as compared to P I and P III period.

Table 1: Growth rate of soybean crop in Madhya Pradesh (1982-2011)

Particulars	Average	SD	Base year	Current year	RC %	CV%	CGR
Area							
1982-1991	2199.03	146.98	2174.27	2285.37	5.11	6.68	0.76*
1992-2001	2453.78	248.13	2275.13	2405.23	5.72	10.11	0.22*
2002-2011	2706.26	250.82	2605.27	3012.7	15.64	9.27	1.85**
1982-2011	2453.02	299.49	2174.27	3012.7	38.56	12.21	1.02
Production							
1982-1991	1514.02	166.55	1476.97	1628.5	10.26	11	1.7*
1992-2001	2125.92	357.3	1808.87	2206.27	21.97	16.81	2.02*
2002-2011	2455.17	470.16	2235.5	2925.7	30.87	19.15	2.96*
1982-2011	2031.7	523.58	1476.97	2925.7	98.09	25.77	2.37
Productivity							
1982-1991	687.28	38.72	678.79	710.1	4.61	5.63	0.93*
1992-2001	862.9	83.57	795.29	909.63	14.38	9.68	1.8*
2002-2011	902.29	118.12	854.17	971.69	13.76	13.09	1.09*
1982-2011	817.49	126.49	678.79	971.69	43.15	15.47	1.33

*5 & **1 % Significant level

The production of gram increased from 1476.97 thousand ton in (1981-82) to 2925.7 thousand ton in (2010-11), that shows a relative change of 98.09 per cent with fluctuation of 25.77 per cent during this study. Overall compound growth rate 2.37 per cent per year of gram was observed positively & non-significant. The growth of production of gram was found positive and significant 1.7, 2.02 & 2.96 per cent per year in the period-I, II & Period-III. The higher relative change 30.87 per cent during the period-III as compared to period-II (21.97%) and period-I period (10.26%) with the fluctuation was also higher in period-III as compared to period-II & Period-I during the study**.**

The productivity of gram increased from 678.79 kg/ha. in (1981-82) to 971.69 kg/ha. in (2010-11), that shows a relative change of 43.15 per cent with fluctuation of 15.47 per cent during this period. Overall compound growth rate 1.33 per cent per year of gram was observed positively and non-significant. The growth of productivity was found positive and significant 0.93,1.8 & 1.09 per cent per year in the period-I, II & Period-III. The higher relative change 14.38 per cent during the period-II as compared to period-I (4.61%) and period-III period (13.76%) with the fluctuation was higher in period-III 13.09 per cent as compared to period-II 9.68 and period-I 5.63 per cent during the study.

Growth rate of Input and Output Index and TFP

Sustainable growth in agriculture led to development, which in turn was critically dependent upon the productivity growth, technological change, economics of scale and efficiency of factor used [Chand, R 2012] [5] Total Factor Productivity of gram and Input - Output Index for different periods of time given in Table 2. The data shows that output index was highest during 2002-2011 (0.479). TFP growth was negative during 1982-91 converted to positive TFP during 1992-2001 and highest growth rate during 2002-2011. The overall growth of input- output index and TFP was positive during the study period of 1992-2011.

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

Period	Output	Input	TFP
1982 to 1991	-0.722	0.206	-0.936
1992 to 2001	0.133	-1.644	1.592
2002 to 2011	0.479	-1.483	2.012
1982 to 2011	0.987	-1.250	2.273**

**Significant at 1% level

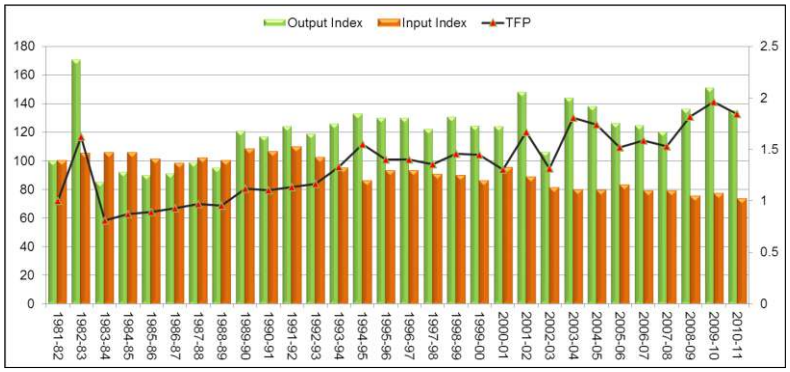

Fig 2: Input Index, Output Index and TFP of Gram Crop in Madhya Pradesh during 1982 to 2011

