



Total factor productivity growth of pigeon pea crop in Maharashtra

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ABSTRACT

Measurement of productivity growth is very essential to take appropriate policy decisions for the development of the agriculture sector. Present study measures total factor Productivity growth of pigeon pea crop in sub-sector of Maharashtra State. The Tornqvist Theil chained Divisia index approach was applied for the measurement of total factor productivity using output and input data of pigeon pea crop. Farm-level data on yield, level of inputs use and their prices for the period 1989-90 to 2008-09 were taken from the state funded cost of cultivation scheme. The multi-variable model was utilized to know the determinants of total factor productivity growth taking total factor productivity as dependent variable. Beside double sown area, other explanatory variables included total amount of loan, net cropped area, area under irrigation, area under high yielding variety, annual rainfall, villages electrified, number of tractors, number of pump sets, road density. The results indicated that total factor productivity growth was positive in pigeon pea crop in sub sector of Maharashtra State. Area under irrigation, area under high yielding varieties, rainfall, and road density has positive and significant impact on total factor productivity of pigeon pea crop in sub- sector.

Key words: Pigeon pea, Productivity, Total Factor Productivity, Tornqvist-Theil Index.

INTRODUCTION

Pulses are basic ingredient in the diet of a vast majority of Indian population as they provide a perfect mix of high biological value when supplemented with cereals. Importance of pulses is relatively more in our country as its contribution in nutrient supply is far more than in Asia and world as a whole. Each plant of pulse crop is virtually a nature's mini nitrogen fertilizer factory, which enables it to meet its own nitrogen requirement and also benefits the succeeding cereal crop. Pulses are also excellent feed and fodder for livestock. Besides, having dietary value and nitrogen fixing ability, pulses also play an important role in sustaining intensive agriculture by improving physical, chemical and biological properties of soil and considered excellent crops for diversification of cereal-based cropping systems. After independence, India has made much progress in agriculture. Indian agriculture, which grew at the rate of about 1 per cent per annum during the fifties, has grown at the rate of 2.6 per cent per annum in the post independence era. Expansion of area was the main source of growth in the period of fifties and sixties. After that, the contribution of increased area under agricultural production has declined over time and increase in productivity became the main source of growth in agricultural production.

TFP is influenced by changes in technology, institutional reforms, infrastructure development, human resource development, investment in research and development, level of technology adoption and other factors.

(Kumar *et al.*, 2008). Recent experience shows a slowdown in productivity growth of various crops or even some setbacks indicating that all is not well. This has given rise to some pertinent questions namely what is the direction of productivity? Are inputs efficiently utilized? What is the growth in inputs and outputs? This needs elaboration from the TFP studies. Empirical studies of the TFP on developing countries in agriculture are becoming increasingly important in providing a complex picture of technological change. The TFP for Indian crop sector was measured by Rosegrant and Evenson (1992), but the results of the sectoral approach cannot be used precisely for policy decisions with respect to individual crops because technological change varies across crops. Thus TFP growth has to be examined for individual crops (Kumar and Rosegrant, 1994). Hence, the main focus of study was to measure the growth in total factor productivity of pigeon pea crop in Maharashtra and its determinants.

MATERIALS AND METHODS

Farm-level data on yield, level of input use and their prices for the period 1989-90 to 2008-09 were collected from the "Scheme for the study of cost of cultivation of principal crops" Government of Maharashtra, for the pigeon pea crop grown in the state. This data set provided a rich source for measuring and analyzing the agricultural productivity. The time series data on infrastructural variables (road density, number of village electrified, number of pump sets, number of tractors), cropping intensity, total loan amount disbursed, annual rainfall, area under irrigation, area

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under high yielding variety, land-use pattern etc were collected from various publications of government of Maharashtra.

Analysis of total factor productivity (TFP): Total Factor Productivity (TFP) sometimes referred as multifactor productivity, is a true measure of economic efficiency. TFP measures the extent of increase in output, which is not accounted by increase in total inputs. There are three main approaches for estimating the TFP, namely the production function approach (PFA), growth accounting approach (GAA) and non parametric approach. The Production Function Approach (PFA) is associated with various problems like multicollinearity, autocorrelation and degree of freedom, whereas non parametric approach like Data Envelope analysis is very sophisticated and uses linear programming methodology. In Growth Accounting Approach (GAA), TFP is measured as a residual factor, which attributes to that part of growth in the output that is not accounted for by the growth in the basic factor inputs. Amongst three approaches, growth accounting approach is popular mainly because it is easy to implement, requiring no econometric estimation.

