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Estimation of Total Factor Productivity Growth of Major Pulse Crops in Rajasthan, India

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ABSTRACT

Background: Pulses, supplemented with cereals, provide a perfect mix of vegetarian protein of high biological value. The productivity of pulses in India is less than half of the productivity levels in the USA and Canada. Present investigation was aimed to Total Factor Productivity (TFP) growth in three pulse crops in the state of Rajasthan from 2000-01 to 2017-18.

Methods: In the current study, the Tornqvist Theil Index was used to compute the total output index, total input index and total factor productivity index. The Tornqvist Index is exact for the homogenous translog production function that can deliver a second order approximation to an arbitrary twice differentiable homogenous production function. The translog function does not require perfect substitutes for inputs. If the relative price of input increases, the producer decreases its use (substituting other inputs) until all marginal productivities are proportional to the new prices.

Result: The results of this study has indicates low TFP in gram (0.98%) despite a 59.23 per cent share in the total pulse output of the state. The annual compound growth rate of TFP of black gram increased at the rate of 1.11 per cent per annum (moderate growth) and the contribution of TFP to output growth was low; at about 41.63. Whereas, the compound growth rate of TFP of annual green gram crop increased at the 2.38 per cent per annum (high growth) while its TFP to output growth was about 66.43 per cent. The real cost of production of gram, black gram and green gram crop increased by 0.77, 1.49 and 1.57 per cent per annum, respectively.

Key words: Growth, Productivity, Production, TFP.

INTRODUCTION

India is the largest producer and consumer of pulses in the world accounting for about 29 per cent of the world area and 19 per cent of the world's production. Even more importantly India is also the largest importer and processor of pulses in the world. The production of pulses in India has caught in the vicious cycle of low and uncertain yields, poor per hectare returns resulting in farmers' least preference to grow pulses on irrigated and fertile parcel of land, thereby leading to unstable and low yields. Inadequate adoption of production technology, higher price volatility, production risk and low level of irrigation are the important influencing factors responsible for stagnation in the productivity of these crops (Thorat, 2006).

Agriculture sector in India contributes as the most strategic component in the country's economy. Agricultural research plays an essential role in improving production of crops and livestock as the agricultural research system has expanded research productivity and research resource allocation, which are the issues of prime concern. The basic challenge every farmer in agriculture faces is to increase output and minimize the cost. For this, one must know how efficiently the farmers are currently using the inputs, identify the inputs that are inefficiently used and then measures can be suggested to efficiently use such inputs to increase production and also to minimize cost (Pandya and Shiyani, 2002).

There are the two key measures of productivity, partial factor productivity and total factor productivity. Partial factor productivity is the ratio of output to a single input. Total factor productivity (TFP) is an index ratio of aggregate output to aggregate input. TFP is one of the most useful to evaluate economic performance as an ex-post facto. (Niranjan *et al*. 2013). TFP may also indicate technological progress realized in an economy. The source of TFP growth is not only technological progress but also progress in the quality of inputs or efficiency improvement depending on better organization or institutional restructuring. Growth rate of agricultural produces simply depict performance of agriculture but does not reveal anything about efficiency of the performance. However, factor productivity reveals efficiency with which the factors as inputs are converted into output within production processes. Therefore, accurate

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measurement of TFP is crucial to understanding changes in productivity growth (Das, 2015).

MATERIALS AND METHODS

The current study is based on secondary data. Analysis has been done on the growth in output, input and total factor productivity indices of the three important pulse crops namely Gram, Black gram and Green gram over the past 19 years *i.e.* 1999-00 to 2017-2018. The calculating of total factor productivity (TFP) and growth rates of inputs and output, the data on input, output and prices of various crops collected under the scheme of "Cost of Cultivation of Principal Crops in Rajasthan" was obtained from the Department of Agricultural Economics and Management, MPUAT Rajasthan College of Agriculture Campus, Udaipur. The data on crop inputs included human labour (man days/ha), bullock labour (pair days/ha), machine labour (man days/ha), seed (kg/ha), manure(tonne/ha), fertilizer (kg/ha), insecticides (Rs/ha) and irrigation (Rs/ha). The expenses incurred toward depreciation (Rs/ha), rental value of owned land (Rs/ha), rental paid for lease in land, land revenue, taxes, cesses, interest on working and fixed capital were included under the head of miscellaneous cost.