Source of Growth in TFP

The source of growth rate in Total Factor Productivity of gram in Madhya Pradesh during different time period was worked out and presented in Table 3. The data presented in table depict that seed as a source of growth during 2002-2011 in gram crop is highest (0.832), while during 1982-91 it was lowest and negative (-0.533), this revealed that the quality seed distribution and gram seed replacement of new varieties by old varieties was higher during 1992-2011.

In case of fertilizer growth was found highest during 1982-91 because during this period HYVs of gram were introduced and adopted by the farmers of the Madhya Pradesh. Overall response of fertilizers as a source of growth was highest among all the input considered in the study for the gram crop.

Table 3: Source of growth in TFP of gram in Madhya Pradesh.

Period	Seed (kg/ha)	Fertilizer (kg/ha)	Manure (q/ha)	Human Labour (Hrs./ha)	Animal Labour (Pair Hrs./ha)
1982 to 1991	-0.533	23.029	20.201	-0.379	-5.608
1992 to 2001	0.725	1.415	-26.152	-1.774	-8.187
2002 to 2011	0.832	1.607	-10.326	-1.730	-11.011
1982 to 2011	0.279	4.390	-5.381	-1.245	-7.068

Manure shows positive growth during 1982-91, while negative growth and less response in gram crop during the 1992-2001 & 2002-2011 because its negligible use. The growth of labour as source of growth was negative during all the periods because substitution of human labour by mechanical power specially in the land preparation and threshing of gram crop, Similarly in case of animal labour shown negative growth during all the period which also found to be increasing over the period of time reflecting that rate of substitution of animal labour by machinery power increased over the period of time at faster rate.

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

Factors affecting Total Factor Productivity (TFP)

Multiple regression has been carried out with Total Factor Productivity (TFP) as dependent variables and seed (kg/ha),

fertilizer (kg/ha), manure (q/ha), human labour (hr/ha), animal labour (pair hr. /ha) and independent variables for gram crop (Table 4). The fitted function was found to be best fitted as R^2 value in all the equation of selected crops was found to be around 95 per cent, which shows that the selected variables contributed 95 per cent variability in dependent variables, while remaining 5 per cent was contributed by other variables.

Table 4: Factors affecting Total Factor Productivity of selected crops in M.P

variables	Constant - (a)	Seed	Fertilizer	Manure	Human labour -	Animal Labour	R^2
Regression coefficient	-7.61	-0.001	0.059**	-0.021	0.017***	0.022**	95.06

** Significant at 5% level and ***Significant at 10% level

As far as gram is concerned human labour was found to be positive and highly significant, while fertilizer and animal labour were found to be positive & significant, Which shows that all the variables contributed significantly towards Total Factor Productivity (TFP).

Conclusion

The growth rate of area, production and productivity of principal crops taken in the research was found to be positive and significant across various periods. The overall TFP analysis shows that input as a source of growth for gram crop was found decline in case of manure, human labour & animal labour revealing that the ratio of output to input declined over the period of time but still fertilizer and seed are the principal source of growth for gram crop in Madhya Pradesh. This indicates that in future more fertilizer responsive and development of varieties resistance to a-biotic and biotic stress will lead to positive growth in gram in Madhya Pradesh. As far as gram is concerned human labour was found to be positive and highly significant, while fertilizer and animal labour were found to be positive & significant, Which shows that all the variables contributed significantly towards Total Factor Productivity (TFP). These particular periods have been selected in conjunction with the government programmes that aimed at improving pulse production and productivity. In 2004, the Integrated Scheme of Oilseeds, Pulses, Oil Palm and Maize (ISOPOM) was implemented. In 2007, the National Food Security Mission was launched with the view of enhancing the production of rice, wheat and pulses. The Rashtriya Krishi Vikas Yojna (RKVY) encouraged states to draw up their own comprehensive production plans. Chickpea is susceptible to a large number of pests. Reduction in the duration of the crop helps in avoiding pests as well as saving the crop from drought and associated stress conditions.

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