Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; Sp 9(3): 683-689
Received: 13-09-2020
Accepted: 21-10-2020

Sarang Monga
Senior Research Fellow, ICAR-Agriculture Technology Application Research Institute, Zone 1, Ludhiana, Punjab, India

Baljinder Kaur Sidana
Scientist (QM) Department of Economics and Sociology, Punjab Agricultural University, Ludhiana, Punjab, India

Corresponding Author:
Sarang Monga
Senior Research Fellow, ICAR-Agriculture Technology Application Research Institute, Zone 1, Ludhiana, Punjab, India

Total factor productivity of coarse cereals in India: State-level analysis using Malmquist approach

Sarang Monga and Baljinder Kaur Sidana

Abstract
Coarse cereals provide food security for both people and livestock. The total factor productivity growth of maize, jowar and bajra in major producing states of India was measured through data envelopment analysis (DEA) based Malmquist Productivity Index (MPI) for the period 1994-95 to 2015-16. The area share of coarse cereals in total cereals has declined from 32 to 25 per cent during study period. Maize has shown positive growth rate in area whereas jowar and bajra showed negative growth rate in study period. Among coarse cereals, maize and bajra crop witnessed total factor productivity growth of 2.6 per cent and 3.1 per cent respectively during overall period whereas jowar witnessed negative TFP growth of -0.2 per cent. The study revealed that the increase in the TFP growth was mainly due to enhancement in technological progress rather than the efficiency growth. TFP growth were higher in second period i.e. 2005-06 to 2015-16 as compared to first period i.e. 1994-95 to 2004-05. Giving priorities to research in low value cereals crop like maize, jowar and bajra and sound strategies of production with ecological balance is the only way forward to meet the food sustainability and nutritional security concerns of millions. Upsurge in agricultural investments, especially in agricultural research, is instantly needed to stimulate growth in TFP.

Keywords: Coarse cereals, India, Malmquist productivity index (MPI), total factor productivity

Introduction

Coarse cereals are group of crops that consists of all cereals except rice and wheat mainly maize, sorghum (Jowar), pearl millet (Bajra), barley, finger millet and small millets. Coarse cereals such as Maize, Jowar and Bajra, the hardiest and least risky cereals, are mainly grown in India's arid and semi-arid regions. These crops possess high nutritive and fodder value and are primarily consumed by their producers (Nagaraj *et al.*, 2013). They also have the potential to improve the food and nutritional security of the world poor since they are more nutritious than the superior cereals. They are rich in nutrients, minerals and vitamins and less in carbohydrate and gluten free nature of these crops also brought about shift in the consumption pattern in the calorie conscious life style. India is in the top list of coarse cereals producers in the world in terms of area and production. Coarse cereals had been traditionally the main components of the food basket of the poor in India and now they are treated as poor man's crop and considered as one of the neglected crop sectors. They are predominantly grown in the resource fragile agro climatic regions of the country mainly in Karnataka, Maharashtra, Tamil Nadu, Madhya Pradesh, Rajasthan and Gujarat. In addition to agricultural allied sectors' demand, it offers a good potential in food processing industry and as a promising exportable commodity. In 2016-17, the area under millets stood at 14.72 million hectares, down from 37 million ha in 1965-66, prior to the pre-Green Revolution era. This decline was largely due to change in dietary habits (induced by a cultural bias against millets post-Green Revolution), low-yield of millets, and conversion of irrigated area towards rice and wheat. Though farmers have been cultivating major coarse cereals such as maize, jowar and bajra production has been volatile largely due to concerns over low productivity and profitability. Coarse cereals provide food security for both people and livestock. Basavaraj *et al*. (2010) and Rao *et al*. (2010), however, note that the consumption of coarse cereals as food in recent years has decreased in both urban and rural areas for various reasons, while increasing their use in the non-food industry. They argue that thanks to favorable government policies on the distribution of low-priced wheat and rice through the state distribution system (PDS), consumers of coarse cereals in rural areas are also switching to rice and wheat. They found that coarse grains are increasingly used in the alcohol, starch, poultry feed, etc. industries. Thus, coarse cereals such as maize, jowar and bajra are important crops, especially for marginal households.

