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Case Study

Analysis of Total Factor Productivity of Pigeon Pea (Red Gram) in North-Eastern Karnataka, India

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ABSTRACT

The present paper explores the growth of total factor productivity of red gram crop in North-Eastern Karnataka. The cost of cultivation data of red gram crop for the period 1990-91 to 2012-13 was used for estimation of Total Factor Productivity. It was found that TFP of red gram crop has substantially increased in North Eastern Dry Zone and the mean TFP index recorded for the entire 23 year period was 1.92. TFP of red gram during the period has registered a growth rate of 5.14 percent per annum implying that change in output growth is due to the factors such as research, extension, soil types, rainfall and infrastructure facilities, etc. In the case of North-Eastern Transitional Zone, the TFP index registered fluctuations over 23 year period and there was no substantial growth in TFP. The total factor productivity estimate of red gram crop shows that there was significant growth in TFP in North-Eastern Dry Zone compared to North-Eastern Transitional Zone.

Highlights

- The total factor productivity estimates of red gram crop indicate that there was substantial growth in TFP in North-Eastern Dry Zone compare to North-Eastern Transitional Zone of Karnataka.

Keywords: Total factor productivity, output, input, red gram, Tornqvist-Theil, etc.

Pigeon pea (*Cajanus cajan*), commonly known as red gram or tur or arhar, is a very traditional and an important pulse crop of India. Pigeon pea is generally grown as an intercrop with other cereals, pulses, oilseeds and annual crops. In India, about 80 - 90 % of the intercropping is practiced with pigeon pea. India ranks first in area (79%) and production (67%) of red gram at global level. The major states which grows red gram are Maharashtra, MP, Karnataka, UP, Gujarat and Jharkhand accounts more than 80 percent of India's red gram production. Karnataka state ranks third in production of red gram crop in the country. It is extensively grown in northern districts of Karnataka such as Gulbarga, Yadgir, Bidar and Raichur. To increase the productivity of red gram crop both public and private sector research institutions has developed many improved technologies and practices/methods. In North-Eastern Karnataka the public institutions like the University of Agricultural Sciences, Raichur, and Dharwad have developed and released many improved technologies/practices to enhance productivity of red gram and income of the farmers (Suresh and Chandrakanth, 2016).) So, total factor productivity analysis will helps to determine the contribution of non-conventional factors in productivity growth (Suresh, 2013). In this

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study an attempt has made to assess the growth of total factor productivity of red gram crop in North-Eastern Karnataka.

MATERIALS AND METHODS

To estimate the TFP index, the time series data on inputs used in red gram production and outputs of red gram were used. The data on quantity of inputs used and output produced in cultivation of red gram were collected from the annual Farm Management Survey reports published by the Directorate of Agriculture, Government of Karnataka. The TFP index of red gram was estimated for North Eastern Dry Zone (NEDZ) and North Eastern Transitional Zone (NETZ) because these two agro climate zones cover most of the North-Eastern Karnataka region.

Total factor productivity index

Total factor productivity is the change in output growth is not due to change in input growth; it is due to non-conventional factors such as research, extension, management skills, better infrastructure facilities like markets, roads, etc. There are various methods are used to compute the TFP. For this study, Tornqvist-Theil indices are computed and it is an exceptional method for measuring TFP change (Evenson *et al.* 1999). The total factor productivity index is worked out by taking ratio of index of total output to an index of total inputs. Therefore, Growth in TFP is the growth rate in aggregate output less the growth rate in aggregate inputs. The assumptions of this index are competitive behaviour, constant returns to scale, Hicks-neutral technical change and input-output separability (Rosegrant and Evenson, 1995).

The Tornqvist index of TFP is expressed in logarithmic form as:

$$\ln(TFP_{t+1}/TFP_t) = \tfrac{1}{2}\sum_j (R_{jt+1} + R_{jt}) \ln (Q_{jt+1}/Q_{jt}) - \tfrac{1}{2}\sum_j (S_{it+1} + S_{it}) \ln(X_{it+1}/X_{it}) \quad \ldots(1)$$

Where,

R_{jt} is the share of output j in returns; Q_{jt} is output j; S_{it} is the i^{th} input share in the total cost of input, and X_{it} is input i, all in period t.

$$R_{jt} = (P_{jt} * Q_{jt}) / \sum_{j=1} (P_{jt} * Q_{jt})$$

Where P_{jt} is the price of output of red gram Q_j in period t

$$S_{it} = (W_{it}X_{it}) / \sum_{j=1} (W_{it}X_{it})$$

Where, W_{it} is the price of input (X_i) in period t.