The use of TFP indices gained prominence since Diewert (1976) proved that the Theil-Tornqvist discrete approximation to the Divisia index is consistent in aggregation and superlative for a linear homogeneous Tran logarithmic production function. In the present study, Divisia-Tornqvist index has been used for computing the total output, total input and TFP for specified year “t” by for selected crops.

Total output index (TOI)

$$TOIt / TOIt-1 = \pi_j(Q_{jt}/Q_{jt-1})(R_{jt} + R_{jt-1})^{1/2} \quad \dots[1]$$

Total input index (TII)

$$TII_t / TII_{t-1} = \pi_j(X_{it}/X_{it-1})(S_{it} + S_{it-1})^{1/2} \quad \dots[2]$$

Where,

R_{jt} is share of the jth output in total revenue

Q_{jt} is Output of the jth commodity

S_{it} is share of the ith input in total input cost

X_{it} is quantity of the ith input

t is the time period

For productivity measurement over a long period of time, chaining indexes for successive time period is preferable. With chain linking, an index was calculated for two successive periods t and t-1 over the whole period 0 to T (samples form time t = 0 to t = T) and the separate index was then multiplied together.

$$TOI(t) = TOI(1) \cdot TOI(2) \dots TOI(t-1) \quad \dots[3]$$

$$TII(t) = TII(1) \cdot TII(2) \dots TII(t-1) \quad \dots[4]$$

Total factor productivity index (TFP) is given by equation [5]:

$$TFP_t = (TOI_t / TII_t) \quad \dots[5]$$

Chain-linking index takes into account the changes in relative values/costs throughout the period of study. This procedure has the advantage that no single period plays a

dominant role in determining the share weights and biases are likely to be reduced. For constructing the total input index, ten important inputs viz. human labour, bullock labour, machine labour, farm yard manure (FYM), nitrogen, phosphate and potash fertilizers, irrigation, plant protection and land were included.

Factors influencing TFP : To know the influence of infrastructural, socio-economic and technological variable on the productivity of major crops a multi-variable model in the form of log linear was estimated as follows. The time series data from the year 1989-1990 to 2008-2009 were considered for the present study.

$$\ln Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + \dots + b_n \ln X_n$$

Where,

Y = TFP

b_i = Elasticities

X₁ = Total amount of loan (short term + medium term + long term loans) sanctioned by commercial banks, regional rural banks, cooperative banks, primary agricultural cooperative societies and land development banks per thousand hector of net cultivated area (in Rs. lakhs).

X₂ = Proportion of double sown area.

X₃ = Proportion of net cropped area under irrigation.

X₄ = Proportion of net cropped area under high yielding varieties.

X₅ = Annual rainfall (mm)

X₆ = Number of villages electrified per 000' ha of net cultivated area

X₇ = Number of tractors per 000' ha of net cultivated area.

X₈ = Number of pump sets per 000' ha area of net cultivated area

X₉ = Road density kilometer per 000' ha of net cultivated area.

In all there were nine factors studied, the step wise regression analysis which gave only more significant variables in the model was run.

RESULTS AND DISCUSSION

Performance of Pigeon pea in Marathwada region: It can be seen from Table 1 that area production and productivity of pigeon pea in

Marathwada as well as Maharashtra region shows positive growth over the study period. In Marathwada region the production of Pigeon pea shows 11.46 % growth rate over the study period as in case of Maharashtra it was found 3.27 %. Use of improved seeds and technologies during study period results in productivity increase in Pigeon pea. Hence increase in production of Pigeon pea is because of increase in area and productivity of Pigeon pea in both Marathwada and Maharashtra region.

Input share: Share of input in cost of cultivation showed the importance of that input in total cost structure. Table 2 depicts input share in cost structure of pigeon pea in Marathwada region. Rental value of land was having major share in cost of cultivation pigeon pea in all the time span of research. labour component was second important input in cost structure of pigeon pea. Farmers adopted conservative agricultural production technologies to cultivate pigeon pea crop which were not suitable for using modern inputs and

TABLE 1: Growth and instability in pigeon pea (1989-90 to 2008-09)

Parameter	Marathwada			Maharashtra		
	Area	Production	Productivity	Area	Production	Productivity
a	3853.51	923.657	354.224	9857.16	5037.37	519.369
b	28.703	105.87	20.78	56.32	165.13	11.97
r	0.674**	0.780**	0.712**	0.692**	0.55 ^{NS}	0.459*
CGR	0.69	11.462	8.174	0.571	3.278	2.304
Mean	4145.9	2035.3	472.429	10448.6	6771.2	644.5
CV (%)	6.059	39.425	36.589	4.607	26.2	23.89
Instability	4.625.31	26.44	3.42	22.48	21.8	

*** Indicate significance at 1% level, ** Indicate significance at 5% level

Note : Area(00 ha), Production (00 tones) and productivity (Kg/Ha)

TABLE 2: Input share in total input cost of pigeon pea in Marathwada region.