Therefore, increasing the productivity of the main coarse grains becomes important for improving the well-being of poor people in these regions. Under this background the paper seeks to examine total factor productivity of coarse cereals of major producing states in India

Data and Methodology

The study is mainly based on secondary data. The basic input data for the estimation was collected from the reports of "Comprehensive Scheme for Cost of Cultivation of Principal Crops" in India carried out by the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India, New Delhi. The states covering almost 80 per cent of the production of coarse cereals were taken. The output variable was yield per hectare (kg/ha) along with seven input variables which include usage of seed (kg/ha), chemical nutrients (NPK, hg/ha), manure (q/ha), animal labour (pair hours/ ha), human labour (human-hours/ha), and real costs of machine labour and irrigation. The analysis was carried out for the overall period of 1994-95 to 2015-16, which was divided into two sub-periods; 1994-95 to 2004-15 (period I) and 2005-06 to 2015-16 (period II). The first period broadly corresponds to the period of turbulence in the economy characterized by dwindling of public expenditure in agriculture. The second period is characterized by sharp reversal of the public investment and agricultural performance. To avoid extreme variations, the triennial ending averages were used. The analysis was carried out by using the software DEAP 2.1 (Coelli, 1996).

Malmquist Productivity Index

The Malmquist Productivity Index (MPI) introduced by Caves *et al.* (1982) [3] is based on distance functions. The output oriented Malmquist TFP index measures the maximum level of outputs that can be produced using a given level of input vector and the given production technology relative to the observed level of outputs (Coelli *et al.* 2005) [5]. It measures the radial distance of the observed output vectors in the period *t* and *t*+1 relative to a reference technology. The Malmquist productivity index for the period *t* is represented by Equation (1):

$$M^t = \frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \quad \text{…. (1)}$$

Malmquist productivity index is defined as the ratio of two output distance functions taking technology at time *t* as the reference technology. Instead of using period t's technology as the reference technology it is possible to construct output distance functions based on period (t+1)'s technology which can be described as:

$$M^{t+1} = \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)} \quad \text{…. (2)}$$

Fare *et al*. (1994) [8] attempt to remove the arbitrariness in the choice of benchmark technology by specifying their Malmquist productivity change index as the geometric mean of the two-period indices, which is defined as

$$M_0(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\left(\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)}\right)\left(\frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)}\right)\right]^{\frac{1}{2}} \quad \text{…. (3)}$$

Where, the notations x and y represents the vector of inputs and outputs, D_0 denotes the distance and *M* denotes the Malmquist index. Fare *et al.* (1994) [8] by using simple arithmetic manipulations have presented the Malmquist Productivity Index as the product of two distinct components, viz. technical change and efficiency change as indicated below:

$$M_0(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)}\right]\left[\left(\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^{t+1}, y^{t+1})}\right)\left(\frac{D_0^t(x^t, y^t)}{D_0^{t+1}(x^t, y^t)}\right)\right]^{\frac{1}{2}} \quad \text{… (4)}$$

Where,

$$\text{Efficiency change} = \left[\frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)}\right] \quad \text{… (5)}$$

and,

$$\text{Technical change} = \left[\left(\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^{t+1}, y^{t+1})}\right)\left(\frac{D_0^t(x^t, y^t)}{D_0^{t+1}(x^t, y^t)}\right)\right] \quad \text{… (6)}$$

The efficiency change can be further decomposed into pure efficiency change and scale efficiency change. Introduction of linear programming based Data Envelopment Analysis popularized the Malmquist index of productivity measurement. DEA involves construction of piece-wise linear frontier based on the distribution of the data of the input and outputs of various entities/ decision making units (DMUs) using linear programming framework. This frontier constructs a piecewise surface over the data such that the observed data lies on or below the constructed production frontier (Coelli *et al*, 2005) [5]. The efficiency measure for each DMU is calculated relative to this production frontier. Fare *et al.* (1994) [8] identified four important advantages of using Malmquist Productivity Index compared to other approaches. They include: (1) the approach requires data on only quantity, and not prices. Information on prices are generally not available for every input and output for many countries; (2) the linear programming based approach doesn't assume an underlying production function, and therefore the stochastic properties associated with the error term; (3) no prior assumption regarding the optimizing behavior of the DMUs; and, (4) Since the approach allows for both movement towards the frontier and shift in the frontier, it is possible to decompose the TFP into its components viz. technical change and efficiency change.

Trends in area, production and productivity of coarse cereals in India

The area under total cereals in the country hovered around 100 million ha from period 1994-95 to 2015-16 (Table 1). The area under coarse cereals has declined at rate of -1.12 per cent and share in total cereals also decreased from about 32 to 25 per cent during study period. Production of total cereals in T.E 1994-95 was 176.92 million tonnes, which increased to 238.63 million tonnes in T.E 2015-16 at rate of the 1.6 per cent due to increases in the productivity which has increased at a growth rate of 1.72 per cent per annum during the same period. During

