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Trends and regional disparity of maize production in India

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This study was aimed at investigating trends, instability, and regional variations of maize production in major producing states of India. Compounded Annual Growth Rate (CAGR), Cuddy Della Valley Index (CDVI), and decomposition analysis were used to examine the data ranging from 1980 to 1981 and 2011 to 2012. The study revealed that area under maize in India has increased from 5.89 to 9.19 Mha and production has increased from 6.49 to 21 Mt between the period TE 1981 to 1982 and TE 2011 to 2012. Such increase in production of maize has been possible mainly due to increase in yield from 1,100 to 2,279 kg/ha. For all India, area has expanded at 1.88% per annum between 1982 to 1983 and 2011 to 2012, while yield increased at a rate of 2.28% per annum during the same period. As a result, production of maize has risen by 4.2% per annum. The area expansion of maize was the highest in Maharashtra (9.19%) followed by Karnataka (7.98%). Production increase of maize was also the highest in Maharashtra (12.24%), which is followed by Karnataka (8.48%) and Andhra Pradesh (8.68%). The growth of yield in Andhra Pradesh was the highest (3.99%) followed by Maharashtra (2.80%). The study witnessed that maize is in the winning ground in India at country level more specifically in the states of Andhra Pradesh, Bihar*, Gujarat, MP*, Rajasthan, and Uttar Pradesh* as increase in yield coupled with decline in instability. The decline in instability and increase in yield in these states might be due to the adoption of modern varieties of maize as also evidenced from the decomposition analysis where yield effect was observed to be the major driver of growth in maize production. More over the expansion of maize in the high potential areas might also bring about increase in yield in the country.

Key words: Maize, growth, instability, decomposition, area effect, yield effect.

INTRODUCTION

Maize is one of the most crucial cereals produced in different parts of the world under diverse climatic and ecological conditions. Due to its increasing importance, maize has become a major staple and cash crop for smallholder farmers around the developing world.

Maize is a preferred staple food for about 900 million poor consumers and about one third of all malnourished children. It is estimated that by 2050, the demand for maize in developing countries would double and maize will have become the crop with the greatest production

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globally and in developing countries (CIMMYT and IITA, 2011).

In India, maize is emerging as the third most important crop, after rice and wheat. Maize was traditionally grown as staple food, primarily for household consumption, but its demand for feed and industrial uses has increased rapidly in the recent past. Maize is cultivated throughout the year in most states of the country for various purposes, including grain, feed, fodder, green cobs, sweet corn, baby corn, popcorn, and industrial products. Maize area, production and productivity in India has shown a steady upward trend in recent years and current consumption pattern of maize is mainly for poultry, pig, fish feed (52%), human consumption (24%), cattle feed and starch (11%), and seed and brewery industry (1%) (Nirupma et al., 2012).

Paroda and Kumar (2000) predict that the area under maize would grow further to meet future food, feed, and other demands, especially in view of the booming livestock and poultry producing sectors in the country. Since opportunities are limited for further expansion of maize area, future increases in maize supply will be achieved through the intensification and commercialization of current maize production systems.

The changing global scenario is compelling policy makers to adhere to the regulations and obligations set by the World Trade Organization (WTO). The resulting new economic regime is expected to alter the economics of existing cropping systems, including maize, in terms of production and trade (Joshi et al., 2005). With this back drop, this study aimed at investigating trends, instability, and regional variations of maize in major producing states of India.

DATA AND METHODOLOGY

The study is based on secondary data collected over a long time period (1980 to 1981 and 2011 to 2012), from various published sources. Data on area, production, and yield of maize were collected from Directorate of Economics and Statistics, Ministry of Agriculture, Government of India.

The study employed statistical tools like growth rates, ratios, and indices of instability to analyze the data set. The growth rates (r) of area, production, and yield maize were estimated using the formula:

$Y_t = AB^t e$

where Y_t is the variable for which growth is calculated at t^{th} period, t is the time variable, A is the constant, B = (1+r), 'e' is the error term.

Transforming this to logarithmic form:

$\ln Y_t = \ln A + (\ln B)t + \varepsilon$

Then CAGR is calculated as:

CAGR (per cent) = [antilog (ln B) - 1] × 100

In this study, the instability in area, production, and productivity was estimated using Cuddy-Della Valle index (CDVI). Though, the coefficient of variation (CV) is commonly used for estimating the dispersion with comparability across various units; it cannot be used in case of time series data characterized by time trend. Any measure of instability needs to exclude the deviation in the data series that may arise due to secular trend or growth. CDVI was originally developed by Cuddy and Valle (1978) for measuring the instability in time series data that is characterized by trend. The estimable form of the equation is as follows:

$$I = CV \times \sqrt{(1 - \overline{R}^2)}$$

where I is the instability index in percent, CV is the coefficient of variation in percent, and $\overline{R}^2$ is the coefficient of determination from time trend regression adjusted by the number of degree of freedom.