In the present study, the Tornqvist Theil index was used for computing the total output index, total input index and total factor productivity index. TFP captures the amount of increase in total output that is not accounted for by increases in total input, but that occurs due to shift in production function, which could be to improved technology, management, knowledge, infrastructure and other knowledge-based factors. Input quantity data were available for some inputs namely seed, fertilizer, manure, human labour and bullock labour. Therefore, input quantity indices were worked out directly for each it. However, for the inputs like irrigation charges, insecticides, machine labour, rental value of land and other paid out cost, data were available only in value terms. Therefore, an indirect method has been used to compare their quantity indices. First, their value indices were prepared which were than divided with respective price indices. Due to non-availability of such regional price indices, all India price indices for pesticides, pump driven irrigation and all commodities have been used under the assumption that the price of proxy inputs represents the price of these inputs and relative price structure remaining the same (Kumar and Parminder, 2012). These indices were calculated as follows:

Total output index (TOI)

Total output indices were constructed using the Tornqvist Theil index approach as follows (Olayiwola *et al.,* 2015):

$$\frac{TOI_t}{TOI_{t-1}} = \pi_j \left(\frac{Q_{jt}}{Q_{jt-1}}\right)(R_{jt} + R_{jt-1})$$

TOI_t = Total output index in t^{th} year.
TOI_{t-1} = Total output index in (t -1) t^{th} year.
Q_{jt} = Output of j^{th} crop in t^{th} year.
Q_{jt-1} = Output of j^{th} crop in (t-1) t^{th} year.
R_{jt} = Output share of j^{th} crop in total revenue in t^{th} year.
R_{jt-1} = Output share of j^{th} crop in total revenue in (t-1) t^{th} year.
R_{jt} was calculated follows:

$$R_{jt} = \frac{\text{Value of } j^{th} \text{ crop output in } t^{th} \text{ year}}{\text{Aggregate crop output value in } t^{th} \text{year}}$$

$$R_{jt} = Q_{jt} \times P_{jt} / \sum_{j-1}^{n} Q_{jt} \times P_{jt}$$

Where,
Q_{jt} = Output of j^{th} crop t^{th} in year.
P_{jt} = Post/farm harvest price of j^{th} crop in t^{th} year.

Thus, total output indices for individual crops were worked out taking 1999-2000 as the base period and was multiplied to arrive TOI for crop sector. The output index includes the main product as well as by products.

Total input index (TII)

Total input indices were constructed using the Tornqvist Theil index approach as follows:

$$\frac{TII_t}{TII_{t-1}} = \pi_j \left(\frac{X_{it}}{X_{it-1}}\right)(S_{It} + S_{It-1})^{½}$$

Where,
TII_t = Total input index in t^{th} year.
TII_{t-1} = Total input index in (t-l) t^{th} year.
X_{it} = Quantity of i^{th} input used in j^{th} crop in t^{th} year.
X_{it-1} = Quantity of i^{th} input used in j^{th} crop in (t-1) t^{th} year.
S_{It} = Share of input 'i' in total input cost in t^{th} year.
S_{It-1} = Share of input 'i' in total input cost in (t-1) t^{th} year.

Thus, input indices for individual inputs were prepared taking 1999-2000 as the base year and was multiplied to arrive at the total input index of individual crops. The input indices for individual crops were then multiplied to get the total input index of crop sector (Rao, 2005).

