



Performance of Millets in Bundelkhand Region of UP State

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ABSTRACT

Time series data on area, production and productivity of major millets (2000-01 to 2019-20) was analyzed for Bundelkhand region of Uttar Pradesh state. Sorghum was the most important millet crop that accounted for highest area (36.6%) and (34%) of total millet area and production in UP state, respectively. Chitrakoot district contributed highest area (31.6%) under millets. Among all the millets, pearl millet recorded highest growth rate in area (0.97%), production (3.57%) and productivity (1.59%) with low instability index for area. The overall area and production of millet crops recorded decline in all the seven districts of Bundelkhand region during overall study period (2000-20). Lalitpur district recorded highest decline in area (-22.02%), followed by Chitrakoot (-10.82%) and Jhansi district (-10.63%) during overall study period, while during the same period Banda district recorded a growth in area (1.16%) and production (4.77 %) of pearl millet. The overall area, production and productivity of millets registered a decline in Bundelkhand region during 2000-20. This calls for aggressive promotional activities for enhancing millets production in the region.

INTRODUCTION

Small-grained cereal grasses are collectively called as 'millets'. They are one of the oldest cultivated foods known to humans (Tomar and Singh, 2017). They are believed to be domesticated by humans even before rice and wheat. Millet is known for their nutritive qualities and they have substantially high amount of protein, fiber and minerals in comparison to rice and wheat (Anbukani et al., 2017; Ganapathy et al., 2021). Due to high nutritive value millets are declared as a Nutri-cereals. Millets are drought resistant and these crops can be grown in harsh circumstances. Traditionally these crops are cultivated in hilly and

semi-arid regions (Bala, 2004; Padulosi et al., 2009; Mal et al., 2010) and are traditional staple food for the rural poor in dry land regions of the country (Rao et al., 2021). India is the largest producer of Millets in the world and share around 41 per cent of total millet production of the world (Gowri and Shivakumar 2020) and is food staple in parts of India (Mishra et al., 2019). Millets can be classified in two categories i.e., Large Millet, including Sorghum and Pearl millet and Small Millet that includes finger, barnyard, little, kodo, foxtail and proso-millet.

Decline in area and production of millets in India (Bhagirath et al., 2019) is being witnessed with increase in area of major cereal crops like wheat and rice since post green revolution time and

increased cultivation of commercial crops like oilseed, cotton, spices, fruits and vegetables (Malathi, et al., 2016). Bundelkhand is a hot and semi-humid region of UP state that lies between the Indo-Gangetic Plain toward the north and the Vindhya Range toward the south. It consists of 7 districts in Uttar Pradesh, namely Banda, Chitrakoot, Hamirpur, Jalaun, Jhansi, Lalitpur and Mahoba. Agriculture in Bundelkhand is rainfed, diverse, risky and vulnerable with long history of droughts (Gupta et al., 2014). The millet crops like pearl millet, sorghum as well as small millets like kodo millet, little millet and barnyard millet are traditional crops of Bundelkhand region of UP state and continue to occupy sizeable area. In view of importance of millets in the region as well as growing importance of millets as nutritional food in the country, attempt was made to analyze the trend of area coverage, production and productivity of millets over past two decades (2000-20) in the region.

METHODOLOGY

To analyze the compound annual growth rate and instability in area, production and productivity of millets and its primary component in Bundelkhand region, necessary time series data of seven districts of Bundelkhand region was collected from published reports of Directorate of Economics & Statistics, Government of Uttar Pradesh, Department of Agriculture and Cooperation, Government of India. Twenty year time series data from year 2000-01 to 2019-20 on area, production and productivity of three major millets crop was analyzed for all seven districts. To smoothen the variability of the data on millets from year to year, Triennium Ending Average (TE) on area, production and productivity of millets was utilized for analysis. The study period (2000-01 to 2019-20) was divided into two phases, period-I (2000-01 to 2009-10), period II (2010-11 to 2019-20) and also the overall period (2000-2001 to 2019-20). The data was subjected to descriptive statistics to ascertain the millet production scenario in UP Bundelkhand region. Compound Annual Growth Rate (CAGR) (Kalia et al., 2021) was computed to inspect the trend in area, production and productivity of the selected millet crops. The compound growth rate has been determined by using the following exponential function (Kumar and Devraj, 2010 and Maurya et al., 2016).