Particular	Pigeon Pea	
	Cost	Share
Total Input cost	11263.92	100.00
Male	1882.52	16.71
Female	1653.05	14.68
Bullock labour	1775.98	15.77
Machine labour	324.53	2.88
Seed / Set	338.58	3.01
Manure	863.09	7.66
Nitrogen	286.57	2.54
Phosphorous	343.88	3.05
Potash	87.53	0.78
Insecticide	396.93	3.52
Rental value of land	2427.00	21.55
Other	782.5	6.95
Total	11263.92	100.00

mechanization; hence farmers utilized more energy in the form of male labour, female labour, and bullock labour.

The low seed cost in Pigeon pea cultivation was due to varieties [BDN-1, BDN-2, BSMR-736, BDN-708 etc] are dominant in farmers field. Not a single Pigeon pea hybrid was successful on farmers' field during last two decade. Nutrients especially nitrogen, phosphorous and potash are required in different quantum hence differences have been observed in nutrient cost.

Input and output growth : Growth rate figures highlighted the trend in input use and output achievement over the time. Results of input and output growth rate of pigeon pea in sub sector Marathwada region of Maharashtra State is presented in Table 3. The pigeon pea yield was increased by 2.90 per cent annually in the Marathwada region. To attend this growth in pigeon pea production, farmers of this region had increased the utilization of some of the important inputs viz male labour (3.95 %), female labour (2.92 %), bullock labour (3.62 %), phosphorous (4.77 %), potash (3.38 %) and insecticide (5.85%). Use of seed and nitrogen remained stagnated over the period of time. The output value of pigeon pea crop increased over the years, this result in positive growth in rental value of land (6.75 %) Fig 1.

TABLE 3: Input-Output growth rate of major crops viz cotton, pigeon pea and sugarcane in Marathwada region.

Particulars	Unit	Pigeon pea		
		Period I	Period II	Overall
Output Input	Qt ha ⁻¹	1.37 ^{NS}	2.51 ^{NS}	2.9*
Male	days ha ⁻¹	2.92 ^{NS}	2.72 ^{NS}	3.95*
Female	days ha ⁻¹	6.65**	4.3**	2.92*
Bullock labour	days ha ⁻¹	1.4 ^{NS}	3.96*	3.62*
Machine labour	Hrs ha ⁻¹	3.38 ^{NS}	1.64 ^{NS}	2.7 ^{NS}
Seed	Kg ha ⁻¹	-2.37**	0.6 ^{NS}	-0.11 ^{NS}
Manure	Qt ha ⁻¹	-8.46**	-0.83 ^{NS}	1.46 ^{NS}
Nitrogen	Kg ha ⁻¹	-5.03**	1.32 ^{NS}	1.68 ^{NS}
Phosphorous	Kg ha ⁻¹	0.15 ^{NS}	5.65*	4.77*
Potash	Kg ha ⁻¹	-1.03 ^{NS}	3.1 ^{NS}	3.38*
Insecticide	Lit ha ⁻¹	2.67 ^{NS}	3.67 ^{NS}	5.88*
Irrigation	No.	—	—	—
Rental value of land	Rs ha ⁻¹	5.08**	5.56**	6.75*

*** Indicate significance at 1% level

** Indicate significance at 5% level

Total factor productivity: 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. The productivity behaviors were examined for two separate decades and overall, the obtained results were presented in Table 4 and 5. Within twenty years, total factor productivity

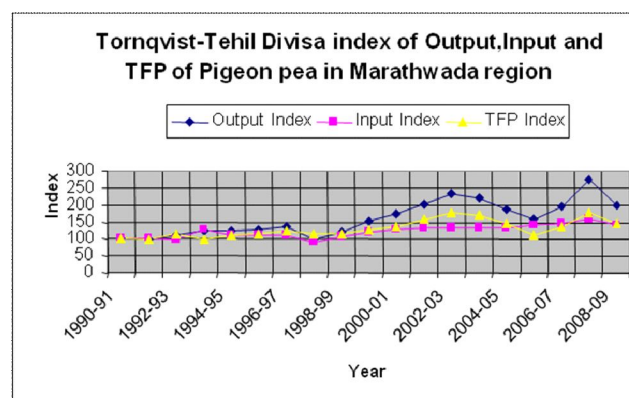
**FIG 1:** Tornqvist – Theil Divisia index of Output, Input and TFP of Pigeon pea in Marathwada region.