Total factor productivity index (TFPI)

Total factor productivity indices were computed as the ratio of total output index (TOI) to total input index (TII).

$$TFPI_t = (TOI / TII_t) \times 100$$

RESULTS AND DISCUSSION

Rajasthan economic performance especially after 1991 reform created good potential for export and could contribute to foreign exchange earning agricultural commodities. In order to identify farmers' specific strategy for development, it is essential to view the pattern of growth of output and input of important crops in Rajasthan. To examine the total factor productivity of crop sector in Rajasthan, 3 important pulse crops were included in the present study.

Growth in input, output and TFP index of gram

Chickpea is major pulse crop in India contributed about 49 per cent of total production. Madhya Pradesh is the highest producer of gram contributing around 35 per cent in the national production, followed Rajasthan and Maharashtra.

Rajasthan contributes 13.19 per cent of total gram production in India.

Table 1 and Fig 1 indicated that the total output index of gram ranged from 94.61 per cent in 2007-08 to 136.34 per cent in 2013-14, whereas total input index varied between 57.47 per cent in 2004-05 and 106.41 per cent in 2015-16 in Rajasthan state. The annual compound growth rate of total output, total input and TFP increased at the 1.30, 0.47 and 0.98 per cent per annum respectively.

In Rajasthan TFP growth of gram had remained low growth to around 1 per cent per annum during the study period. The contribution of TFP to output growth was about 60.23 per cent (Table 4) during the period 2000-01 to 2017-18. The analysis had clearly indicated that in general the technical change in gram crop. On the other hand gram crop have exhibited deceleration in technical change, which calls for further research on gram crops. There is a need to focus on developing varieties suitable for different agro-climates and emerging farming systems. The real cost of production of gram crop increased by 0.83 per cent per annum (Table 4). It implies the input prices, quantity of inputs and labour charges increased for gram crop in during the study period.

The gram crop scientist should give effort to break the present yield ceiling of gram by developing high yielding new varieties, the government should give more attention to allocate sufficient fund for further development of gram and Policy makers should give attention to minimize inputs price and maximize the output price by any means.

Table 1: Growth in input, output and TFP index of gram.

Years	Output index	Input index	TFP index
1999	100.00	100.00	100.00
2000	96.17	98.39	97.74
2001	114.85	87.34	131.49
2002	104.90	90.85	115.46
2003	99.99	61.39	162.87
2004	106.63	57.47	185.54
2005	97.86	91.42	107.04
2006	115.64	97.43	118.69
2007	94.61	92.72	102.03
2008	135.63	75.27	180.19
2009	120.91	76.46	158.13
2010	129.72	74.91	173.16
2011	112.88	93.49	120.74
2012	108.47	98.56	110.05
2013	136.34	90.21	151.13
2014	125.29	89.70	139.67
2015	113.25	106.41	106.43
2016	112.22	105.21	142.23
2017	134.23	75.23	152.26
CGR (%)	1.30	0.47	0.98

Growth in input, output and TFP index of black gram

Black gram is one of the important pulse crop grown throughout India. It is consumed in the form of 'dal' (Whole or split, husked and un-husked) or perched. Urad differs from other pulses in its peculiarity of attaining a mucilaginous pasty character when soaked in water. It is consumed variety of ways across the north to south in preparation of different regular and popular like vada, idli, dosa, halwa, imrati in combination with other food grains. Also used as a nutritive fodder for miltch cattle. The main areas of production being Madhya Pradesh, Rajasthan, Uttar Pradesh, Punjab, Maharashtra, West Bengal andhra Pradesh and Karnataka. Rajasthan contributes 10.26 per cent of total gram production in India.