The output index, input index and TFP index are constructed separately for the red gram crop. The main product and by-product of red gram are included in the output index. Inputs included in the computation of input index are seeds, manure, chemical fertilizer, human labor, bullock labor, machine labor, plant protection chemicals, and farm prices of inputs. The TFP index is worked out by dividing total output index by the total input index. It is specified that the index is equal to 1.00 in a base year i.e. 1990-91 and the TFP chain index is estimated as it shows annual changes in productivity over time (Coelli *et al.* 2005).

Growth model

To estimate the annual growth rates in output use, input use and TFP of red gram,

Exponential function is expressed in the following form,

$$Y = ab^x$$

On applying natural logarithm, we get,

$$ln\ Y = ln\ a + x\ ln\ b$$

Where,

Y is TFP, output and input indices; a is the intercept; b is the regression coefficient and x is the time in years, here compound growth rate is = antilog of ($Ln\ b$) –1.

RESULTS AND DISCUSSION

The red gram is a major legume rich in proteins and popularly used in daily consumption. To improve the productivity of crops, researchers have made significant contribution in development of improved technology in red gram. The total factor productivity estimates of red gram indicate policymakers and scientists regarding the contribution of non-conventional inputs in the output (Table 1).

The results obtained by employing Tornqvist-Theil index method for estimating output index, input index, TFP index are given in Table 1 and 2. The TFP index of red gram crop in North- Eastern Dry Zone increased from 0.83 in 1991-92 to 2.10 in 2012-13 with usual variations in growth. The low TFP index recorded was 0.7 in 1997-98 because there was deficit rainfall in the region. The highest TFP index was noticed during the year 2003-04 (3.79) implying contribution of assured rainfall, adoption of improved technologies and better marketing, etc. The average TFP index was 1.92 over 23 years and TFP index was recorded more than unity in most of the agriculture year. The output index in NEDZ increased from 1.17 in 1991-92 to 1.54 in 2012-13, whereas input index increased from 0.96 in 1991-92 to 3.23 in 2012-13. The lowest output index was in 1993-94 (1.03) and the highest output index was 5.03 in 2001-02. The average output index was 1.47 for the 23 year period. The input index was the lowest in 1996-97 (0.96) and highest in 2001-02 (5.03). The average input index was 2.80 for the period of 23 years.

The indices graphically presented in the fig. 1 reveals that the TFP index has increased substantially over the years and remained below the total output index in most of the years. The output index has shown tremendous change after the year 1998-99 and didn't show falling trend till 2012-13. It is also seen from the Fig. 1 that the total output index always above the total input index except during the year 1997. We can also examine that when total output index falls then the TFP index also falls. So, there exists a positive relationship between TFP index and output index. The total input index has shown a trend of more fluctuations from 1991-92 to 2012-13. It was higher than TFP index during initial period and remained below the TFP index curve after 1999. It is confirmed the TFP index and input index have inverse relationship. The TFP The positive change in TFP index indicates the change in output growth is due to the factors such as research, extension, soil types, rainfall and infrastructure facilities, etc.

The TFP index in North-Eastern Transitional Zone registered fluctuations over 23 year period (Table 2). The TFP index increased from 0.64 in 1991-92 to 0.85 in 2012-13 with high variations. The NETZ is entirely different from NEDZ with respect to climate, topography and rainfall pattern. This zone receives assured rainfall during kharif season and soil type varies from shallow to medium black, clay and lateritic. The highest TFP index is noticed during 2003-04 (1.97) and the lowest 0.48 during 1997-98. The average TFP index was 1.01 over 23 years, which indicates there is not much contribution from non-conventional factors for TFP growth. The graphical presentation of indices (Fig. 2) shows that the TFP index in NETZ recorded volatile behaviour in most of the year. The input index remained above the TFP index with increasing trend. The higher input index than TFP index is mainly due to over use of farm inputs such as seeds, chemical fertilizers, plant protection chemicals and labor, etc. The output index also has shown a volatile behaviour during the period 1991-92 to 2012-13. The findings of the study are in line with (Suresh and Chandrakanth, 2015), (Mukherjee *et al.* 2017).