$$Y = AB^t$$

The log form of the above exponential equation is expressed as:

$$\text{Log}(Y) = \text{Log}(A) + t \text{Log}(B)$$

The compound growth rate percentage (r %) can be expressed using linear regression analysis (Shrivastava et al., 2021),

$$r\% = [\text{Antilog}(B) - 1] * 100$$

Where Y= acreage/production/productivity of crop, A= Constant,

r = Compound growth rate,

t= time variable in a year

Instability in area, production and productivity was estimated to examine the extent of risk in these variables using Cuddy-Della Valle Index (Cuddy and Della Valle, 1978) which is given as (Kolar et al., 2020).

$$CDVI = CV * \sqrt{1 - \bar{R}^2}$$

Here CV is the coefficient of variation in percent and \bar{R}^2 is Adjusted Coefficient of Determination from a time trend regression. Instability will be low if CDVI lies between 0 to 15, medium if belongs to 15 and 30 and high if greater than 30.

RESULTS AND DISCUSSION

Sorghum, pearl millet and small millets like kodo millet, little millet and barnyard millet, are the major millets cultivated in Bundelkhand region of UP state. The region contributes about 8 per cent of total area and 5 per cent of total production of millets in the UP state. The region witness a lower (108 kg/ha) productivity as compared the state (135 kg/ha) (Table 1). Among the millets, sorghum is the most important millet crop in Bundelkhand region of UP state that accounts for 36.6 percent (54.9 thousand ha) of total area and 34 percent (62 thousand tons) of total millet production in UP state (Table 1). Uttar Pradesh state contributed about 13 per cent of the total area and about 21 per cent of total production of pearl millet in the country. Bundelkhand region contributed 27 thousand ha area and 36 thousand tons of production of pearl millet. Small millets together occupied about 8.2 per cent of total area and contributed about 8.7 per cent of total production of small millets. The average productivity of sorghum, pearl millet and overall total millets in Bundelkhand region was found to be low (114, 132 and 108 kg/ha) as compared to the productivity of these crops in the UP state (125, 203 and 135 kg/ha), however the productivity in the region was found higher as compared to National average (98, 124 and 99 kg/ha). In contrast, the productivity of small millets (78 kg/ha) was reported in region to be higher in comparison to state and national average.

Chitrakoot district contributed maximum area 29.35 thousand hectare (31.6%) under millets in Bundelkhand region. Crop wise analysis reflected that, pearl millet contributed maximum area (37%) in Chitrakoot district, while considerable area (29%) was also reported under sorghum. Small millets occupied about 395 ha in Bundelkhand region, with a major contribution (82%) from Chitrakoot district and correspondingly the district contributed maximum production (84%) in the region. Millets occupied about 25.7 thousand hectare in Banda district, which was about 27.7 per cent of the total millets area. The district contributed maximum area (22.4 thousand ha) that was 35.5 per cent of total sorghum area in the region. Jalaun district also contributed about 22 per cent of the

Table 1. Millet production scenario in Bundelkhand region of UP (2018-19)

	India			Uttar Pradesh			Bundelkhand		
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
Sorghum	3840	3760	98	150(3.90)	180(4.78)	125	54.9(36.6)	62(34.44)	114
Pearl millet	6930	8610	124	880(12.69)	1780(20.67)	203	27.07(3.08)	36(2.02)	132
Small Millet	350	330	75	6.1(1.74)	4.6(1.39)	76	0.5(8.20)	0.4(8.70)	78
Total Millets	1120	12700	99	1036.1(9.32)	1960(15.43)	135	82.47(7.96)	98.4(5.02)	108

Source: Authors calculation from secondary data, *Area-'000'thousand Hectare *Production- '000'thousand tons *Yield - kg/ha, *Figures in the parenthesis indicates percentage

