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Research Paper

Trends in production and productivity of *Jowar* and *Bajra* in India

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ABSTRACT : Coarse grains like *Bajra* and *Jowar* has a greater role to play in improving small and marginal farmers conditions in arid and semi arid regions in adapting to regions having permanent climatic and geographical impediments. Growth patterns and instability in production and productivity of these crops over the time was studied using the compound annual growth rate and coefficient of variation. The analysis shows the changing cropping pattern in the country from coarse grains to high cash crops, which is reflected by decline in area of coarse grains by 15 per cent in 2000's, however, the productivity is on the rise in both *Bajra* and *Jowar* due to release of improved hybrids and varieties by public and private sector research in response to their industrial and nutritional value as Nutri-cereals. But relation of yield with relative instability in most of the states, growing *Jowar* and *Bajra* has been increasing over the period, which is a matter of serious concern. Hence, the study points out to the significant policy interventions to maintain the stability of coarse grains along with production in the wake of its increasing nutritional and commercial value in suiting to the fragile environmental conditions.

KEY WORDS : *Jowar, Bajra,* Nutri-cereals

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INTRODUCTION :

World cereal production has been expanding over the past decades and India from being a food deficit country prior to independence, today has achieved the status of being not only self sufficient but also net exporter of food grains which was made possible due to inception of green revolution in the 1960's.Today Indian economy has changed structurally with declining share of agriculture in GDP from 55 per cent in 1950-51 to 15.35 per cent in 2015-16 at 2011-12 prices but still 58 per cent of households depend on agriculture for their livelihood (IBEF, 2015) and consist of more than 80 per cent of farmers under small and marginal categories, most of them coming under arid and semi arid regions are heavily dependent on coarse cereals to suite to the harsh climate and scanty rainfall conditions. In favoured environmental regions of India like the Indo-gangetic plains with good irrigation facilities farmers have changed their consumption patterns from millets and sorghum to rice, wheat, maize and other high value crops (Seetharam *et al.*,1989).On the other hand farmers demand to millet crops and varieties in the arid and semi arid regions (including Rajasthan, Maharashtra, Karnataka, Andhra Pradesh and Gujarat) is unlikely to decline in near future, as there are hardly few crops to substitute in the fragile

growing environments for the farmers with low levels of income (Pray and Nagarajan, 2009).Thus, coarse grains play a vital role in stabilising the income as well as nutritional security along with environmental suitability to millions of farmers.

Millets belong to the group of annual grasses, found growing in semi-arid and arid regions across the world, and are cultivated for use as grain in daily diet and also to larger extent as fodder to cattle. Sorghum (*Sorghum bicolor*) also known as *Jowar* is grown in the arid and semi-arid regions of India receiving as little as 400 to 500 mm rainfall per year. As many as 100 distinct cultivars of sorghum have been identified in the sorghum-growing regions of India (Pray and Nagarajan, 2009). Pearl millet (*Pennisettum typhoides*) also known as *Bajra* is the most important coarse grain next to *Jowar* and is important staple crop, especially for marginalized households, for whom coarse cereals account for a larger share of everyday diets than wheat and rice (Ramaswami, 2002). Pearl millet too has distinct cultivars adopted across the country and India is considered to be the second center of origin for *Bajra* and is grown mainly in Rajasthan, Gujarat, Haryana and some parts of Karnataka.

India is a major producer of *Jowar* and millets and they account to nearly 5 per cent (each) of the total cropped area with increasing production in absolute terms from 33 million tonnes in the beginning of 2000 to 42 million tonnes in 2014-15 (4^{th} advanced estimates), but the area has declined by about 15 per ceny from 28.9 million hectares to 24.7 million hectares for the same period (State of Indian agriculture, 2015-16). However, the productivity of coarse cereals has increased significantly during the period in all the major states due to new hybrids and cultivars released from AICRP's on millets and sorghum (All India Co-ordinated Research Project), ICRISAT (International Crop Research Institute for Semi Arid Tropics) and other private firms with the new seed industries growth in the country. With emerging awareness about coarse grains, sorghum and millets are not only used as mere feed and fodder but also in commercial production (Bakery items), Industrial usage (Starch and Alcohol) and for their nutritional supplements they are rightly termed as Nutri-cereals along with other minor millets (Proso millet, Kodo millet, Fox tail millet, Finger millet etc). Sorghum is also used as source of energy in production of bio fuel, thus, with public and private research the increased yields have helped millions of farmers in arid and semi-arid regions. But the concern is to stabilise the yield variations and maintain the productivity of these crops to enhance production in all the major states which are lagging behind, as Pray *et al*. (1991) showed that 80 to 90 per cent of the benefits from the adoption of hybrids in coarse grains accrued mainly to small and marginal farmers than to the seed companies, even after meeting sufficient benefits to induce the firms to invest. Across the major coarse cereals producing states of Maharashtra, Karnataka, Andhra Pradesh, Rajasthan and Gujarat on an average, *Jowar* and *Bajra* constitute, 50 per cent of the total cereals consumption even today (Das, 2015). With this the study tries to capture the trends in growth of sorghum and *Bajra* along with instability over the period in major coarse grain producing states of India.