Table 1: Trends in area, production and productivity of coarse cereals in India

		TE (1994-95)	TE (2004-05)	TE (2015-16)	CGR Period I	CGR Period II	CGR Overall
Maize	Area	6.13	7.45	9.02	1.93	1.71	2.24
	Production	9.73	14.62	23.67	4.38	4.91	4.98
	Productivity	1588	1962	2624	2.41	3.15	2.68
Jowar	Area	11.42	9.03	6.01	-2.48	-4.04	-3.30
	Production	9.74	7.19	5.08	-3.43	-5.18	-2.79
	Productivity	853	798	846	-0.97	-1.18	0.54
Bajra	Area	9.84	9.81	7.42	-0.63	-3.14	-1.19
	Production	6.80	9.24	8.83	2.20	0.72	1.80
	Productivity	688	934	1190	2.85	3.99	3.03
Coarse Cereals	Area	31.67	29.63	24.93	-0.99	-1.82	-1.12
	Production	31.00	35.05	41.56	0.89	1.79	1.86
	Productivity	979	1182	1666	1.90	3.68	3.01
Total Cereals	Area	100.23	98.84	99.63	-0.35	-0.09	-0.06
	Production	176.92	192.91	238.63	0.65	2.06	1.65
	Productivity	1765	1951	2395	1.00	2.15	1.72

***Productivity in Kg/ha and CGR in per cent per annum**

The last 22 years, the area cultivated under jowar and bajra showed declining trend in the country. While in case of maize, positive growth rate in area were found during the study period. Production of jowar and bajra increased only due to improvement in productivity

Maize

Maize is the third most important cereal crop after rice and wheat in India (Table 2). Six major producing states of maize viz. Andhra Pradesh, Bihar, Karnataka, Madhya Pradesh, Rajasthan and Uttar Pradesh cover almost 80 per cent of the production of maize in the country, were selected for study. This significant improvement in the yield was noted in maize at national level which increased from 1588 to 2624 kg/ha at the rate of 2.68 per cent per annum during the period 1994-2016. All states showed positive growth with regard to productivity. The highest productivity was found in Andhra Pradesh (4310 kg/ ha) followed by Karnataka (2920 kg/ha) and Bihar (2821 kg/ha). Madhya Pradesh, Rajasthan and Uttar Pradesh had lesser productivity than national level throughout the study period. Andhra Pradesh and Rajasthan showed impressive growth in productivity during the study period. Karnataka showed declination trend in productivity during first period which improved in second period and during overall period it showed positive growth.

Table 2: Trends in productivity of Maize in major producing states of India

States	T.E 1994-95	T.E 2004-05	T.E 2015-16	CGR Period-I	CGR Period-II	CGR Overall
Andhra Pradesh	2630	3134	4310	1.55^{NS}	0.95^{*}	2.69^{**}
Bihar	1759	2180	2821	2.30^{**}	4.06^{**}	1.71^{**}
Karnataka	2986	2327	2920	-2.80^{NS}	0.03^{NS}	0.10^{NS}
Madhya Pradesh	1349	1729	1999	5.25^{**}	6.29^{NS}	1.58^{NS}
Rajasthan	930	1320	1565	4.71^{*}	2.69^{NS}	2.94^{**}
Uttar Pradesh	1362	1436	1754	1.16^{NS}	3.33^{NS}	1.12^{NS}
India	1588	1962	2624	2.41^{**}	3.15^{**}	2.68^{**}