Table 1: Total output, total input and total factor productivity of red gram crop in North Eastern Dry Zone of Karnataka

Sl. No.	Year	Total output index	Total input index	TFP index
1	1990-91	1.00	1.00	1.00
2	1991-92	0.96	1.17	0.83
3	1992-93	1.16	1.28	0.90
4	1993-94	1.72	1.23	1.40
5	1994-95	1.52	1.03	1.48
6	1995-96	2.30	1.87	1.23
7	1996-97	2.33	1.59	1.46
8	1997-98	1.39	1.97	0.70
9	1998-99	1.74	1.58	1.10
10	1999-00	1.89	1.36	1.39
11	2000-01	2.61	1.87	1.40
12	2001-02	5.03	1.65	3.05
13	2002-03	4.73	1.68	2.82
14	2003-04	3.92	1.04	3.79
15	2004-05	4.84	1.88	2.57
16	2005-06	4.60	1.72	2.66
17	2006-07	3.72	1.18	3.16
18	2007-08	3.51	1.81	1.94
19	2008-09	2.90	1.39	2.09
20	2009-10	2.50	1.44	1.74
21	2010-11	3.96	1.41	2.81
22	2011-12	2.90	1.17	2.48
23	2012-13	3.23	1.54	2.10
	Mean	**2.80**	**1.47**	**1.92**

Table 2: Total output, total input and total factor productivity of red gram crop in North Eastern Transitional Zone of Karnataka

Sl. No.	Year	Total output index	Total input index	TFP index
1	1990-91	1.00	1.00	1.00
2	1991-92	0.48	0.75	0.64
3	1992-93	0.58	1.17	0.49
4	1993-94	0.94	1.25	0.75
5	1994-95	1.72	1.26	1.36
6	1995-96	3.24	3.27	0.99
7	1996-97	2.79	2.99	0.93
8	1997-98	1.48	3.07	0.48
9	1998-99	2.18	1.97	1.11
10	1999-00	1.68	1.66	1.01
11	2000-01	1.82	1.44	1.27
12	2001-02	2.65	1.50	1.77
13	2002-03	2.31	1.52	1.52
14	2003-04	2.41	1.35	1.78
15	2004-05	2.12	1.39	1.53
16	2005-06	2.26	2.97	0.76
17	2006-07	1.02	1.74	0.59
18	2007-08	2.09	1.95	1.07
19	2008-09	1.85	2.76	0.67
20	2009-10	2.96	3.27	0.90
21	2010-11	1.66	3.14	0.53
22	2011-12	1.70	1.35	1.26
23	2012-13	2.70	3.19	0.85
	Mean	**1.90**	**2.00**	**1.01**

A perusal of Table 3 reveals that, in the North Eastern Dry Zone, over the entire period of study (1990-91 to 2012-13), TFP of red gram grew by 5.14 percent per annum. During the same period, the output index is increased by 5.83 percent per annum and the input index marginally increased by 0.65 percent per annum. In the case of North Eastern Transitional Zone, the output index and input index has shown positive growth of 3.79 percent and 3.35 percent per annum, respectively. The TFP index has registered a marginal growth of 0.43 per annum. The TFP of red gram has recorded positive growth in North-Eastern Karnataka and this was mainly due to adoption of improved technologies/ practices by farmers in North-Eastern Karnataka region. Apart from research and extension efforts other factors such as rainfall, markets, roads or infrastructure also contributes for change in TFP of red gram crop. The results corroborate the findings of (Rao, 2005), (Kumar and Mittal 2006), (Suresh, 2013) and (Suresh and Chandrakanth, 2015).

Table 3: Annual growth rates in input use, output use and TFP growth in red gram in Karnataka: 1990-91 to 2012-13 (in percent)

Sl. No.	Particulars	Total Output	Total Input	TFP growth
1	North-Eastern Dry Zone	5.83	0.65	5.14
2	North-Eastern Transitional Zone	3.79	3.35	0.43