MATERIALS AND METHODS :

The study was conducted using secondary data for a period of 22 years from 1990-91 to 2012-13. Area, production and productivity data of sorghum and *Bajra* from the period 1990-1991 to 2012-2013 for major coarse grain growing states were obtained from the Directorate of Economics and Statistics, Ministry of Agriculture, Govt. of India, New Delhi. The period of study was divided in to two parts, from 1990-2000 (period I) and 2001-2013 (period II) to make comparisons in trends over the period and draw valid conclusions.

Analytical techniques :

To see the trends in area, production and productivity of *Jowar* and *Bajra*, state-wise compound annual growth rate was computed making use of state-wise time-series data for the period 1990-1991 to 2012-13 from Directorate of Economics and Statistics, Ministry of Agriculture, Government of India.

Compound growth rate was found using CAGR formula, by computing moving averages of the time-series data.

Compound annual growth rate:

$$Y_t = Y_0 (1+ r)^t \quad \text{.....(1)}$$

Taking natural logarithm of above equation,

$$\ln Y_t = \ln Y_0 + t \ln (1+r) \quad \text{...(2) (taking log of eq1)}$$

$$\ln_t Y = a + bt \quad \text{.....(3)}$$

where,

$a = \text{Ln } Y_0$ and $b = \text{Ln } (1+r)$

CAGR (%) = r = (antilog b-1)*100

where,

Y_t = Production/area/ productivity at t^{th} period

t = Is the time variable

A= Constant indicating Y in the base period (t=0)

b = Regression co-efficient indicating the extent to which production and productivity changes per unit time (t), e= Error term.

To measure the instability in area, production and productivity simple co-efficient of variation was used.

Co-efficient of variation :

Measures of variability such as range, standard deviation, variance, co-efficient of variation etc. have been used in the literature. Here we have made use of simple Variance and co-efficient of variation for measuring instability in area, production and productivity of *Jowar* and *Bajra*. The time series data on these parameters were detrended by fitting linear regression function (Mehra, 1981). Co-efficient of variation was used to measure the instability of parameters and the formula used for co-efficient of variation of the detrended series is given below:

C.V. = (S.D./mean)*100

where,

C.V. = Co-efficient of variation

S.D. = Standard deviation.

RESULTS AND DATA ANALYSIS :

Despite the fact that area under *Jowar* and *Bajra* has been declining over the years, the yield levels are on the rise in these coarse grains in most of the states, reduction in area from coarse cereals is due to crop diversification in favour of fine cereals like rice and wheat (Janaiah *et al*., 2005), as a result share of coarse cereals to total cereal area and production has declined. Since the green revolution in the 1960's rice and wheat enjoyed most of the policy support in terms of support pricing (MSP), subsidized fertilizer supply and government procurement of output (Barker and Herdt, 1985; Gulati and Rao, 1994; Rosegrant and Pingali, 1994 and Pingali and Heisey, 1999). However, farmers demand and yield increase in coarse grains were met by the efforts of public and private sector research, 55 per cent of the area under *Jowar* and *Bajra* in India were planted with high-yielding varieties (HYVs) during 1992–94, doubling the productivity with no yield plateau in sight compared with the pre-a HYV era. But these positive changes in terms of cultivar diversity and adoption occurred primarily in relatively favourable environments and in states with well-developed seed production infrastructure (Rai *et al*., 1999), leaving behind the states with harsh climatic conditions.