Any change in the output of a crop in physical term depends fundamentally on the changes in the area under the crop and its average yield. To determine the source of production growth and to measure the effect of area, productivity, and their interaction in increasing crop output, differential equation given by Sharma (1977) was used:

$\Delta P = A\Delta Y + Y\Delta A + \Delta A\Delta Y$

The first term on the right hand side is considered as yield effect, second term as the area effect, and the third as the interaction effect. Thus, total change in output can be decomposed into three effects; yield effect, area effect, and interaction effect due to change in yield and area.

RESULTS AND DISCUSSION

Trends and share of maize production in India

In TE 2012, India produced 2.47% (21.52 Mt) of world maize production from 5% (8.55 Mha) of the area. Globally, it was ranked fourth in area after USA, China, and Brazil; but due to its low productivity, India's rank in production is fifth. Yield of maize in India was observed to be 2.53 tons/ha which is about half of the world average, whereas in USA 8.86 tons/ha and China 5.72 tons/ha (Table 1).

The area under maize in India has increased from 5.89 to 9.19 Mha and production has increased from 6.49 to 21 Mt between the period TE 1981 to 1982 and TE 2011 to 2012. Such increase in production of maize has been possible mainly due to increase in yield from 1,100 to 2,279 kg/ha during the corresponding period (Figure 1).

At national level, during TE 1981 to 1982, Uttar Pradesh* had the highest share in area (20.11%) and production (14.44%) followed by Rajasthan (area of 15.28% and production of 10.87%) and Bihar* (area of 14.51% and production of 12.46%). In TE 2011 to 2012, Karnataka had the highest share (14% of area and 18.32% of production). The share of maize area has declined steadily in Bihar* and Uttar Pradesh* between these two TE periods, which might be due to low benefit cost ratio of maize in both states than competing crops (Ayalew and Sekar, 2015). Share of Uttar Pradesh* has declined by more than half in area and production, whereas share of maize in Maharashtra has increased by about eight fold for area and about five fold for

Table 1. Area, production, and yield of maize in major producing countries in the world.

Country	Area (Mha)			Production (Mt)			Yield (tones/ha)		
	TE1993	TE2002	TE2012	TE1993	TE2002	TE2012	TE1993	TE2002	TE2012
Argentina	2.26(1.68)	2.77(2.02)	3.38(1.98)	9.76(1.95)	15.62(2.58)	24.06(2.77)	4.31	5.66	7.17
Brazil	12.77(9.53)	11.90(8.66)	13.37(7.83)	28.06(5.59)	36.59(6.05)	60.77(6.98)	2.21	3.07	4.53
China	21.18(15.81)	24.02(17.48)	33.68(19.71)	99.34(19.80)	113.98(18.86)	192.90(22.17)	4.69	4.74	5.72
India	5.94(4.43)	6.61(4.81)	8.55(5.01)	9.22(1.84)	12.12(2.00)	21.52(2.47)	1.55	1.83	2.52
Mexico	7.20(5.37)	7.35(5.35)	6.71(3.93)	16.44(3.28)	19.00(3.14)	21.00(2.41)	2.28	2.58	3.12
USA	27.50(20.52)	28.40(20.67)	34.10(19.96)	197.19(39.31)	240.33(39.77)	301.32(34.63)	7.13	8.46	8.86
World	133.96	137.37	170.86	501.61	604.30	870.06	3.74	4.40	5.10

Author's calculation based on data from FAOSTAT data base. Figures in parentheses indicate share from world.

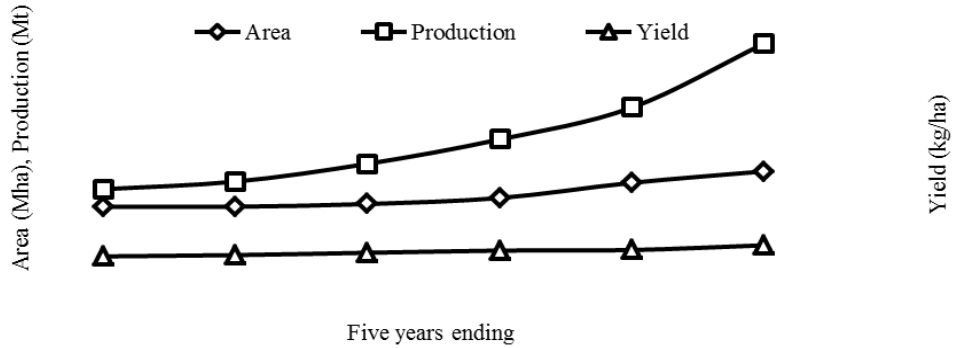

Figure 1. Trends of area, production, and yield of maize in India.

production. Similarly, share of Karnataka has increased by fivefold for area and three fold in production of maize (Table 2).