Note: Productivity in Kg/ha and CGR in per cent per annum

**,*Significant at 1 per cent, and 5 per cent level of significance; NS: non-significant

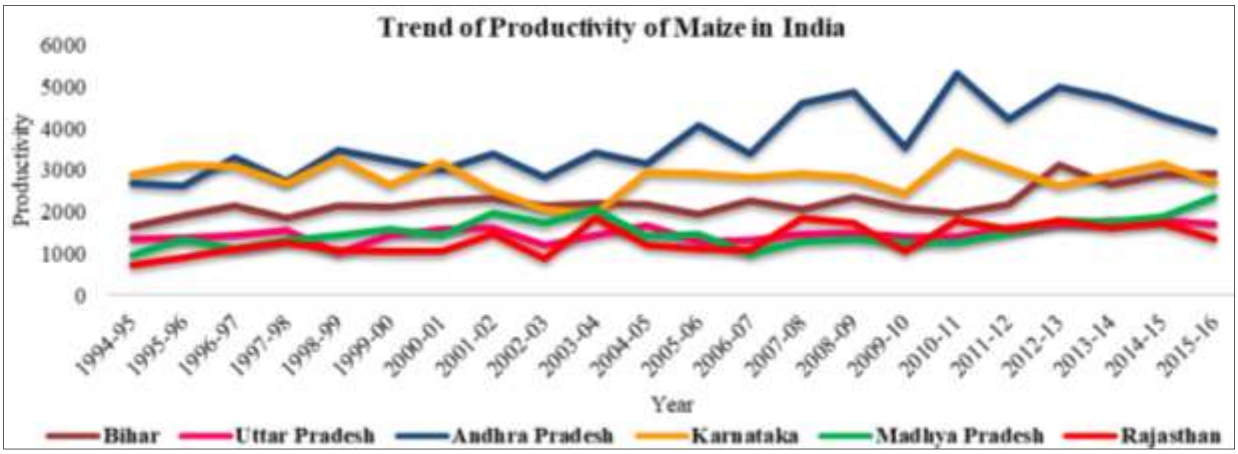

Fig 1: Trend of Productivity of Maize in India

The Trend in productivity of maize among major maize producing state in India has been presented in figure 1. Among maize producing states, highest productivity came out to be in Andhra Pradesh; where as in state itself highest productivity has been reported in the year 2010-11 (5317 kg/ha). In Karnataka state lowest productivity has been reported in the year 2003-04 (1957kg/ha) while highest productivity had been found in the year 2000-01(3450 kg/ha).

Jowar

In Jowar, the average productivity has been found much low, and is not showing any significant improvement (Table 3). The productivity of Jowar in Maharashtra was lower than national level productivity and also declined from 985 kg/ha to 618 kg/ha which was very low as compared to other states during the period 1994-95 to 2015-16. Except Maharashtra, all states showed positive growth rate in productivity. Highest productivity in jowar crop was found in Andhra Pradesh i.e. 1909 kg/ha followed by Madhya Pradesh (1710 kg/ha).

Table 3: Trends in productivity of jowar in major producing states of India

States	T.E 1994-95	T.E 2004-05	T.E 2015-16	CGR Period-I	CGR Period-II	CGR Overall
Andhra Pradesh	791	1050	1909	5.45**	5.63**	5.41**
Karnataka	845	670	1047	-2.32NS	-0.95NS	1.88*
Madhya Pradesh	919	1030	1710	2.98**	6.56**	4.51**
Maharashtra	985	740	618	-2.45**	-5.05**	-1.53**
Tamil Nadu	1094	647	1383	-4.74NS	5.88**	1.36NS
India	853	798	846	-0.97 NS	-1.18 NS	0.54**

Note: Productivity in Kg/ha and CGR in per cent per annum

**,*Significant at 1 per cent, and 5 per cent level of significance; NS: non-significant

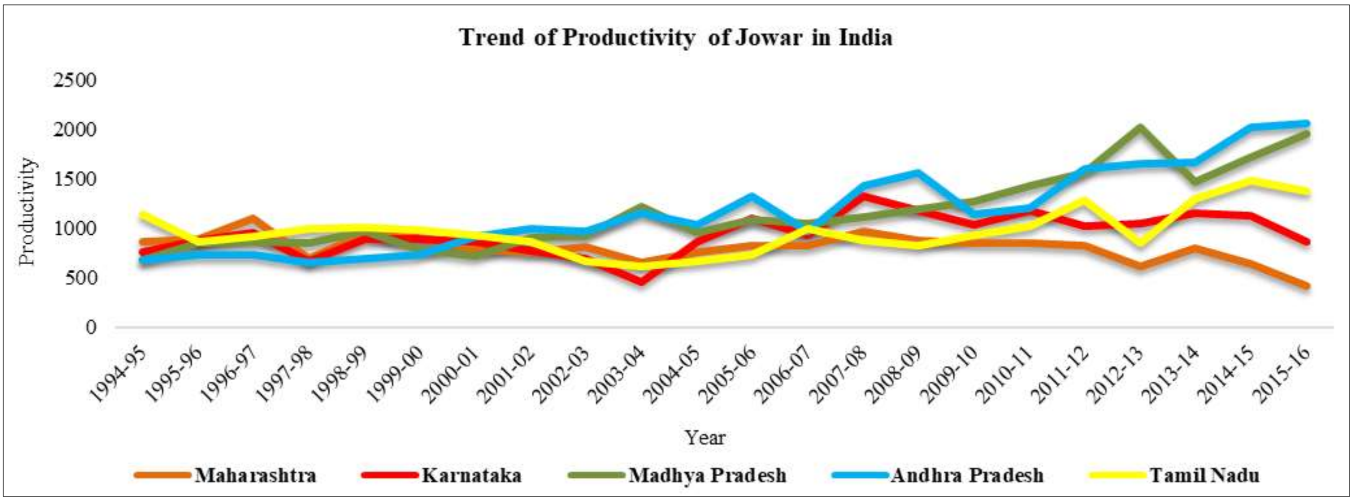

Fig 2: Trend of Productivity of Jowar in India

As shown in Figure 2 the production of jowar in Karnataka state was lowest in 2003-04 (460 kg/ha) which increased and became 865 kg/ha in 2015-16. The productivity of Jowar in MP was Highest in the year 2012-13 (2011 kg/ha) and remined still same in 2015-16 as well.