***Jowar* :**

Decadal all India annual average growth rates of area, production and yield showed significant decline in area and production with positive yield growth in the second period. The area under *Jowar* has declined in absolute terms from 14.36 million hectares in 1990-91 to 5.8 million hectares in 2013-14, while production declined from 11.68 million tonnes to 5.54 million tonnes for the same period (Agricultural Statistics at a Glance, 2015).The table below (Table 1) shows the state wise scenario for *Jowar* in absolute terms along with percentage area under irrigation, productivity levels is on the rise in all the states and the state of Maharashtra followed by Karnataka cover the highest area under *Jowar* among all other states and Karnataka registers productivity growth of 1.1 tonnes/ha in TE*2010-13,from 0.8 tonnes/ha in TE 1990-93 at the national level.

* TE denotes triennium ending everages

A comparative picture of growth and instability in

Table 1 : State-wise planted area, yield and percentage irrigated area of jowar in India

States	Planted area (Rs. 000 ha)	Yield (tonnes/ha)			% Irrigated area
	2010-13	1990-93	2000-03	2010-13	2010-13
Maharashtra	3839.7	0.9	0.8	0.9	9.5
Karnataka	1251.7	0.8	0.8	1.1	11.5
Madhya Pradesh	425.7	0.9	0.8	1.4	0.2
Andhra Pradesh	305.0	0.7	1.0	1.3	17.2
Tamil Nadu	226.6	1.1	0.8	1.1	15.5
All India	6407.3	0.82	0.77	0.93	9.7

area, production and yield of *Jowar* in major states of the country during 1990 to 2013 are presented below (Table 2). Looking at the trends in area, production and productivity we see declining trends in area and production growth of *Jowar* during the entire study period and the results were in consensus with Pray and Nagarajan, (2009). Across the states Andhra Pradesh, Tamil Nadu and Karnataka experienced significant positive yield growth during the 2000 decade, while all the states showed negative production growth in both the periods except Karnataka which attained positive growth rate in production in the second study period (2001-2013), with dip in area expansion among all the states. The ever increase in yield growth although with declining area is supported by study of Reddy *et al.* (2007), due to the popularity of hybrids produced by ICRISAT along with private sector partnership for sorghum improvement, where around 80 per cent of the area is planted with more than 70 private sector hybrids, of which 54 are based on ICRISAT-parental lines like VJH540, MLSH 296 etc.

For clear understanding of the growth scenario, the paper presents the association between area and yield growth during both the periods separately. Four scenarios were built based on the association between growth rates of area and yield of rice crop. I- positive growth rate of

Table 2 : State-wise trends in growth and instability in area, production and yield of *Jowar*

States	Period	Compound annual growth rate (%)		
		Area	Production	Yield
Maharashtra	1990-2000	-2.03 (8.31)	-2.83 (21.39)	-0.66 (16.73)
	2001-2013	-3.00 (14.05)	-2.28 (17.29)	0.84 (11.17)
	1990-2013	-2.27 (17.00)	-2.94(27.19)	-0.62 (14.98)
Karnataka	1990-2000	-2.05 (7.39)	-1.30 (13.36)	0.76 (12.93)
	2001-2013	-3.94 (14.84)	0.62 (19.32)	4.75 (25.02)
	1990-2013	-2.94 (19.50)	-1.32 (18.83)	1.69 (21.84)
Madhya Pradesh	1990-2000	-9.20 (31.56)	-10.21 (40.20)	-1.05 (14.91)
	2001-2013	-5.41 (26.00)	-0.44 (16.76)	5.47 (26.13)
	1990-2013	-5.76 (45.48)	-3.29 (38.57)	2.70 (29.41)
Andhra Pradesh	1990-2000	-5.48 (18.47)	-5.17 (17.67)	0.37 (9.96)
	2001-2013	-8.80 (35.06)	-4.96 (23.39)	4.22 (19.79)
	1990-2013	-6.93 (44.36)	-3.08 (24.26)	4.18 (31.54)
Tamil Nadu	1990-2000	-5.34 (19.32)	-7.14 (26.21)	-1.87 (9.1)
	2001-2013	-5.49 (22.48)	-3.12 (13.93)	2.71 (21.90)
	1990-2013	-4.09 (31.07)	-5.07 (42.20)	-0.95 (18.02)
All India	1990-2000	-3.55 (12.32)	-3.89 (18.69)	-0.29 (11.82)
	2001-2013	-3.55 (14.62)	-1.47 (10.28)	2.00 (10.09)
	1990-2013	-3.11 (22.30)	-2.63 (22.93)	0.45 (10.85)