The result presented in Table 2 and Fig 1 indicated that, the annual compound growth rate of total output, total input and TFP increased at the 2.49, 1.42 and 1.11 per cent per annum, respectively under the study period in Rajasthan. The output index of urad varied between 47.56 in 2002-03 to 192.60 per cent in 2010-11. Input index varied 97.05 per cent in 2002-03 to 172.71 per cent in the year 2008-09. It implies that input index and output index fluctuated in different years. Input index were more than 100 for 13 years. It shows that mostly years input prices increased during the study period. There is a need for government to subsidies price of seeds and to encourage more hybrid seeds that will enhance more outputs. Adequate farm inputs must be made available at cheap price to the farmers and government must follow a clear channel supply system of inputs. Annual growth

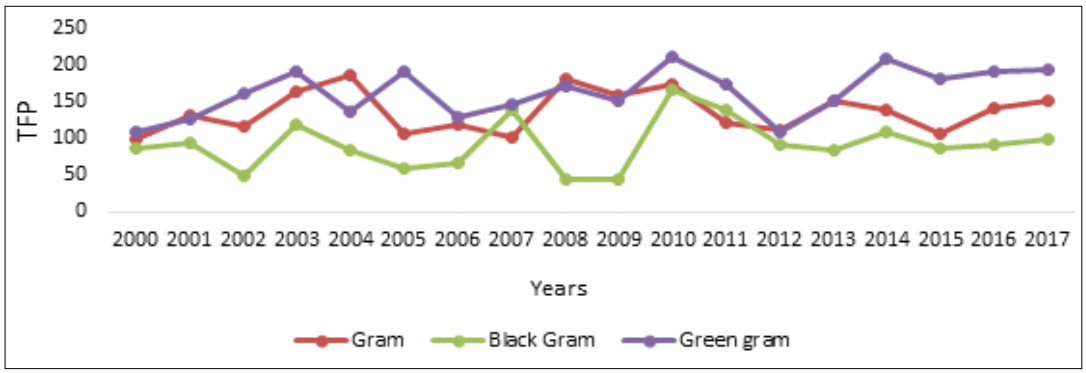


Fig 1: TFP Index of gram, black gram and green gram in Rajasthan state for the year 2000-01 to 2017-18.

in output index was higher than the inputs-use index, leading to positive moderate growth in TFP for urad in India. As far as the total output and TFP indices of urad were concerned, many ups and downs were witnessed. The TFP index was the highest in 2007-08 (139.04 per cent) and the lowest in 2008-09 (44.79 per cent). Similar findings were observed by (Suresh and Reddy, 2016) in Madhya Pradesh in urad crop.

The real cost of production and share of TFP in output growth of crops presented in Table 4. The contribution of TFP to output growth was low about 35.14 in during the study period. It indicated that urad crop need more efficiently technological breakthrough to increase productivity and proper price incentive to pace with other crops in the state. The growth of real cost of production increased by 1.70 per cent per annum during the study period, indicating that input-use had increased faster than productivity. It implies that urad production was increasingly becoming input intensive with low yield response.

Growth in input, output and TFP index of green gram

Green gram is an excellent source of high-quality protein with easy digestibility, consumed as whole grains, dal and sprouted in variety of ways. As value addition, split and dehusked, fried, fried in fat, fetch good value as snacks. Maharashtra is the largest producer of green gram accounting nearly for 23.05 per cent of the total production followed by Karnataka (17.46 per cent), Andhra Pradesh (17.39 per cent), Bihar (14.69 per cent) and Rajasthan (7.50 per cent).

It can be observed from Table 3 and Fig 1 that the total output index of moong ranged from 98.41 per cent in 2004-05 to 224.22 per cent in 2010-11, whereas total input index varied between 72.56 per cent in 2005-06 and 106.52 per cent in 2010-11 during the study period of 16 years in Rajasthan. The total output index of moong was relatively higher than those of the total input index in all years. It indicated that output prices increased more than input prices during the study period. The annual compound growth rate of total output, total input and TFP increased at the 3.59, 1.13 and 2.38 per cent per annum, respectively. The technological change in modern variety of moong production during the study period was mostly cost effective for the farmers (Sanap *et al*. 2016) in pigeon pea crop.