Bajra

At the national level, the productivity of bajra increased from 688 kg/ha to 1190 kg/ha at the growth rate of 3.03 per cent per year during the period from 1994-95 to 2015-16 (Table.4) Uttar Pradesh experienced highest productivity i.e. 1918 kg/ha followed by Gujarat (1808 kg/ha) during T.E 2015-16. Productivity of bajra varied the selected states as shown in Figure 3. All states showed positive productivity growth during the period 1994-95 to 2015-16. Rajasthan showed impressive significant growth rate in productivity i.e. 4.61 per cent per annum during the study period.

Table 4: Trends in productivity of Bajra in major producing states of India

States	T.E (1994-95)	T.E (2004-05)	T.E (2015-16)	CGR Period-I	CGR Period-II	CGR Overall
Gujarat	996	1210	1808	1.00**	5.29**	2.48**
Maharashtra	746	718	691	0.08NS	-2.67 NS	0.32 NS
Rajasthan	445	672	928	4.90**	4.78**	4.61**
Uttar Pradesh	1119	1367	1918	1.91**	3.36**	2.63**
India	688	934	1190	2.85**	3.99**	3.03**

Note: Productivity in Kg/ha and CGR in per cent per annum

**,*Significant at 1 per cent, and 5 per cent level of significance; NS: non-significant

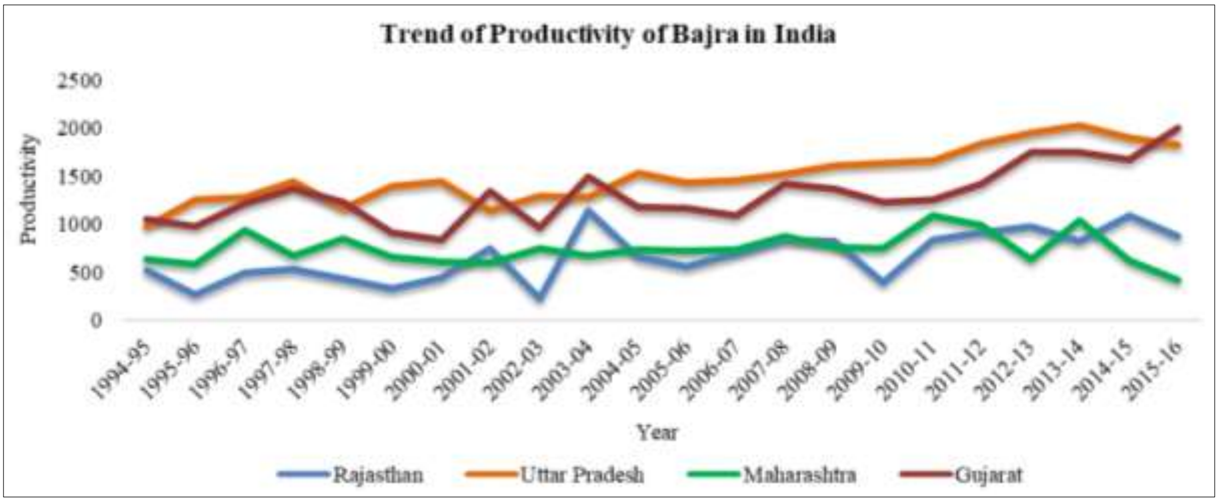

Fig 3: Trend of productivity of Bajra in India

As Shown in Figure 3 among the major bajra producing state, Uttar Pradesh showed highest productivity of 2033 kg/ha in the year 2013-14 which further went up to 1821kg/ha in year 2015-16.

Total Factor Productivity of major coarse cereals in India
Maize

During the overall period, the mean TFP change in maize was observed 2.6 per cent during a span of 22 years (Table 5). As indicated by decomposition analysis, the change in TFP was