Growth and instability in production of maize in India

Area, production, and yield of maize have shown an increasing trend over the time period 1982 to 1983 and 2011 to 2012. For all India, area has expanded at 1.88% per annum between 1982 to 1983 and 2011 to 2012, while yield increased at a rate of 2.28% per annum during the same period. As a result, production of maize has risen by 4.2% per annum. The area expansion of maize was the highest in Maharashtra (9.19%) followed by Karnataka (7.98%). Production increase of maize was also the highest in Maharashtra (12.24 %), which is followed by Karnataka (8.48%) and Andhra Pradesh (8.68%). The growth of yield in Andhra Pradesh was the highest (3.99 %) followed by Maharashtra (2.80%) (Table 3 and Figure 2).

The decomposition analysis of source of growth in maize output over the period 1982 to 1983 and 2011 to 2012 showed that yield effect contributed about 44% and area effect about 26% at country

Table 2. State-wise share of area, production, and yield of maize in India.

State	Area ('000 ha)				Production ('000 t)			
	TE1981-82	TE1991-92	TE2001-02	TE2011-12	TE1981-82	TE1991-92	TE2001-02	TE2011-12
AP	314 (5)	308 (5)	469 (7)	787 (9)	584 (9)	650 (7)	1503 (12)	3459 (16)
Bihar*	854 (14)	685 (12)	804 (12)	1047 (11)	808 (12)	1173 (13)	1733 (14)	2026 (10)
Gujarat	308 (5)	345 (6)	406 (6)	495 (6)	313 (5)	454 (5)	559 (4)	713 (3)
Karnataka	149 (2)	261 (4)	618 (9)	1286 (14)	392 (6)	733 (8)	1730 (14)	3847 (19)
MP*	773 (13)	878 (15)	991 (14)	1048 (11)	675 (10)	1186(13)	1571 (12)	1462 (7)
Maharashtra	77 (1)	107 (2)	312 (4)	831 (9)	131 (2)	123 (1)	441 (3)	2288 (11)
Rajasthan	899 (15)	959 (16)	974 (14)	1128 (12)	705 (11)	1129 (13)	1155 (9)	1622 (8)
UP*	1184 (20)	1101 (19)	979 (14)	806 (9)	936 (14)	1394 (16)	1530 (12)	1235 (6)
All India	5887	5893	6864	9191	6486	8892	12657	20999

Author's calculation based on data from DES, GOI. Figures in parenthesis denote share of states from all India (percentage). Bihar*: Bihar and Jharkhand; Madhya Pradesh* (MP*): Madhya Pradesh (MP) and Chhattisgarh; Uttar Pradesh* (UP*): Uttar Pradesh and Uttarakhand.

Table 3. Compounded annual growth rate (CAGR) in area, production, and yield of maize in selected states of India.

State	Area				Production				Yield			
	1982-1983 to 1991-1992	1992-1993 to 2001-2002	2002-2003 to 2011-2012	1982-1983 to 2011-2012	1982-1983 to 1991-1992	1992-1992 to 2001-2002	2002-2003 to 2011-2012	1982-1983 to 2011-2012	1982-1983 to 1991-1992	1992-1992 to 2001-2002	2002-2003 to 2011-2012	1982-1983 to 2011-2012
AP	-0.80	5.47	3.49	4.21	1.78	8.68	8.93	8.37	2.59	3.05	5.25	3.99
Bihar*	-1.32	1.02	1.65	1.80	3.63	3.85	1.02	3.70	5.01	2.80	-0.62	1.87
Gujarat	1.43	1.46	0.53	1.97	3.52	3.82	1.47	3.34	2.06	2.33	0.94	1.34
Karnataka	6.72	9.38	8.88	7.98	9.10	8.13	13.24	8.48	2.23	-1.14	4.01	0.46
MP*	0.92	1.46	-0.32	1.08	2.42	3.65	-2.30	1.98	1.48	2.16	-1.99	0.90
Maharashtra	3.96	5.55	11.12	9.19	1.22	3.97	16.77	12.24	-2.64	-1.50	5.08	2.80
Rajasthan	0.59	0.71	1.20	0.74	2.29	4.22	4.57	2.82	1.69	3.48	3.33	2.06
UP*	-0.31	-1.36	-1.59	-1.26	1.98	-0.03	0.65	0.01	2.30	1.34	2.28	1.28
All India	0.21	1.88	2.61	1.88	2.31	4.09	6.31	4.20	2.09	2.16	3.61	2.28