Rajasthan state had shown an outstanding performance of TFP growth in moong. The achievement of high growth of TFP (>2%) for moong in Rajasthan state was credited to the release of varieties *viz*., K.851 in1982, P.D.M-11 in 1987, pusa vishal in 2001 and S.M.L 668 in 2003 by then the different agricultural university of Rajasthan state, which remarkably increased the productivity of moong crop. The unit cost of moong production had been increased by 1.57 per cent per annum in the state (Table 4). It is implying the rapidly increased the prices of inputs including labour charges during the period of study. The contribution of TFP to output growth was about 68.47 per cent (Table 4) in during

Table 2: Growth in input, output and TFP index of black gram.

Years	Output index	Input index	TFP index
1999	100.00	100.00	100.00
2000	100.21	115.45	86.79
2001	94.60	101.23	93.45
2002	47.56	97.05	49.00
2003	136.42	115.38	118.23
2004	94.08	113.68	82.75
2005	64.29	107.49	59.81
2006	76.31	113.07	67.48
2007	138.25	99.43	139.04
2008	77.36	172.71	44.79
2009	68.73	157.83	43.54
2010	192.60	116.10	165.89
2011	134.85	98.10	137.46
2012	150.27	162.72	92.34
2013	94.08	112.11	83.91
2014	145.30	134.89	107.71
2015	100.35	117.05	85.73
2016	112.65	143.25	92.25
2017	133.23	122.23	98.25
CGR (%)	2.49	1.42	1.11

Table 3: Growth in input, output and TFP index of green gram.

Years	Output Index	Input Index	TFP Index
1999	100.00	100.00	100.00
2000	98.46	91.43	107.68
2001	99.71	79.63	125.21
2002	119.04	74.50	159.78
2003	146.63	77.31	189.66
2004	98.41	72.90	134.99
2005	137.71	72.56	189.78
2006	128.90	99.23	129.90
2007	141.90	96.61	146.87
2008	152.01	88.43	171.89
2009	125.46	82.65	151.79
2010	224.22	106.52	210.49
2011	183.78	106.22	173.01
2012	106.88	97.71	109.38
2013	138.65	91.99	150.72
2014	187.40	89.52	209.33
2015	182.45	100.67	181.23
2016	190.25	98.23	190.23
2017	194.25	99.32	192.35
CGR (%)	3.59	1.13	2.38

Table 4: Annual growth rates of real cost of production and share of TFP in output growth for selected pulses crops in Rajasthan during the period 2000-01 to 2017-18.

Crops	Real cost of production (%)	Share of TFP in output growth (%)
Gram	0.77	59.23
Black gram	1.49	41.63
Green gram	1.57	66.43

the study period. It indicated the technological change in moong crop including agronomical practices, plant protection measures and mechanization had helped to sustain TFP growth. These finding were also in consonance with studies done by (Suresh and Reddy, 2016) during the second period (2004-05 to 2014-15) in moong crop.

CONCLUSION

The annual compound growth rate of total output, total input use and TFP of gram were 1.30, 0.47 and 0.98 per cent per annum, respectively. Black gram registered positive TFP growth (1.11 per cent per annum) with positive growth in total output (2.49 per cent per annum) and also in total input use (1.42 per cent per annum). Green gram recorded positive growth in total output, total input and TFP index were 3.59, 1.13 and 2.38 per cent per annum, respectively. To address the issue of technological progress and crop sustainability in Rajasthan, the selected crops were classified into five groups according to the magnitude of growth in TFP, as under, as given by (Chand *et al.* 2011).

Negative growth	TFP growth less than zero
Stagnant growth	TFP growth positive but less than 0.5%
Low growth	TFP growth of 0.5 to 1%
Moderate growth	TFP growth of >1-2%
High growth	TFP growth of more than 2%

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