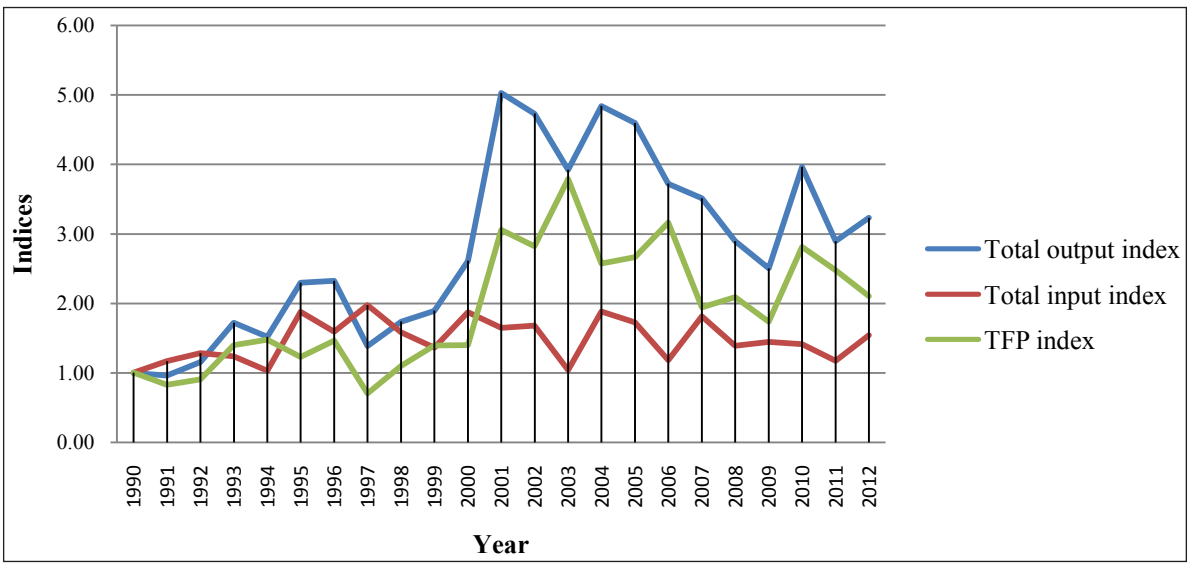

Fig. 1: Trend in Total output, total input and total factor productivity of red gram crop in North- Eastern Dry Zone of Karnataka

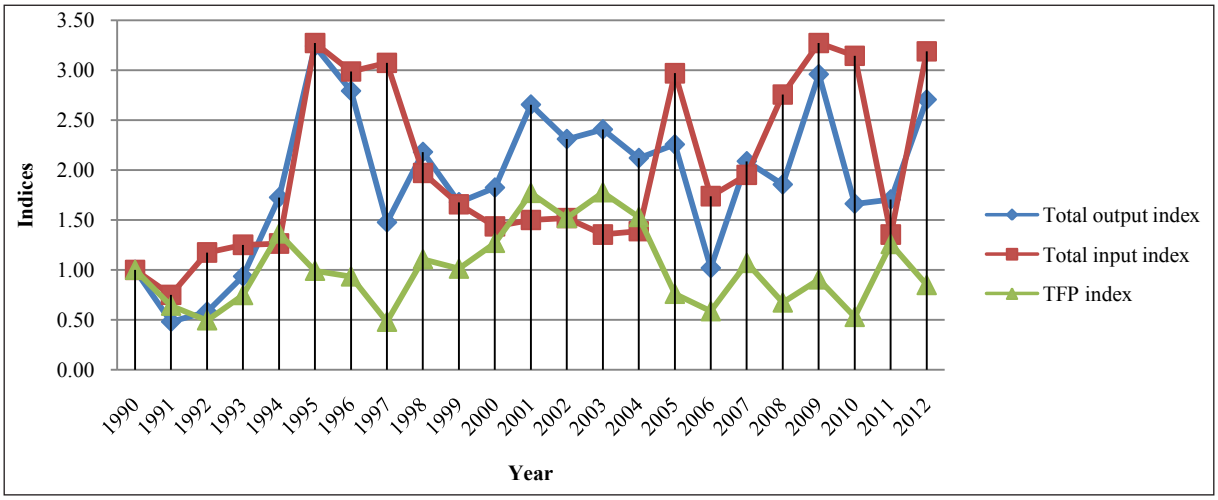

Fig. 2: Trend in Total output, total input and total factor productivity of red gram crop in North- Eastern Transitional Zone of Karnataka

CONCLUSION

Total factor productivity is the change in output growth is not due to change in input growth; it is due to non-conventional factors such as research, extension, education, infrastructure, rainfall etc. The total factor productivity estimates in red gram crop indicate that there was impressive growth in TFP of red gram in North-Eastern Dry Zone compare to North Eastern Transitional Zone. The agricultural research and extension efforts were the reasons for positive TFP growth. The TFP of red gram has registered positive change in both zones (Zone 1 and 2) of North-Eastern Karnataka region because of a significant improvement in the adoption of improved technologies/practices by farmers, transfer of technologies through agricultural extension agents, rainfall pattern, and better marketing facilities, etc. The marginal growth of TFP in North-Easter Transitional Zone implies that there is need of induction of new technologies/ practices for productivity improvement in red gram crop. So there is urgent need of new strategies and plans to increase the total factor productivity of red gram crop in North-Eastern Transitional Zone by giving priority for investment in Research and Extension activities.

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