



Scenario of changing dynamics in production and productivity of major cereals in India

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ABSTRACT

Cereals occupy prime position in diet composition of all human beings, with rice, wheat and maize being the major staple cereals with more than 70% share among all the food grains. With the inception of green revolution, India from being a food deficit and net importer of food grains not only became self reliant but also one of the major exporters of food grains with the adoption of modern wheat and rice varieties. Thus the present study was undertaken to analyze the trends in area, production and productivity of rice, wheat and maize for the period 1990-91 to 2012-13 obtaining data from the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India, New Delhi. The compound annual growth rate (CAGR) and coefficient of variation were also used to see the growth patterns and instability in the production and productivity of these cereals overtime. The results showed that in both rice and wheat instability increased in area, production and productivity but most of the states registered an increasing growth trends during the period. Notably Maize showed increase in area, yield and production since 2000 due to its increasing demand for industrial usage and had significant growth in the decade due to its growing commercial value with emergence of promising new hybrids. The study points out to the significant intervention of policy to help maintain stability in case of major cereals of India's food security.

Key words: Coefficient of variation, Compound annual growth rate (CAGR), Instability, Maize, Rabi, Rice, Triennium ending (TE), Wheat

Around the world cereals have been considered as the principal component of human diet among the food crops, for thousands of years. They constitute rice, wheat, maize and to lesser extent jowar and millets. More than 50% of world daily caloric intake is derived from cereal grain consumption directly. Today cereal grains are the single most important source of calories in the world to a majority of the population.

Green revolution in India had a significant change in cereal production over the period of 1950-51 to 1977-78; the figure of 125 million tonnes during 1978 reflects sharp contrast to the production of 1950's standing out to be just little over 55 million tonnes (Kabra and Ittyerah 2009). Since then cereal production in India showed an increasing trend with 2.3% in 1970's to 2.8% in 1990's and then slowed down to 2.02%, even the yield growth reflected the same trend, but the superior cereals rice and wheat as a percentage of total cereal production increased from 20% during 1970's to 41% per year during the same period (Singh 2006). Thus the present study was undertaken considering rice, wheat and maize (corn) emerging out to

be the three most important cereals in the world including India, contributing more than half of calorie intake of all human beings all over the globe. Other studies also reveal that the total cereal requirement of India by 2020 will be between 290 and 350 million tonnes depending on income growth (Bhalla *et al.* 1999, Kumar *et al.* 2004), which shows that the demand for rice and wheat is expected to increase to 122 and 103 million tonnes respectively, by 2020 assuming a medium income growth (Kumar *et al.* 2004). This will have to be produced from the same or even shrinking land resource. Thus, by 2020 the average yields of rice and wheat need to be increased significantly, under this background the paper seeks to examine the trends in area, production, productivity of rice, wheat and maize along with instability in the growth trends for major producing states of India.

MATERIALS AND METHODS

The study was largely based on secondary data for a period of 22 years from 1990-91 to 2012-13. Area, production and productivity of rice, wheat and maize for major states were obtained from the Directorate of Economics and Statistics (DES), Ministry of Agriculture (MoA), Government of India, New Delhi. The study was divided in to two periods from 1990-2000 (period I) and 2001-2013 (period II) to make comparisons across the period and draw conclusions.

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Compound annual growth rate (CAGR), was computed for examining trends in area, production and productivity of rice, wheat and maize using state-wise time-series data for the study period 1990-1991 to 2012-13 from DES, Government of India, New Delhi.

The time series data on these parameters were detrended first by fitting linear regression function. The instability was measured by estimating the coefficient of variation of production, area as well as yield. Association between growth in area and yield during both the periods is presented by classifying states falling in to four scenarios, I- positive growth rate of area associated with positive growth rate of yield. This indicates that one crop is either replacing other crop or is grown in the newly cultivated area and the overall yield of crop is increased. II- positive growth rate of area associated with negative growth rate of yield. III- negative growth rate of area associated with positive growth rate of yield. This indicates that one crop area has been replaced by other crop or has gone out of cultivation and the yield on the remaining area has increased. IV-negative growth rate of area associated with negative growth rate of yield. Even the dynamics between growth and instability in yield were examined by four classifications, as I- increase in yield growth associated with decrease in yield instability. II-decrease in yield growth associated with increase in yield instability. III- decrease in yield growth associated with decrease in yield instability. IV- decrease in yield growth associated with increase in yield instability.