Note: Figures in the parenthesis indicates co-efficient of variation

Table 3 : Categorization of states according to growth and instability in area and yield of *Jowar*

Association between growth in area and yield of jowar			Association between growth in yield and instability in yield of jowar	
Type of association	1990-2000	2001-2013	Type of association	Period II compared to period I
Positive area growth and positive yield growth	-	-	Increase in yield with decrease in instability	Maharashtra
Positive area growth and negative yield growth	-	-	Increase in yield with increase in instability	Karnataka, Madhya Pradesh, Andhra Pradesh, Tamil Nadu
Negative area growth and positive yield growth	Karnataka, Andhra Pradesh	Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh, Tamil Nadu	Decrease in yield with decrease in instability	-
Negative area growth and negative yield growth	Maharashtra, Madhya Pradesh, Tamil Nadu	-	Decrease in yield with increase in instability	-

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.

Likewise the nutshell scenario of association between area and yield growth of *Jowar* during the 1990's and the 2000 decade depict none of the states to have positive area growth. However, in the later period, majority of the states like Madhya Pradesh, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu experienced positive yield growth with negative growth in area expansion. Association between yield growth and instability in yield in period II over period I show that only Maharashtra experienced an increase in yield growth accompanied by decrease in yield instability. Major *Jowar* growing states such as Karnataka, Madhya Pradesh, Andhra Pradesh and Tamil Nadu registered an increase in yield growth associated with increase in yield instability in period II as compared to period I, which is a matter of serious concern and policy attention (Table 3).

Bajra :

State wise scenario of *Bajra* along with irrigation coverage is given in the Table 4, Haryana has the maximum area under irrigation (34.8%) and Gujarat (22.3%) with Rajasthan having highest area under *Bajra* of 5225 hectares. A look at the compound growth rate in area, production and productivity of major *Bajra* growing states during 1990's to 2013, it shows significant increase

Table 4 : State-wise planted area, yield and percentage irrigated area of *Bajra* in India

States	Planted area (Rs. 000 ha)	Yield (tonnes/ha)			% Irrigated area
	2010-13	1990-93	2000-03	2010-13	2010-13
Rajasthan	5225.7	0.4	0.5	0.7	2.9
Uttar Pradesh	891.0	1.1	1.3	1.7	12.1
Gujarat	804.0	1.0	1.0	1.3	22.3
Haryana	607.7	0.9	1.1	1.8	34.8
All India	9098.25	0.7	0.7	1.0	8.5

Table 5: State-wise trends in growth and instability in area, production and yield of *Bajra*

States	Period	Compound annual growth rate (%)		
		Area	Production	Yield
Rajasthan	1990-2000	-2.03 (7.44)	-2.83 (35.50)	-0.66 (30.30)
	2001-2013	-3.00 (16.97)	-2.28 (40.89)	0.84 (33.61)
	1990-2013	-2.27 (13.39)	-2.94 (51.20)	-0.62 (43.81)
Uttar Pradesh	1990-2000	0.56 (4.91)	3.11 (15.01)	2.55 (12.75)
	2001-2013	0.57 (4.49)	3.81 (17.52)	3.22 (15.10)
	1990-2013	0.39 (5.15)	2.59 (21.38)	2.20 (18.03)
Gujarat	1990-2000	-2.69 (9.24)	0.15 (26.66)	2.97 (24.03)
	2001-2013	-2.51 (15.69)	-0.35 (18.57)	2.36 (15.02)
	1990-2013	-2.31 (17.59)	-0.53 (22.28)	1.89 (22.45)
Haryana	1990-2000	0.35 (5.59)	3.12 (26.82)	3.07 (24.25)
	2001-2013	0.26 (11.22)	5.19 (24.55)	4.98 (20.87)
	1990-2013	0.20 (8.77)	4.36 (34.91))	4.20 (32.86)
All India	1990-2000	-1.26 (5.39)	0.66 (19.57)	2.03 (17.22)
	2001-2013	-0.35 (10.40)	2.48 (22.46)	3.13 (19.49)
	1990-2013	-0.64 (9.14)	2.07 (24.99)	2.79 (25.72)