Author's calculation based on data from DES, GOI.

level. Area effect was the highest in Karnataka (69.16%) followed by Maharashtra (43.99%), Andhra Pradesh (38.34%) and Gujarat (37.92%), whereas yield effect was the highest in Uttar Pradesh* (171.75%) followed by Rajasthan (63.25%), Bihar* (52.48%), and Madhya Pradesh* (48.99%) as shown in Table 4. Instability of area under maize has increased from 2.04% between 1982 to 1983 and 1991 to 1992 to 2.85% during 1992 to 1993 and 2001 to 2002, but it has declined from about 15 to 6% for yield and from about 14 to 5% for production. Between the period

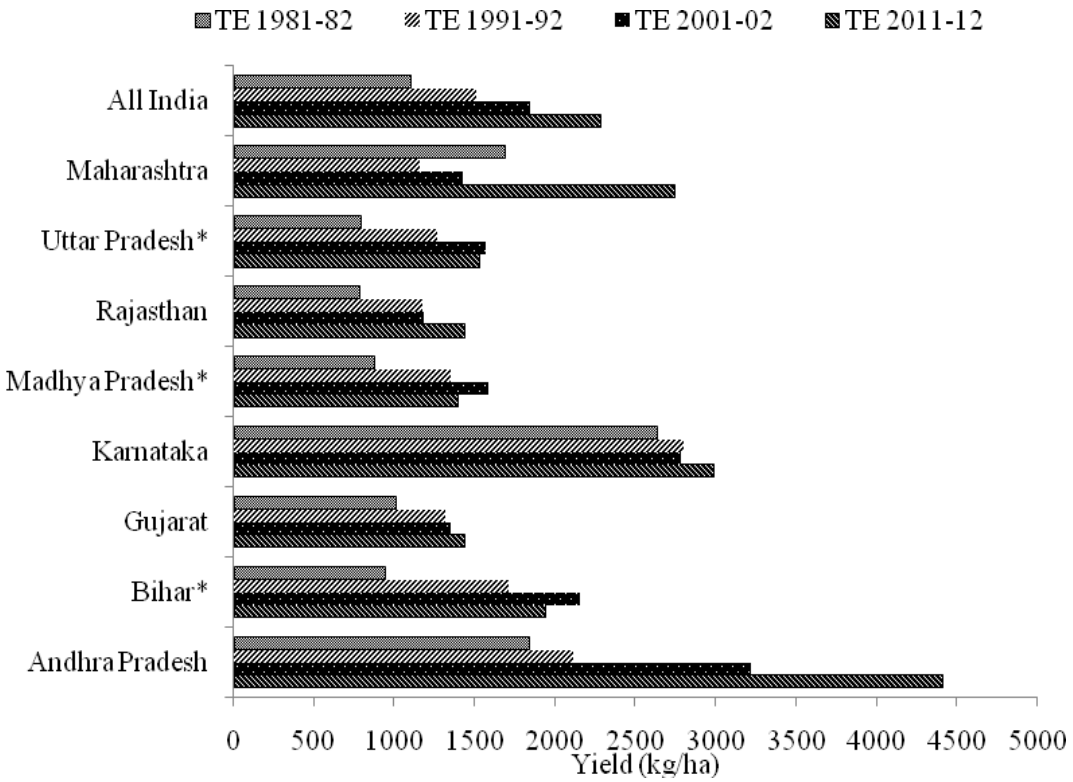

Figure 2. Yield of maize in selected states of India.

Table 4. Source growth of maize production in selected states of India between 1982 to 1983 and 2011 to 2012.

State	Change in output ('000 t)	Area effect		Yield effect		Interaction effect	
		('000 t)	Percent	('000 t)	Percent	('000 t)	Percent
AP	2914	1117	38.34	718	24.65	1078	37.01
Bihar*	1316	360	27.37	691	52.48	265	20.15
Gujarat	480	182	37.92	187	38.93	111	23.15
Karnataka	3737	2584	69.16	137	3.66	1016	27.18
MP*	827	281	33.91	405	48.99	141	17.10
Maharashtra	2325	1023	43.99	124	5.33	1179	50.68
Rajasthan	1008	188	18.67	638	63.25	182	18.08
UP*	553	-186	-33.59	950	171.75	-211	-38.16
All India	16280	4301	26.42	7230	44.41	4749	29.17

Author's calculation based on data from DES, GOI.