Table 5: Trends in TFP change for Maize in major states, 1994-95 to 2015-16

State	Period-I (1994-95 to 2004-05)			Period-II (2005-06 to 2015-16)			Overall (1994-95 to 2015-16)		
	Efficiency Change	Technical Change	TFP Change	Efficiency Change	Technical Change	TFP Change	Efficiency Change	Technical Change	TFP Change
	Maize								
Andhra Pradesh	100	107.7	107.7	100	105.4	105.4	100	106.8	106.8
Bihar	100	113.3	113.3	100	113	113	100	112.4	112.4
Karnataka	100	100.5	100.5	100	102.9	102.9	100	102.2	102.2
Madhya Pradesh	100	81	81	100	110.4	110.4	100	93.3	93.3
Rajasthan	99.7	99	99	101.4	105.6	105.6	98.3	102.2	102.2
Uttar Pradesh	100	105.2	105.2	100	97.8	97.8	100	101.2	101.2
Mean	99.6	100.6	100.2	100.2	105.7	106	99.7	102.9	102.6
	Jowar								
Andhra Pradesh	100	94.1	94.1	100	103.9	103.9	100	99	99
Karnataka	103.2	102.6	105.9	100	99.8	99.8	101.6	102.2	103.8
Madhya Pradesh	100	96.6	96.6	100	89.2	89.2	100	95.7	95.7
Maharashtra	100	101.5	101.5	100	95.3	95.3	100	99.4	99.4
Tamil Nadu	100	97.5	97.5	100	103.2	103.2	100	101.2	101.2
Mean	100.6	98.4	99	100	98.2	98.2	100.3	99.5	99.8
	Bajra								
Gujarat	98.2	102.6	100.8	102.7	104	106.8	100	103.7	103.7
Maharashtra	100	100.7	100.7	96.3	99.2	95.5	98.3	100.3	98.6
Rajasthan	100	108	108	100	104.9	104.9	100	104.8	104.8
Uttar Pradesh	100	90.1	90.1	100	140.5	140.5	100	105.3	105.3
Mean	99.5	100.1	99.7	99.7	111	110.7	99.6	103.5	103.1

Associated with technical progress of 2.9 percent and decrease in efficiency change at a rate of -0.3 percent. In maize, all states except Madhya Pradesh showed positive trend in TFP. Among the selected major producing states, the highest TFP growth was experienced in Bihar (12.4 per cent) followed by Andhra Pradesh (6.8 per cent). On the other hand, only Madhya Pradesh (-6.7per cent) showed negative TFP growth with no change in technical efficiency. In four out of six states i.e. Andhra Pradesh, Bihar, Karnataka and Uttar Pradesh a positive technical change was associated with no-change in efficiency, while for Rajasthan, technical change of 2.2 percent was coupled with efficiency change of -1.7 per cent.

The mean TFP growth increased from 0.2 per cent in the period I to 6.0 per cent during period II. This TFP change was associated with an improvement in the technical change (from 0.6 per cent to 5.7 per cent) and in efficiency (from -0.4 per cent to 0.2 per cent). Except Uttar Pradesh all states showed high rate of TFP growth during the second period as compared to the first period and Bihar showed almost similar TFP growth in both periods. On the other hand, only Uttar Pradesh showed highest TFP trend during Period-I than Period II. The results revealed that during the two periods, the TFP change in second period has shown high level of margin as compared to the first period and the highest absolute increase was recorded in the case of Madhya Pradesh (by 29.4 percentage points). The increase in the TFP growth of states was mainly due to the improvement in technological change rather than the efficiency change. On the other hand, in Uttar Pradesh, the decline in technical growth from 5.2 per cent to -

2.2 per cent, with efficiency remaining unchanged, deteriorate the TFP growth in this state. The technical change was the main reason which increased the TFP growth in maize productivity among the states rather than the efficiency change. This clearly reveals that the role of management input in increasing productivity predicted no change (as shown by 100 per cent efficiency change); whereas the role of research or technology by new varieties or technique of production played a major role in enhancing maize productivity.

Jowar

Total Factor Productivity of jowar has been shown in Table 5. The TFP change was declining in jowar crop. The mean TFP change for jowar showed negative growth i.e. -0.2 per cent during the overall period 1994-2016. The contribution of efficiency change (0.3 per cent) was greater than technical change (-0.5 per cent) to overall change in TFP in all states. In case of jowar, technical progress has not much improved as in other cereals like wheat, paddy and maize so reducing the TFP growth.

The TFP change varied considerably across states, three out five states showed negative trends and remainig posted positive TFP growth. Among the states, the highest TFP change was experienced in Karnataka (3.8 per cent) followed by Tamil Nadu (1.2 per cent). On the other hand, declining TFP growth was witnessed in three states i.e. Andhra Pradesh, Madhya Pradesh and Maharashtra mainly due to deterioration in technical change. A positive growth in both efficiency change and technical change can be noticed only in Karnataka state. It was significant to note that Maharashtra which is contributed highest production of jowar in the country showed negative TFP growth (-0.6 per cent). Only Karnataka and Tamil Nadu posted positive technical change associated with no-change in efficiency.

At the national level, the mean TFP growth declined from -1.0 per cent during period I to -1.8 per cent during period II. This declining TFP change was related with decreased technical change (from -1.6 per cent to -1.8 per cent) and efficiency change (from 0.6 per cent to zero). In both study period, TFP growth fluctuated among the states. All major jowar growing states exhibited negative growth in technical change and only Andhra Pradesh and Tamil Nadu showed increase in efficiency change during the study period. It can be concluded that decline in TFP growth in jowar is attributed to decline in technical change. The decrease in public investment in research and development in post reform period-II has put a setback to jowar crop as its TFP declined in Period-II as compared to Period-I. This observation calls for higher research attention to this crop.