RESULTS AND DISCUSSION

Growth trends in area, production and yield

The total cereal production showed a significant increase since the Green Revolution period, and this was possible because of area expansion and yield improvements mainly in rice and wheat crops. The incremental increases in rice and wheat areas have primarily come from reduction in area from coarse cereals and pulse crops as a result of crop diversification in favour of fine cereals (Janaiah 2010). Consequently, share of coarse cereals to total cereal area and production has declined. Rice and wheat crops largely enjoyed most of the policy support in terms of subsidized fertilizer supply, support pricing, and assured procurement of output (Barker and Herdt 1985, Rao and Gulati 1994, Rosegrant and Pingali 1994, Pingali and Heisey 1999).

Currently rice occupied 42.9 million ha of area, and registered an impressive growth in productivity from 1.75 tonnes/ha in triennium ending (TE), 1993 to 2.75 tonnes/ha in TE2012-13 (Table 1). The largest share of rice area is occupied by Uttar Pradesh (5.6 m ha) followed by West Bengal (5.3 m ha), Odisha (4.2 m ha), Andhra Pradesh, Punjab and Tamil Nadu. In case of wheat, the crop is being grown in 29 million ha with average yield of 3 tonnes/ha. Uttar Pradesh constitutes the largest area followed by Madhya Pradesh, Punjab, Rajasthan and Haryana (Table 2). All the major states consistently showed increase in yield levels during the study period, with Punjab and Haryana having the highest yield

(4.6 ton/ha). As a coarse cereal, maize stands in an important position next to rice and wheat, due to its multiple uses with yield increases from about 1.5 ton per ha during 1990-93 to 2.4 ton per ha during 2010-13. Maize occupies 0.85 m ha area in the country; Karnataka and Rajasthan share the highest area. Andhra Pradesh, Uttar Pradesh, Madhya Pradesh and Bihar are other major maize growing states and Andhra Pradesh showed the highest yield of 4.3 tonnes/ha (Table 3).

A Comparative picture of growth and instability in area, production and yield of rice in major states of the country during 1990 to 2013 are given in Table 4. All India rice area, production and productivity registered a positive growth during the period I (1990-2000) of the study and results were in consensus with Kumar and Mittal, (2006). However, it substantially declined during the period II (2001-2013) and registered even negative growth in area. Except Odisha and Tamil Nadu, all other states registered a decline in productivity during the period II as compared to period I. Similarly, all states showed a decline in production growth during the period II than period I except Andhra Pradesh

Table 1 State-wise yield and percentage irrigated area of rice in India

State	Yield (tonnes/ha)			% irrigated area
	1990-93	2000-03	2010-13	2013
West Bengal	2.0	2.4	2.6	48.2
Uttar Pradesh	1.8	2.0	2.2	80.4
Andhra Pradesh	2.4	2.8	3.1	97.1
Punjab	3.3	3.5	3.8	99.5
Bihar	1.0	1.4	1.5	61.1
Odisha	1.3	1.2	1.6	32.2
Tamil Nadu	3.2	3.2	3.0	93.7
Karnataka	2.2	2.3	2.7	75.2
Madhya Pradesh	1.1	0.8	1.1	21.7
Kerala	2.0	2.2	2.6	100
All India	1.75	1.90	2.76	58.9

Source: Authors computed and data on irrigated area is taken from DES

Table 2 State-wise yield and percentage irrigated area of wheat in India

State	Yield (tonnes/ha)			% irrigated area
	1990-93	2000-03	2010-13	2010-13
Uttar Pradesh	2.2	2.7	3.0	98.1
Punjab	3.8	4.4	4.6	98.9
Madhya Pradesh	1.5	1.6	2.0	89.3
Haryana	3.6	4.1	4.6	99.5
Rajasthan	2.4	2.6	3.1	99.2
Gujarat	2.2	2.2	3.0	90.8
All India	2.33	2.69	2.97	92.9