2002 to 2003 and 2011 to 2012, instability in area has declined to 1.84%, but yield instability has increased to 7%. As a result, instability of production also increased to 7.81%. The instability in area was the highest in Maharashtra and Karnataka, whereas for yield it was the highest in Gujarat across the periods (Table 5).

The instability and yield growth analysis indicated different associations among the study states between the period 1981 to 1982 and 2011 to 2012. Majority of the states fall under the group of increase in yield with decline in variability of maize yield. Instability in yield has declined and yield has increased for the states of Andhra Pradesh, Bihar*, Gujarat, Madhya Pradesh*, Rajasthan, and Uttar Pradesh*. In Karnataka and Maharashtra states, it was seen that there was an increase in yield growth along with increase in instability. There was no state coming under the category of decrease in yield with higher variability (Table 6).

Table 5. Instability in area, production and yield of maize in selected states of India.

State	Area				Production				Yield			
	1982-1983 to 1991-1992	1992-1993 to 2001-2002	2002-2003 to 2011-2012	1982-1983 to 2011-2012	1982-1983 to 1991-1992	1992-1992 to 2001-2002	2002-2003 to 2011-2012	1982-1983 to 2011-2012	1982-1983 to 1991-1992	1992-1992 to 2001-2002	2002-2003 to 2011-2012	1982-1983 to 2011-2012
AP	4.65	9.71	5.36	18.58	24.89	9.08	15.23	32.39	22.17	8.15	13.47	14.94
Bihar*	4.59	9.48	4.92	10.87	12.83	8.11	8.79	10.03	9.13	5.74	5.97	10.92
Gujarat	7.48	5.29	5.91	5.94	43.02	36.32	29.62	31.61	41.07	31.46	29.46	31.57
Karnataka	7.13	9.41	5.03	19.78	14.28	14.15	12.84	28.26	8.99	12.96	11.89	12.59
MP*	1.20	7.87	2.34	5.20	24.93	22.07	18.07	20.31	24.06	16.31	16.51	18.09
Maharashtra	18.23	10.91	7.41	27.26	41.35	29.06	14.94	55.57	12.44	20.20	16.43	19.74
Rajasthan	6.04	2.92	3.60	4.75	37.69	18.85	26.04	29.31	37.97	12.83	9.72	27.19
UP*	4.57	4.64	7.91	5.27	19.06	19.01	12.33	16.52	18.31	13.19	8.68	12.98
India	2.04	2.85	1.84	7.36	14.93	6.24	7.81	14.90	13.62	4.86	7.01	8.53

Author's calculation based on data from DES, GOI.

Table 6. Change in yield and instability in maize in India (I^{st} period: 1982-1983 to 1991-1992, II^{nd} period: 2002-2003 to 2011-2012).

Types of associations			
AA: Increase in yield with decrease in variability	**AB: Increase in yield with increase in variability**	**BA: Decrease in Yield with decrease in variability**	**BB: Decrease in Yield with increase in variability**
Andhra Pradesh	Karnataka	-	-
Bihar*	Maharashtra	-	-
Gujarat	-	-	
MP*	-	-	-
Rajasthan		-	-
Uttar Pradesh*	-		-

Conclusions

Maize area, yield, and production have increased globally and the share of India in area and production has grown despite low rate in yield. Maize production has expanded mainly in Maharashtra and Karnataka. The increase in production of maize was mainly due to yield effect at country level and for the states mainly due to area in Karnataka, Maharashtra, and Andhra Pradesh but due to yield effect in Uttar Pradesh*, Rajasthan, Bihar*, Madhya Pradesh*, and Gujarat. Instability of area, production, and yield of maize has declined over the decades at country level while it has increased for area in Uttar Pradesh* and for yield in Maharashtra and Karnataka. Instability in yield has increased for the states Andhra Pradesh, Bihar*, Gujarat, Madhya Pradesh*, Rajasthan, and Uttar Pradesh*, while instability increase with increase in yield was observed in Karnataka and Maharashtra. The study witnessed that maize is in the winning ground in India at country level more specifically in the states of Andhra Pradesh, Bihar*, Gujarat, MP*, Rajasthan, and Uttar Pradesh* as increase in yield coupled with decline in instability. The decline in instability and increase in yield in

these states might be due to the adoption of modern varieties of maize as also evidenced from the decomposition analysis where yield effect was observed to be the major driver of growth in maize production. More over the expansion of maize in the high potential areas in future might also contribute to the continuous increase in yield in the country.

Conflict of interests

The authors have not declared any conflict of interest

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