Table 2. District wise contribution of millets in Bundelkhand district of UP state (2019-20)

Crop	Area (ha)							Total
	Banda	Chitrakoot	Hamirpur	Jalaun	Jhansi	Lalitpur	Mahoba	
Pearl millet	3268 (11.15)	10810 (36.89)	5149 (1.75)	14663 (50.03)	23 (0.08)	00 (0.00)	28 (0.10)	29306 (100)
Sorghum	22404 (35.50)	18212 (28.86)	13049 (20.68)	5471 (8.67)	799 (1.27)	209 (0.33)	2960 (4.69)	63104 (100)
Small millet	21 (5.32)	324 (82.03)	4 (1.01)	0 (0)	23 (5.28)	8 (2.03)	15 (3.80)	395 (100)
Total millets	25693 (27.68)	29346 (31.62)	13567 (14.62)	20134 (21.69)	845 (0.91)	217 (0.23)	3003 (3.24)	92805 (100)
<i>Production (T)</i>								
Pearl millet	5989 (10.94)	19969 (36.49)	949 (1.73)	27727 (50.66)	43 (0.08)	1 (0.00)	52 (0.10)	54730 (100)
Sorghum	41439 (43.59)	28103 (29.56)	14727 (15.49)	7689 (8.09)	787 (0.83)	206 (0.22)	2114 (2.22)	95065 (100)
Small millet	15 (5.21)	243 (84.38)	2 (0.69)	0 (0)	12 (4.17)	5 (1.74)	119 (3.82)	288 (100)
Total millets	47443 (31.61)	48315 (32.19)	15678 (10.45)	35416 (23.60)	842 (0.56)	212 (0.14)	2177 (1.45)	150083 (100)

total millet area with pearl millet crop covering 14.7 thousand ha that was highest contribution (50%) in the region. In consistent with the area occupied by pearl millet, Jalaun district contributed about 51 per cent of the total pearl millet production in the region. In similar line, Chitrakoot district followed by Banda and Jalaun districts added about 32.2, 31.6 and 23.6 per cent of total millet production in the region. Lalitpur and Jhansi districts contributed only about 0.23 per cent and 0.91 per cent of total millets area in Bundelkhand region and contributed about 0.14 and 0.56 per cent of total millets production in the region. The findings are in agreement with Malathi et al., (2016), who reported decline in area coverage under over the years in the country, while Anbukani et al., (2017) specifically reported drastic reduction of area under minor millet in India over five decades (1955-56 to 2013-14) (Table 2).

Decadal variations

Crop wise decadal analysis indicated that among all millet crops, pearl millet recorded 18.76 per cent enhancement in area coverage and 76.2 per cent enhancement in production from TE 2000 to TE 2020. In addition pearl millet also recorded area enhancement by 8.15 per cent from TE 2000 to TE 2010 and by

9.81 per cent from TE 2010 to 2020. The production figures of pearl millet showed a decrease by 20 per cent from TE 2000 to TE 2010, while it showed an enhancement by 120 per cent from TE 2010 to TE 2020. The decrease in production during 2000-10 could be attributed to negative growth rate of pearl millet productivity during the same period (Table 3).

During overall study period (2000-20), among all the millets, pearl millet recorded highest growth rate in area (0.97%), production (3.57%) and productivity (1.59%) in the region. Further, though the growth rate of area coverage under pearl millet during period I was 0.88 per cent, production registered lower growth rate of 1.41 per cent owing to a decline in productivity by 0.2 per cent. In contrast, during period II, though the growth rate of in area under pearl millet was lower (0.86%) than the period I, the production recorded growth rate of 6.9 per cent, which could be attributed to a high growth rate of productivity (4.9%) during the same period. The instability index for area coverage of pearl millet crop was recorded to be low during period I, period II and overall period. In contrast, the instability index for production and productivity of pearl millet for period I (27.29% & 23.30%) was medium, while it was high for overall period (30.84 % & 33.94%). In contrast to pearl