TABLE 4: Tornqvist-Theil Divisia Index of Output, Input and TFP of pigeon pea in Marathwada region.

Year	Pigeon pea		
	Output Index	Input Index	TFP Index
1990-91	100.00	100.00	100.00
1991-92	97.00	100.64	96.38
1992-93	109.21	96.70	112.94
1993-94	123.01	126.70	97.08
1994-95	122.12	111.67	109.36
1995-96	128.64	111.59	115.27
1996-97	135.32	110.34	122.64
1997-98	99.25	87.76	113.09
1998-99	117.59	104.57	112.45
1999-00	150.22	119.54	125.66
2000-01	174.05	127.76	136.23
2001-02	203.98	129.19	157.89
2002-03	234.38	131.64	178.04
2003-04	219.11	129.63	169.03
2004-05	187.43	129.47	144.77
2005-06	155.84	141.00	110.52
2006-07	192.70	144.16	133.67
2007-08	273.66	155.04	176.50
2008-09	199.30	138.37	144.03

was recorded highest in the year 2002-03 which was 178.04. Lowest total factor productivity was observed in the year 1991-92 which was 96.38. The Input index (2.29 %) & output index (4.82 %) growth in Pigeon pea were positive, which leads to positive total factor productivity for overall period (2.54 %). In both the decade, output growth was more than input growth resulted positive TFP growth in pigeon pea (Chand *et al* 2012).

Near about eighteen season, were categorized as good season for pigeon pea cultivation where as two seasons falls under bad category. Wilt and sterility were the major problem in pigeon pea. These two problems were counteracted through better breeding programme and new agronomic practices which were adopted by agriculture research station, Badnapur Dist. Jalana and have developed varieties like BDN-1, BDN-2, BSMR-736, BDN-708 etc which are resistant against wilt and sterility. These new genotype is a key for getting positive TFG growth; because they are resistant against wilt and sterility as well as they give good response for better agriculture practices specially for nutrient management.

Factors influencing total factor productivity growth: The step down multiple regression method was used to identify significant parameters by avoiding problem of Multicollinearity. The results obtained are presented in Table 6. Proportion area under high yielding varieties, proportion

TABLE 5: Output, Input and TFP indices growth rates of pigeon pea and in Marathwada region.

Period	Pigeon pea			
	Output Index	Input Index	TFP	TFP Share in output (%)
Period I	1.87	-0.12	1.99	106.58
Period II	2.45	2.10	0.35	14.39
Overall	4.82	2.29	2.54	52.59

TABLE 6: Factors influencing total factor productivity growth of pigeon pea in Marathwada region.

Variables	Pigeon Pea	
	Parameter estimate (b _j)	
Intercept (a)	6.04* (2.55)	
Proportion of double sown area	-0.93 ^{NS} (0.46)	
Proportion of area under irrigation	0.92 ** (0.23)	
Proportion of area under high yielding variety	1.27 ** (0.28)	
Number of villages electrified	2.94* (0.87)	
Number of tractors	1.94 ^{NS} (1.59)	
Road density (km/hr)	0.98** (0.32)	
R ²	0.75	

area under irrigation, number of villages electrified, number of tractor available for cultivation and road density were the important factors which have influence on total factor productivity in Pigeon pea.

CONCLUSION

The TFP growth rate was positive in crop sub-sector of pigeon pea in Maharashtra State. The positive TFP growth is because of technological and infrastructural breakthrough in pigeon pea production system. It was also realized that, an appropriate policy environment, infrastructure, institutions and favorable weather conditions were pre conditions for a steady TFP growth in crop sub sector.

POLICY IMPLICATIONS

1. Increase in production of pigeon pea is because of increase in area and productivity of Pigeon pea in Maharashtra state so that there should be the innitiative action for increase in the area of the pigeon pea in Maharashtra.
2. Wilt and sterility were the major problem in Pigeon pea. These two problems were counteracted through better breeding programme and new agronomic practices.
3. Infrastructural developement leads to increse in productivity of of the pieon pea Government should focus on these developemental issues which are much needed for increse in productivity.

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