Source: Authors computed and data on irrigated area is taken from DES

Table 3 State-wise yield and percentage irrigated area of maize in India

State	Yield (tonnes/ha)			% irrigated area
	1990-93	2000-03	2010-13	2010-13
Andhra Pradesh	2.2	3.1	4.3	49.3
Karnataka	2.9	2.6	3.0	39.2
Bihar	1.7	2.3	2.2	65.5
Rajasthan	1.1	1.1	1.5	0.8
Madhya Pradesh	1.4	1.7	1.4	2.0
Uttar Pradesh	1.3	1.5	1.6	34.6
All	1.53	1.86	2.35	25.2

Source: Authors computed and data on irrigated area is taken from DES.

and Odisha, while instability significantly increased at all India level in yield and production parameters.

In case of major wheat growing states during the study period 1991-92 to 2010-13, the trends show all the states to decline in area, production and productivity growth during the period II consistently as compared to period I, except Punjab in area and Gujarat in area, production and yield as well but most states showed decline in instability over the period. At the all India level though instability was found to be constant in area, yield and production rates, growth in wheat yield slowed down from 1.71% in period I to 1.15% in period II (Table 5), which has to be considered seriously from the policy side. Decade-wise growth rates for maize in all the states for area, production and yield was found to be positive in both the periods (Table 6), except for Madhya Pradesh and Uttar Pradesh. At the all India level

though growth rate in area turned negative in the second period still maize exhibited positive trends in yield as well as production and the instability too declined in the second period for area, production and yield as well. For all the three crops the graphical representation of growth trends in area and yield have been plotted state wise for the whole study period 1990-2013 to facilitate quick comparisons (Figs 1, 2 and 3).

Scenario of states based on growth and instability in area and yield

For clear understanding of the growth scenario, the

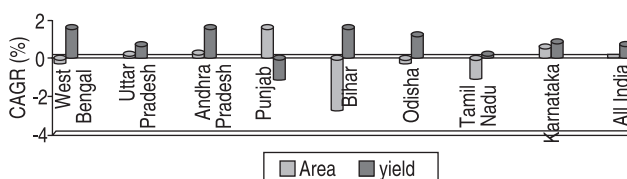


Fig 1 Growth trends in area and yield over the period 1990-2013 for rice

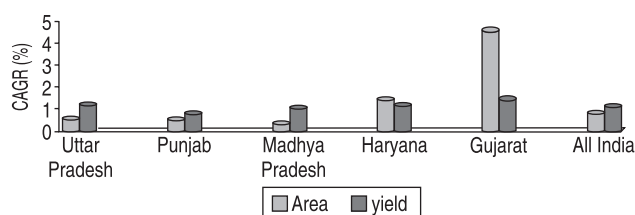


Fig 2 Growth trends in area and yield over the period 1990-2013 for wheat

Table 4 State-wise trends in growth and instability in area, production and yield of rice

State	Period	Compound annual growth rate (%)			Instability in growth rates (%)		
		Area	Production	Yield	Area	Production	Yield
West Bengal	1990-2000	0.35	2.05	1.70	3.07	7.56	6.92
	2001-2013	-0.88	0.02	0.91	5.19	3.83	3.308
Uttar Pradesh	1990-2000	1.10	3.28	2.16	3.93	10.68	7.81
	2001-2013	-0.15	0.81	0.98	5.53	13.25	9.50
Andhra Pradesh	1990-2000	1.28	2.61	1.23	7.50	12.90	7.00
	2001-2013	1.92	2.95	1.06	15.49	18.55	6.11
Punjab	1990-2000	2.55	2.44	7.25	9.48	10.90	63.06
	2001-2013	1.01	2.15	-0.51	4.52	8.06	4.70
Odisha	1990-2000	0.03	-2.05	-2.06	1.37	13.79	13.24
	2001-2013	-0.58	2.44	3.08	4.13	17.02	16.89
Tamil Nadu	1990-2000	0.42	0.50	0.06	6.46	26.52	25.14
	2001-2013	-0.02	0.69	0.81	12.17	23.75	15.92
Karnataka	1990-2000	1.47	3.06	1.57	6.77	12.82	6.63
	2001-2013	1.24	2.25	1.07	10.52	23.30	16.76
All India	1990-2000	0.77	1.93	1.15	2.51	6.63	4.49
	2001-2013	0.04	1.67	0.07	2.97	9.98	8.59