Table 3. Decadal variation in area, production and productivity of millet crops

Crop	Area (ha)								
	TE			CAGR			Instability		
	2000	2010	2020	2000-10	2010-20	2000-20	2000-10	2010-20	2000-20
Pearl millet	23997.67	25953.3	28501	0.88	0.86	0.97	9.66	12.77	11.51
Sorghum	150323.00	82546.00	61885.33	-5.69	-2.85	-4.09	11.14	10.52	13.62
Small millet	4916.00	1232.333	455.33	-12.55	-1.62	-13.26	39.68	43.24	56.51
Total	179236.67	109731.7	90841.67	-4.54	-1.80	-2.99	10.06	9.08	11.57
<i>Production (T)</i>									
Pearl millet	24638.00	19696.33	43393.3	1.41	6.90	3.57	27.29	28.69	30.84
Sorghum	107258.33	50780	79890	-9.36	-1.27	-2.70	23.01	34.00	32.90
Small millet	3101.67	731	328	-13.04	-6.15	-11.35	51.82	52.30	65.63
Total	134998.00	71207	123611	-7.19	1.13	-1.15	21.15	31.71	30.42
<i>Productivity (T/H)</i>									
Pearl millet	0.91	0.71	1.16	-0.20	4.95	1.59	23.30	37.43	33.94
Sorghum	0.68	0.67	1.17	-2.17	0.49	1.48	23.89	24.83	25.68
Small millet	0.64	0.39	0.58	-1.87	-4.59	2.47	23.22	15.01	28.09
Total	0.74	0.59	0.97	-1.29	0.91	1.81	17.49	22.55	22.25

millet, the area coverage under sorghum crop continued to decrease by 45 per cent from TE 2000 to TE 2010, by 25 per cent from TE 2010 to TE 2020 leading to decrease by 59 per cent from TE 2000 (0.15 million ha) to TE 2020 (0.06 million ha) in the region. In the same lines, the production of sorghum crop was recorded to decline by 53 per cent from TE 2000(0.1 million tonnes) to TE 2010 (0.05 million tonnes) while increased by 57 per cent from TE 2010 (0.05 million tonnes) to TE 2020 (0.08 million tonnes). However, an overall decline in production of sorghum by 25 per cent was observed from TE 2000 to TE 2020. A steady negative growth rate was witnessed in area coverage and production of sorghum during period I and period II and overall study period. The growth rate in area coverage was recorded to be lower (-5.69%) in period I as well as period II (-2.85%). However, sorghum productivity recorded positive growth rate (0.49%) in period II and overall study period (1.48%) in contrast to a decline in productivity by 2.17 per cent during period I. The low instability index of area coverage of sorghum for all periods reflected on lesser fluctuations in area allocation under the crop.

Continuous decline in area under small millets in the region was observed during 2000-20. The decline was recorded to be 75 per cent from TE 2000 (4916 ha) to TE 2010 (1232 ha) and by 63 % from TE 2010(1232 ha) to TE 2020 (455 ha). Further, the decline rate of area under small millets was recorded to be -12.55, -1.62 and -13.26 per cent in period I, period II and overall study period, respectively. Corresponding to the decline in area under small millets, their production also registered decline by 76 per cent from TE 2000 (3101 T) to TE 2010 (731 T) and by 55 per cent from TE 2010 (731 T) to TE 2020 (328 T), leading to an overall decline by as high as 89 per cent from TE 2000 to TE 2020. A detailed analysis revealed that the production of small millets witnessed a negative growth during period I (-13.04%), period II (-6.15%) and overall period (-11.35%). Productivity of small millets declined from TE 2000 (0.64 q/ha) to TE 2010 (0.39 q/ha), while it witnessed an increase from TE 2010 (0.39 q/ha) to TE 2020 (0.58 q/ha). The productivity of small millets recorded growth during overall period (2.47%). The instability index was recorded to be high for area and production of small millets, while for productivity the instability was observed to be medium during all study periods.