Bajra

In bajra crop, the mean TFP showed positive growth i.e. 3.1 per cent during the study period. The contribution of technical change (3.5 per cent) was greater than efficiency change (- 0.4 per cent) to overall change in TFP in all states (Table 5). In contrast to jowar, technical progress in bajra was improved like maize so it lifted up the TFP growth.

Among the states, only Maharashtra showed negative trends and remaining posted positive TFP growth. The highest TFP growth was experienced in Uttar Pradesh (5.3 per cent) and Rajasthan (4.8 per cent). The mean TFP growth improved from -0.3 per cent in the period I to 10.7 per cent during period II. This increased TFP change was related with improvement in the technical change (from 0.1 per cent to 11.0 per cent with) low efficiency in both study periods. This underline the fact that efficiency which is due to operations of scale or management factor could not catch up with the technical progress, and was pulling down the TFP growth. Except Maharashtra, TFP growth highly increased in second period as compared to first period. A picture of contrasting performance has been noted in Maharashtra and Uttar Pradesh. In Uttar Pradesh the rate of declining TFP growth was very high in the period I which increased during period-II (from -9.9 per cent to 40.5 per cent), while in Maharashtra the increasing TFP growth during Period-I has deteriorated in period-II (from 0.8 per cent to -4.5 per cent). Gujarat and Rajasthan showed positive trend of TFP growth due to increase in technical change during both study periods. In bajra crop, the results clearly show more effective technical change in relation to efficiency change.

Growth in input use in coarse cereals production in major producing states in India

The result of TFP change in major coarse cereals i.e. maize, jowar and bajra revealed that in the selected states, the efficiency change is almost negligible leaving one or two states i.e. input growth

Table 8: Growth in input use in coarse cereals production in study states during TE 1994-95 to 2015-16 (Per cent)

States	Seed	Fertilizer	Manure	Human Labour	Animal Labour	Irrigation	Machine Labour
	Maize						
Andhra Pradesh	0.5	4.3	1.8	-1.5	-6.2	2.7	5.9
Bihar	0.3	2.3	-2.9	-2.5	-47.7	5.8	1.2
Karnataka	0.6	2.7	-1.7	0.5	-2.4	2.4	4.6
Madhya Pradesh	-0.6	5.5	15.1	-1	-2.1	-13.7	5.9
Rajasthan	-0.2	6.2	-5.6	-0.5	-5.7	-2.9	9.3
Uttar Pradesh	0.3	2.9	-51.1	-1.2	-8.5	4.3	0.4
	Jowar						
Andhra Pradesh	1.4	3.7	-22.3	-0.4	-5	23.2	12.1
Karnataka	0.6	1.9	-36.5	0.7	-2.9	-0.9	5.2
Madhya Pradesh	-0.4	5.1	6	-1.6	-3.8	-21.7	6.6
Maharashtra	2	1.1	-8.7	-1	-5.4	8.9	3.5
Tamil Nadu	1	4.1	1.7	-2.9	-15.5	-4.4	0
	Bajra						
Gujarat	1.8	4.8	-0.9	0.6	-6.9	2.3	-0.5
Maharashtra	2.2	5.8	5.2	1.4	-6.6	10.4	7.4
Rajasthan	-0.6	8.7	2.3	5	-8.8	-1.6	0.8
Uttar Pradesh	0.2	3.2	-12.5	-0.4	-14.7	37.6	0.4

Has not taken place and it is the technological progress which has led to TFP change. For strengthening of the results, the growth in input use was analyzed for primary inputs namely irrigation, fertilizer, human labour, seed, manure, animal labour and machine labour for a span of 22 years. There was negative growth in use of human labour in maize and jowar whereas bajra witnessed positive growth. This underline the fact that human labour has been replaced by machine labour in maize and jowar indicate technological breakthrough which was less in case of bajra crop. The growth rate in use of fertilizers have been positive, though the growth in magnitude varied widely across study states. The animal labour has been replaced by machine labour implying increased use of technology which is reflected through increased in technical change in the study states in TFP growth.