Source: Authors computed

Table 5 State-wise trends in growth and instability in area, production and yield of wheat

State	Period	Compound annual growth rate (%)			Instability in growth rates (%)		
		Area	Production	Yield	Area	Production	Yield
Uttar Pradesh	1990-2000	0.85	2.99	2.12	3.31	10.58	7.78
	2001-2013	0.31	1.73	1.39	1.92	9.05	7.73
Punjab	1990-2000	0.18	2.12	1.92	1.84	9.54	8.09
	2001-2013	0.36	0.88	0.52	1.36	6.39	5.51
Madhya Pradesh	1990-2000	3.03	5.40	2.34	9.60	17.18	8.77
	2001-2013	1.04	3.01	2.09	12.14	30.50	17.52
Haryana	1990-2000	2.22	3.75	1.48	8.53	14.39	5.85
	2001-2013	0.96	2.31	1.30	4.07	11.56	7.72
Gujarat	1990-2000	0.32	1.30	0.92	25.33	30.95	9.60
	2001-2013	11.15	14.02	2.65	32.41	40.56	12.70
All India	1990-2000	1.67	3.41	1.71	5.45	11.26	6.48
	2001-2013	1.12	2.34	1.15	5.46	12.20	6.58

Source: Authors computed

Table 6 State-wise trends in growth and instability in area, production and yield of maize

State	Period	Compound annual growth rate (%)			Instability in growth rates (%)		
		Area	Production	Yield	Area	Production	Yield
Andhra Pradesh	1990-2000	4.85	9.67	4.64	19.19	32.03	16.91
	2001-2013	5.43	10.05	4.36	20.26	35.73	19.92
Karnataka	1990-2000	10.51	10.40	0.02	33.65	35.06	8.24
	2001-2013	8.26	10.14	1.86	27.94	36.94	15.42
Bihar	1990-2000	0.84	3.32	2.40	13.56	23.48	14.03
	2001-2013	0.03	0.67	0.58	10.84	15.43	18.38
Madhya Pradesh	1990-2000	0.22	1.06	0.81	3.51	16.07	15.13
	2001-2013	-0.83	-3.29	-2.37	6.12	21.07	19.30
Uttar Pradesh	1990-2000	-1.34	-0.75	0.62	5.35	13.28	14.18
	2001-2013	-1.99	-1.69	0.50	10.51	15.54	11.64
All India	1990-2000	1.15	3.47	2.29	4.73	13.74	9.40
	2001-2013	-0.04	1.67	0.07	2.97	9.98	8.59

Source: Authors computed

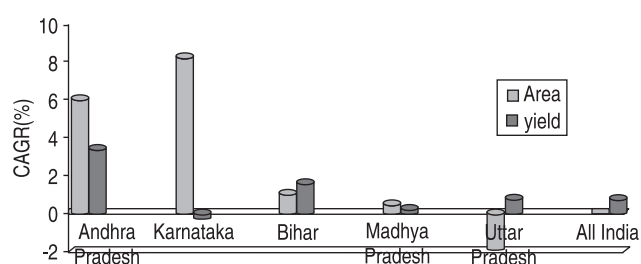


Fig 3 Growth trends in area and yield over the period 1990-2013 for maize

paper presents the association between growth in area and yield during both the periods separately. Following four scenarios were built, I- positive growth rate of area associated with positive growth rate of yield. II- positive growth rate of area associated with negative growth rate of yield. III- negative growth rate of area associated with

positive growth rate of yield. IV- negative growth rate of area associated with negative growth rate of yield. In case of rice, the results depict Karnataka and Andhra Pradesh registering a steady positive growth in area and productivity in both the periods. However, in the period I, West Bengal, Uttar Pradesh, Bihar and Tamil Nadu attained positive growth in area and yield levels, but they slipped to III category (negative area growth and positive yield growth) during the period II. Punjab is the only state which experienced negative growth in area but positive yield growth during 2000 decade (Table 7). The results for different wheat growing states (Table 8), on association between area and yield growth registered a steady positive growth in area and productivity in both the periods. When we look at maize during the 1990's and the 2000 decade it shows, Andhra Pradesh, Bihar, Karnataka and Rajasthan to have a steady positive growth in area and productivity in both the periods.