Among all millet crops, Pearl millet recorded highest growth rate area (0.88%) and production (1.41%) during period in the region while its productivity recorded a decline at -0.20 per cent. In contrast, during the same period, small millet recorded highest decline in area (-12.55%), production (-13.04%) while sorghum crop recorded highest decline in productivity (-2.17%). In similar lines, during period II area and production of sorghum and small millets registered negative growth rate. However, the productivity of sorghum witnessed positive growth rate during period II. Productivity of all the millets registered growth during the study period (2000-20), implying effective diffusion of improved production technologies among the farmers of Bundelkhand region of UP state.

District wise variation

District wise analysis of growth rate reflected decline in overall area and production of millet crops in all the seven districts of

Table 4. District wise CAGR of area and production of major millets in Bundelkhand region of UP

Crop	Banda						Chitrakoot						Hamirpur						Jalaun						
	CAGR of area		CAGR of production		CAGR of area		CAGR of production		CAGR of area		CAGR of production		CAGR of area		CAGR of production		CAGR of area		CAGR of production						
	2000-2010	2000-2020	2010-2020	2000-2010	2000-2020	2010-2020	2000-2010	2000-2020	2010-2020	2000-2010	2000-2020	2010-2020	2000-2010	2000-2020	2010-2020	2000-2010	2000-2020	2010-2020	2000-2010	2000-2020	2010-2020				
Pearl millet	1.16	-4.24	2.73	4.77	-3.54	7.69	1.11	1.65	-0.98	3.42	3.22	2.6	-1.61	0.39	-1.66	3.22	3.11	-1.01	0.69	0.8	2.21	3.67	-0.91	9.68	
Sorghum	-2.12	-5.85	-1.94	0.86	-9.19	1.65	-2.08	-5.52	1.09	-1.52	-6.4	1.17	-5.65	-8.27	-6.79	-6.26	-19.94	-8.51	-4.67	-4.59	-3.69	-3.87	-5.51	-2.07	
Small millet	-14.95	-6.53	-10.61	-14.1	-9.62	-13.65	-10.82	-11.47	1.06	-7.68	-11.2	-4.19	-13.42	-25.43	-8.14	-13.57	-13.05	-14.34	NA	NA	NA	NA	NA	NA	NA
Total millets	-1.81	-5.64	-1.51	1.19	-8.61	2.23	-10.82	-3.72	0.28	0.20	-3.57	1.78	-5.57	-8.12	-6.65	-6.06	-19.08	-8.16	-1.40	-1.56	0.42	0.47	-2.45	5.82	

Crop	Jhansi						Lalitpur						Mahoba											
	CAGR of area		CAGR of production		CAGR of area		CAGR of production		CAGR of area		CAGR of production		CAGR of area		CAGR of production									
	2000-2010	2000-2020	2010-2020	2000-2010	2000-2020	2010-2020	2000-2010	2000-2020	2010-2020	2000-2010	2000-2020	2010-2020	2000-2010	2000-2020	2010-2020									
Pearl millet	-8.69	-8.33	-14.53	-6.73	-9.91	-7.08	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sorghum	-11.74	1.8	-10.66	-8.12	-1.4	-11.97	-21.88	-9.54	-3.4	-20.27	-5.45	-2.96	-6.68	-3.95	-5.49	-6.98	-8.8	-6.53	-8.8	-6.53	-8.8	-6.53	-8.8	-6.53
Small Millet	NA	NA	9.56	NA	NA	4.75	-24.46	-14.39	-6.07	-23.49	-15.47	-9.99	-15.76	-17.7	-13.55	-15.44	-18.7	-19.22	-18.7	-19.22	-18.7	-19.22	-18.7	-19.22
Total millets	-10.63	1.75	-11.24	-8	-1.64	-11.69	-22.02	-10.11	-4.34	-20.35	-6.28	-4.39	-6.75	-4.17	-5.37	-7.01	-8.88	-6.41	-8.88	-6.41	-8.88	-6.41	-8.88	-6.41

Table 4 contd...