Conclusions

This study has analysed the TFP growth of major coarse cereals in India, viz. maize, jowar and bajra from 1994 to 2016. During the last 22 years, the area under coarse cereals has declined at rate of -1.12 per cent and share in total cereals also decreased from about 32 to 25 per cent during study period. The area cultivated for jowar and bajra were seems to have declining trend. While in case of maize, positive growth rate in area were found during the study. Among coarse cereals, maize and bajra crop witnessed total factor productivity growth of 2.6 per cent and 3.1 per cent respectively during overall period whereas jowar witnessed negative TFP growth of -0.2 per cent. In maize, except Madhya Pradesh all states under consideration were seen positive TFP growth and the highest change in the TFP growth experienced in Bihar (12.4 per cent). Andhra Pradesh, Madhya Pradesh and Maharashtra states showed declining in TFP growth in jowar crop mainly due to deterioration in technical but efficiency remain unchanged. In bajra, only Maharashtra showed negative trends and remaining posted positive TFP growth. The study revealed that the increase in the TFP growth was mainly due to improvement in technological progress rather than the efficiency growth. TFP growth were higher in second period i.e. 2005-06 to 2015-16 as compared to first period i.e. 1994-95 to 2004-05. Giving priorities to research in low value cereals crop like maize, jowar and bajra and sound strategies of production with ecological balance is the only way forward to meet the food sustainability and nutritional security concerns of millions. The study has also discussed whether the recent slowdown in yield growth is due to technology fatigue or sluggishness in input intensification. However, the rate of growth of input application has been declining over the years. Therefore, rather than technological exhaustion, it could be the sluggish input intensification that is contributing to stagnant or slowdown in yield growth of coarse cereals in the recent years. As the results have shown that efficiency change has remained unchanged i.e. there is no change in efficiency, so the extension service is the only way to enhance the efficiency. Upsurge in agricultural investments, especially in agricultural research, is instantly needed to stimulate growth in TFP.

References

1. Bhushan S. Total factor productivity growth of wheat in India: A Malmquist approach. Indian Journal of Agricultural Economics 2005;60(1):32-48.
2. Bhushan S. TFP growth of wheat and paddy in post-green revolution era in India: parametric and non-parametric analysis. Agricultural Economics Research Review 2016;29(1):27-40.
3. Basavaraj G, Parthasarathy Rao P, Bhagavatula S, Ahmed W. Availability and utilization of pearl millet in India. Journal of SAT Agricultural Research 2010;8:1-6
4. Caves DW, Christensen LR, Diewert WE. The economic theory of index numbers and the measurement of input, output and productivity, Econometrica 1982, 1393-1414.
5. Chand R, Kumar P, Kumar S. Total factor productivity and contribution of research investment to agricultural growth to agricultural growth in India. Policy Paper No 25. National Centre for Agricultural Economics and Policy Research (NCAP), New Delhi 2011.
6. Coelli TJ. A Guide to DEAP Version 2.1: A Data Envelopment Analysis (Computer Program), Centre for Efficiency and Productivity Analysis, University of New England, Australia 1996.
7. Coelli TJ, Rao DSP, O'Donnell CJ, Battese GE. An introduction to efficiency and productivity analysis. Springer, New York, USA 2005.
8. Desai MB, Namboodiri NV. Determinants of total factor productivity in Indian agriculture. Economic & Political Weekly 1997;32(52):165-171.
9. Fare R, Grosskopf S, Lindgren B, Roos P. Productivity developments in Swedish hospitals: A Malmquist output index approach. (In) Data Envelopment Analysis: Theory, Methodology and Applications. Charnes A, Cooper WW, Lewin A Y and Seiford L M (Eds). Kluwer Academic Publishers, Boston 1989.
10. Fare R, Grosskopf S, Norris M, Zhang Z. Productivity growth, technical progress, and efficiency change in industrialised countries. The American Economic Review 1994, 66-83.
11. Janaiah, Aldas, Achoth, Lalith, Bantilan, Cynthia. Has the green revolution bypassed coarse cereals? The Indian experience. Journal of Agricultural and Development Economics 2005;2(1):20-31.
12. Joshi PK, Kumar P. Food demand and supply projections for India. Mimco, International Food Policy Research Institute, New Delhi 2011.
13. Kumar S, Chand R. Research resource allocation across disciplines and states in Indian Agriculture: An Illustration using composite scoring approach. New Delhi: National Centre for Agricultural economics and Policy Research, Mimeo 2014.
14. Kumar S, Anwer ME. Estimation of Productivity and Efficiency of Rapeseed and Mustard Production in India. Economics Affair 2015;60(4):809-20.
15. Monga S and Sidana B K. Performance of Productivity of Rice and Wheat Crops in India: A Malmquist Total Factor Productivity Analysis. Research Journal of Agricultural Science 2019: 10(5/6): 733-740.
16. N Nagaraj, G Basavaraj, P Parthasarathy Rao, Cynthia Bantilan, Surajit Haldar. Sorghum and Pearl Millet Economy of India Future Outlook and Options Economic & Political Weekly 2013;XLVIII(52):74-81
17. Parthasarathy Rao P, Basavaraj G, Ahmad W and Bhagavatula S. An analysis of availability and utilization of sorghum grain in India. Journal of SAT Agricultural Research 2010, 8.
18. Suresh, Reddy. Total Factor Productivity of major Pulse Crops in India: Implication for Technology Policy and Nutritional Security. Agricultural Economics Research Review 2016; 29:87-98.