Table 7 Categorization of states according to growth and instability in area and yield of rice

Dynamics between growth in area and yield			Dynamics between growth and instability in yield	
Type of association	1990-2000	2001-2013	Type of association	Period II compared to period I
I. Positive area growth and positive yield growth	West Bengal, Uttar Pradesh, Andhra Pradesh, Punjab, Bihar, Tamil Nadu, Karnataka	Andhra Pradesh, Karnataka	I. Increase in yield with decrease in instability	Tamil Nadu
II. Positive area growth and negative yield growth	Odisha	Punjab	II. Increase in yield with increase in instability	Odisha
III. Negative area growth and positive yield growth		West Bengal, Uttar Pradesh, Bihar, Odisha, Tamil Nadu	III. Decrease in yield with decrease in instability	West Bengal, Andhra Pradesh, Punjab
IV. Negative area growth and negative yield growth			IV. Decrease in yield with increase in instability	Uttar Pradesh, Bihar, Karnataka

Table 8 Categorization of states according to growth and instability in area and yield of wheat

Dynamics between growth in area and yield			Dynamics between growth and instability in yield	
Type of association	1990-2000	2001-2013	Type of association	Period II compared to period I
I. Positive area growth and positive yield growth	Uttar Pradesh, Madhya Pradesh, Haryana, Rajasthan, Gujarat	Uttar Pradesh, Punjab, Madhya Pradesh, Haryana, Rajasthan, Gujarat	I. Increase in yield with decrease in instability	
II. Positive area growth and negative yield growth			II. Increase in yield with increase in instability	Gujarat
III. Negative area growth and positive yield growth			III. Decrease in yield with decrease in instability	Uttar Pradesh, Punjab, Rajasthan
IV. Negative area growth and negative yield growth			IV. Decrease in yield with increase in instability	Madhya Pradesh, Haryana

However, in the later period, Madhya Pradesh slipped into the category of negative growth in area and yield during 2000 decade, which is a matter of serious concern. Uttar Pradesh consistently remained in the same category showing negative area expansion with positive yield growth in both the periods (Table 9).

Similarly, the association between growth and instability in yield of rice, wheat and maize is presented in Table 7, 8 and 9. Four different types of association were examined I- increase in yield growth associated with decrease in yield instability. II-decrease in yield growth associated with increase in yield instability. III- decrease in yield growth associated with decrease in yield instability. IV- decrease in yield growth associated with increase in yield instability. Tamil Nadu was the only state which experienced an increase in yield growth accompanied by decrease in yield instability in case of rice during period II over period I. While Odisha experienced increase in yield growth associated with increase in yield instability. West Bengal, Andhra Pradesh and Punjab fell in the category of decreased yield growth associated with decreased yield instability. In case of wheat

none of the states experienced an increase in yield growth accompanied by decrease in yield instability. But Gujarat experienced increase in yield growth with increasing yield instability in period II in comparison to period I. Uttar Pradesh, Punjab and Rajasthan were found in the category of decreased yield growth associated with decreased yield instability. Distribution of maize growing states based on the types of association between yield growth and relative instability in yield show that none of the states experienced an increase in yield growth accompanied by decrease in yield instability. While Karnataka and Rajasthan, major maize producing states in the country experienced increase in yield growth associated with increase in yield instability in period II as compared to period I and it seems to be a real concern as maize is one of the important commercial crops. The same is true for Andhra Pradesh, Bihar and Madhya Pradesh which recorded decrease in yield growth with increase in yield instability.

The results on production and productivity trends in rice depicted except Uttar Pradesh, Bihar and Odisha, all the major states exhibited higher yield levels than all India during

Table 9 Categorization of states according to growth and instability in area and yield of maize

Dynamics between growth in area and yield			Dynamics between growth and instability in yield	
Type of association	1990-2000	2001-2013	Type of association	Period II compared to period I
I. Positive area growth and positive yield growth	Andhra Pradesh, Karnataka, Bihar, Rajasthan, Madhya Pradesh	Andhra Pradesh, Karnataka, Bihar, Rajasthan	I. Increase in yield with decrease in instability	
II. Positive area growth and negative yield growth			II. Increase in yield with increase in instability	Karnataka, Rajasthan
III. Negative area growth and positive yield growth	Uttar Pradesh	Uttar Pradesh	III. Decrease in yield with decrease in instability	Uttar Pradesh
IV. Negative area growth and negative yield growth		Madhya Pradesh	IV. Decrease in yield with increase in instability	Andhra Pradesh, Bihar, Madhya Pradesh