Table 5. Correlation between irrigated area and total area under millets

S.No	Crop	Mean	SD	1	2	3	4	5
1	Pearl Millet	26913.72	3545.2	1.00				
2	Sorghum	87805.33	24028.8	-0.299	1.000			
3	Small millets	1530.22	1362.4	-0.410	0.871**	1.000		
4	Total millets	116249.3	24371.1	-0.172	0.991**	0.855**		
5	Irrigated area	215441.9	35060.4	0.411	-0.874**	-0.728**	-0.843**	

** Significant at 0.01 level

Bundelkhand region of UP state during overall study period (2000-20), though variations were observed in different period (Table 4). Highest decline in area was recorded in Lalitpur (-22.02%), followed by Chitrakoot (-10.82%) and Jhansi district (-10.63%) during overall study period. In contrast, Banda district recorded a growth in area (1.16%) and production (4.77%) of pearl millet during overall study period. Area coverage and production of pearl millet recorded a decline at -4.24 and -3.54 per cent respectively during period in the district, while during period II, area coverage and production recorded a growth 2.73 and 7.69 per cent, respectively. In Chitrakoot district the overall millets area though witnessed a decline by -10.8 per cent while pearl millet witnessed a growth in area (1.11%) and production (3.42%) during overall study period (2000-20). In contrast, the area and production of small millet (-10.82% and -7.68%) recorded a steep decline in the district during the same period (Table 4). Hamirpur district witnessed decline in area coverage under all the millets in overall study period. The same trend was recorded with regard to production of all the millet crops except, pearl millet that witnessed growth in production by 3.42 per cent during overall study period. Area coverage under pearl millet recorded a growth by 0.69 per cent with corresponding enhancement in production by 3.67 per cent during overall study period (2000-20) in Jalaun district. In Jhansi district, sorghum and pearl millet recorded a decline in area by -11.74% & -8.69% while they recorded decline in production by -8.12% and -6.73 per cent, respectively. In Lalitpur small millet witnessed highest decline in area (-24.46%) and production (-23.49%) district, while sorghum witnessed highest decline in area (-21.88%) and production (-20.27%) among all the districts of the region, during 2000-20 (Table 4). Similar pattern was observed in Mahoba district, wherein small millet and sorghum crop recorded decline in area (-15.76% & -6.68%) and production (-15.44% & -6.98%) during the same period. District wise trends analysis reflected that among all the millet crops, pearl millet recorded highest growth rate in all the district of Bundelkhand region of UP state except Jhansi and Hamirpur districts. In contrast, small millet production registered decline in all the districts of Bundelkhand with highest decline recorded from Lalitpur district.

Irrigated area versus total area under millets

The total area under millets crops in Bundelkhand region was found to be significantly negatively correlated ($r=-0.843$, $p<0.01$) with area under irrigation. The area under sorghum and small millets was also found to be significantly and negatively correlated with total irrigated area and total area under sorghum ($r=-0.874$, $p<0.01$) and small millets ($r=-0.728$, $p<0.01$) in the region. In contrast, correlation of the area under pearl millet and total irrigated area in the region was observed to be positively but statistically non-

significant (sorghum ($r=0.411$)). The results imply that increased in irrigated area would lead to low area under millets in the region (Table 5).

In case of pearl millet, presence of larger number of options of high yielding varieties and hybrids suitable for the region and strong role of private seed companies with strong push for marketing may be the reason for the growth of pearl millet in the region.

CONCLUSION

The overall area, production and productivity of millets registered a decline in Bundelkhand region during 2000-20. District wise decline in overall area and production of millet crops in all the seven districts of Bundelkhand region during the study period was observed. Pearl millets recorded highest growth rate in area, production, and productivity in the region, whereas the area coverage under small millets registered a decline during overall study period. In contrast to declining rate of area coverage and production of millets except pearl millet, the productivity of all millets registered positive growth during last two decades. The situation warrants aggressive promotion of millet in these rainfed tracts in view of increased recognition for their nutritional value among people. The positive trend in productivity of all the millets in overall study period reflect on percolation of improved production technologies in the region, however, promotional activities for enhancing the area coverage under millets need to be strengthened.

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