Note: Figures in the parenthesis indicates co-efficient of variation

in production and productivity, but growth rate in area expansion is negative with increasing instability in both area and production at all India level, while instability in yield was found to decline over the period in all the states (Table 5).The results are supported by the declining area under *Bajra* in absolute terms from 10.4 million hectares in 1990-91 to 7.8 million hectares in 2013-14, but production has increased from 6.89 million tonnes to 9.3 million tonnes with significant yield jump from 0.6 tonnes/ha to1.2 tonnes/ha for the same period (Agricultural Statistics at a Glance, 2015).The productivity growth in *Bajra* due to increased yield levels is substantiated by the contribution of hybrids from ICRISAT along with private sector partnerships using ICRISAT derived lines like JKBH 26, hybrid 9444 (Mula *et al*.,2007) and also other public hybrids developed by agricultural universities like HHB 67 from Haryana agricultural university in 1996 adopted by farmers in Rajasthan and Haryana covering more than 400,000 hectares (Hash *et al*., 2007). This clearly reflects that *Bajra* production is driven mainly by yield increases and not through area expansion. The association between area and yield growth of *Bajra* during the nineties and the 2000 decade showed that Uttar Pradesh and Haryana registered a steady positive growth in area and productivity in both the periods. Gujarat and Rajasthan too experienced positive yield growth but with decrease in area expansion, while association between yieldgrowth and relative instability in yield in period II over period I depict that only Haryana experienced an increase in yield growth accompanied by decrease in yield instability. While Rajasthan and Uttar Pradesh experienced increase in yield growth associated with increase in yield instability in period II as compared to period I and Gujarat falls in the category of decreased yield growth associated with decreased yield instability (Table 6).

Conclusion :

Coarse cereals grown mostly in fragile environmental conditions have emerged as important crop of dry lands due to their physical characteristics. These crops are tolerant to drought or abiotic stress *i.e.* high temperature and low levels of moisture and are mainstay to food security of poor people in marginal production environments. Unlike the fine cereals and maize, the decade-wise all India annual average growth rate of area, production and yield of *Jowar* showed significant decline in area and production growth during both the periods, except positive yield growth during the period II and major *Bajra* growing states during 1990 to 2013 showed significant increases in production and productivity, but with negative growth in area at all India level. Noticeably these yield increases would not have been possible without the public sector research, as we know that in the absence of public sector research, private profit oriented industries would have developed much more slowly.

The distribution of *Jowar* growing states according to the types of association between yield growth and relative instability in yield in period II over period I show that only Maharashtra experienced an increase in yield growth accompanied by decrease in yield instability. All other major *Jowar* growing states such as Karnataka, Madhya Pradesh, Andhra Pradesh and Tamil Nadu registered an increase in yield growth associated with increase in yield instability in period II as compared to period I, which is a matter of serious concern.While in case of *Bajra* during the 1990's and the 2000 decade Uttar Pradesh and Haryana registered a steady positive growth in area and productivity in both the periods and Gujarat showed decreasing instability but yield was also on the decline in the second period. All the other states showed increasing yield levels along with increase in yield instability thus, needing policy attention for this crop. We see that *Bajra* production has been driven mainly by yield

Table 6 : Categorization of states according to growth and instability in area and yield of *Bajra*

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

increases and not through area expansion. But for *Jowar* though the yield rates are positive and rising, production growth rate is still on negative side except for Karnataka thus leaving the gap to be bridged by the policy makers. Likewise both the crops depict increasing levels of instability in yield and production for all most all the states requiring immediate attention. Thus, *Jowar* and *Bajra* being important coarse grains and any improvement in yield in these crops will have direct impact on the poorest households specially in the arid and semi-arid states in India where coarse grains are more important in diet of the poor than rice and other fine cereals even today. In the wake of increasing commercial value of *Jowar* and *Bajra* as fuel, feed and fodder for the growing livestock and poultry industries and their enhanced nutritional value in diet than rice and wheat, government should take measures to include the coarse grains in the public distribution systems (PDS) as our PDS is dominated largely by rice and wheat and also safeguard the production interests of small farmers by assured support prices (MSP).As any improvement made in these crops will enhance the productivity and welfare of the poor, small and marginal households directly, than mere increasing productivity in rice and wheat which are already well supported in the system.

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