TE 2010-13. But all the states showed decline in production growth during the period II (2001-2013) than period I (1990-2000) except Andhra Pradesh and Odisha. In case of wheat, all the major states consistently showed increase in yield levels with Punjab and Haryana having the highest yield (4.6 tonnes/ha). The results on association between area and yield growth of wheat showed that all the states registered a steady positive growth in area and productivity in both the periods. Association between yield growth and instability in yield reflects no state to be showing an increase in yield growth accompanied by decrease in yield instability. While Gujarat experienced increase in yield growth associated with increase in yield instability in period II as compared to period I. It thus shows the urgency to stabilise the yield levels of rice and wheat to maintain productivity and new varieties like HD 2967 and HD3059 suitable to irrigated conditions are the reasons of Gujarat's higher yields in wheat, and have proved their worth. This in turn calls for policy attention in terms of varietal research and development.

All maize growing states showed increase in productivity levels; Andhra Pradesh showing the highest yield (4.3 tonnes/ha). Bihar is emerging as new centre for maize productivity due to higher yield levels in rabi maize. Karnataka, Andhra Pradesh, and Rajasthan registered a steady positive growth in area and productivity in both the periods. However, in the later period, Madhya Pradesh slipped into the category of negative growth in area as well as yield, which is a matter of serious concern and needs policy attention. The distribution of maize growing states according to the types of association between yield growth and relative instability in yield reflected that none of the maize growing states experienced an increase in yield growth accompanied by decrease in yield instability. This seems to be a real concern as maize is an important commercial crop along with staple use. Even Karnataka registered low levels of productivity despite having largest share in area. Thus focussing on yield levels through MH8, QPM2, MH9 and Vivek hybrids along with nutrient management practices to stabilise the productivity in maize,

must be the future way out and needs similar policy attention in all the other crops too, only then we can have the stable growth scenario required to meet the food security concerns for the future of millions.

REFERENCES

- Ahmad I M, Samuel E, Makama S A and Kiresur V R. 2015. Trend of area, production and productivity of major cereals: India and Nigeria Scenario. *Research Journal of Agriculture and Forestry Sciences* 3(2): 10-5.
- Barker R and Herdt R W. 1985. *Rice Economy of Asia*. Resources for the Future, Washington, DC.
- Bhalla G S, Hazell P and Kerr J. 1999. Prospects of India's cereal supply and demand to 2020. Food Agriculture and the Environment Discussion Paper 29, International Food Policy Research Institute (IFPRI), Washington, DC.
- IBEF .2015. Indian agriculture Industry; an overview. [online] URL: <http://www.ibef.org/>
- Janaiah A, Achoth L and Bantilan C. 2005. Has the green revolution bypassed coarse cereals? The Indian Experience. *Journal of Agricultural and Development Economics* 2(1): 20-31.
- Kumar P, Kumar A and Mittal S. 2004. Total factor productivity of crop sector in the Indo-Gangetic plain of India: Sustainability issues revisited. *Indian Economic Review* 39(1): 169-201.
- Kumar P and Mittal S. 2006. Agricultural productivity trends in India: Sustainability issues. *Agricultural Economics Research Review* 19(Conference No.): 71-88.
- Pingali P L and Heisey P W. 1999. Cereal crop productivity in developing countries. *CIMMYT Economics Paper* 99-03.
- Rao C H and Gulati A. 1994. Indian agriculture: Emerging perspectives and policy issues. *Economic and Political Weekly* 158-69.
- Rosegrant M W and Pingali P L. 1994. Policy and technology for rice productivity growth in Asia. *Journal of International Development* 6: 665-88.
- Kabra K N and Ittyerah A. 2009. The public distribution system in India, Eastern book, New Delhi.
- Singh S. 2006. Food security effectiveness of the public distribution system in India, MBA thesis, Faculty of Economics, University of Ljubljana, Slovenia.