



Dynamics of Pulse Scenario in Bundelkhand Region of Uttar Pradesh: A Temporal Analysis

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ABSTRACT

The paper examines the temporal changes in the area, production and productivity of major pulse crops in Bundelkhand region of UP during last two decades (2000-2020). Published data on area, production and productivity was utilized for the purpose. Study period was divided into period-I (2000-10) and period II (2010-20) and overall period III (2000-2020). Consistent decline in overall pulse area (-0.64%) and production (-0.36%) was observed, however, the overall pulse productivity registered marginal upward trend (0.06%) during the analysis period (2000-20). Chickpea (-5.03% and -0.64 %) and lentil (-0.51% and -4.37%) crops registered highest decline in overall area and production respectively. Urdbean registered highest decline (-6.52%) in productivity during the said period. In contrast, mungbean crop followed by urdbean recorded highest growth in area (3.48%, 3.02%), and production (3.61%, 2.71%), while field pea registered highest growth in productivity (1.96%). Instability of pulse production over the study period was high (30.31%), however the instability in pulse area was low (11.7%). Analysis of inter district variation in pulse performance reflected decline in area and production of pulses in all districts except in Lalitpur. Inter district variations helped in identifying the potential districts in the Bundelkhand region of UP state.

INTRODUCTION

Bundelkhand region of Uttar Pradesh is a central semi-arid plateau of India that spans across seven districts in Uttar Pradesh state comprising Jhansi, Jalaun, Lalitpur, Hamirpur, Mahoba, Banda and Chitrakoot districts and covering over 7.1 million hectares area. The region is home to a total population of 18.3 million, 32 per cent of whom live below poverty line (Census 2011). The region

is characterized by hot climate with temperature variation ranging from 3.0°C to 47.8°C and undulating topography. The zone receives about 867 mm of average annual rainfall. The region is complex, rainfed, risky, under invested, vulnerable, socio-economical heterogeneous, ethnically unique, agrarian and backward (Samra, 2008).

Agriculture is the mainstay of this drought-frequented region. The average irrigation intensity in the zone is approximately 108

percent with gross irrigated area accounting to 48 per cent of the gross area sown. Bundelkhand region is among the most vulnerable regions of India with respect to climate change (Bisht and Sheikh, 2015). Variability in temperature and rainfall has adversely affected the livelihoods of farmers of this region (Singh, 2020). Acute ecological degradation due to deforestation, soil erosion and lack of rain water conservation also characterize this region. Low irrigation facilities, low use of external inputs and lower mechanization result in poor crop productivity. Small land holders cultivating less than 2 ha account for about 70 per cent households, who collectively own only about 35 per cent of the total operated areas. Further, poor adoption of improved agricultural technology has limited the farm economy to subsistence level in this region. At the National level Pulses are finding new niches and most of the pulses have moved from traditional to non-traditional areas (Joshi, 2002). The productivity of crop showed wide variations across the districts as well as states in the whole country (Kumar, 2013). Due to the slow growth rate in area and production during 1980s, 1990s and 2000 decades the per capital availability of pulses decreased from 61 g to 31 g from 1991 to 2010 (Narayan and Kumar, 2015).

Bundelkhand a major pulse-growing region of Uttar Pradesh state of India (Sharma and Sisodia and Sharma, 2018; Kumar et al., 2017) is rightly called as the pulse bowl of the state (Pandey et al., 2019). Pulse crops assume a significant space in the farm economy as well as daily diets of local habitants in this region as affordable dietary proteins (Sah et al., 2021). Pulse crops also cater to the requirement of fodder and fuel for the farm families in the region. These crops in the region are primarily cultivated as main crops under climate-sensitive rainfed production situation. The area, production and productivity of major pulses witnessed tremendous variation over the period of time. Attempt was therefore made in this paper to analyse the temporal dynamics in area, production and productivity of major pulse crops of Bundelkhand region during last two decades i.e., 2000-2010 and 2010-20 as well as the overall period of 2000-20.

METHODOLOGY

Time series data on pulses of seven districts of Bundelkhand region for past twenty years was collected from published reports of Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Government of India and Directorate of Economics and Statistics, Government of Uttar Pradesh. To smoothen the fluctuation of data, Triennium (TE) i.e., three years average, for area, production and productivity of pulse crops was computed for analysis. Twenty-year time series data from 2000-01 to 2019-20 on area, production and productivity of major pulse crops namely, chickpea (*Cicer arietinum*), pigeon pea (*Cajanus cajan*), lentil (*Lens culinaris*), mungbean (*Vigna radiata*), urdbean (*Vigna Mungo*) and field pea (*Pisum sativum*) were worked upon. Data for all six major pulse crops was analyzed and presented for all seven districts of UP namely Banda, Hamirpur, Chitrakoot, Jalaun, Mahoba, Jhansi and Lalitpur. In addition, the combined data for the period of 2000-2020 was also processed adequately.

The study period (2000-01 to 2019-20) was mainly divided into two periods viz. period -I (2000-01 to 2009-10), period II (2010-11 to 2019-20) besides the overall period (2000-2001 to

2019-20). The data was subjected to descriptive statistics to ascertain the pulse production scenario in Bundelkhand region of UP. Compound Annual Growth Rate (CAGR) (Kalia et al., 2021) was computed to inspect the trend in area, production and productivity of the cultivated pulse crops taken in the study. The compound growth rate was determined by using the following exponential function (Maurya et al., 2016).

$Y = AB^t$ Where, Y = The variable for which growth rate is calculated, t = Time variable, B = the regression coefficient, A = intercept

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).

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

To examine the extent of fluctuation or instability in area, production and productivity of pulses in different years, Cuddy Della Valle Index (CDVI) (Cuddy and Della Valle, 1978) was used. The CDVI is computed as given below:

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

CV = Coefficient of Variation, \bar{R}^2 = Adjusted Coefficient of Determination, CDVI = Cuddy Della Valle Index, Low instability = between 0 to 15, Medium instability = 15 < CDVI < 30, High instability = greater than 30

RESULTS AND DISCUSSION

Bundelkhand region of Uttar Pradesh (UP) state contributed 5.84 per cent (1.35 million tonnes) of total pulse production in the country and accounts for about 53 per cent (1.21 M ha) of pulse area (2019-20). The region accounted for about 57 per cent (1.35 MT) of the total pulse production in Uttar Pradesh (Table 1). Pulse crops occupy about 1.2 million hectare area. The region contributed as high as 74.5, 74.1, 43 and 41 per cent of total field pea, chickpea, and lentil and mungbean production in UP state, respectively (Table 1). Crop wise area allocation reflects that among the pulse crops grown in the region, chickpea occupied highest area (0.4 million ha) and correspondingly contributed about 46.6 per cent (0.63 MT) of the total pulse production in the region. It was followed by urdbean that covered about 0.28 million ha area (22.7% of the total pulse area in the region) and contributed 2.4 per cent (0.03 MT) to the total pulse basket in the region, reflecting on low productivity level (0.24 t/ha). Field pea occupied about 20 per cent of the total pulse area with 31 percent (0.42MT) share to the total pulse production with an average productivity level of 1.47 t/ha. Mungbean and pigeon pea covered the least area (2.6% and 4.6%) and contributed lowest to the total pulse production in the region in that order.

Inter district variations and district wise categorisation of Bundelkhand region

Lalitpur (21.43%) followed by Jhansi (17.42%) and Mahoba district (16.29%) contributed highest area under pulse crops, while Jhansi (21%) followed by Jalaun (17.6%) and Mahoba (16.8%) contributed highest pulse production in the region. The district wise

Table 1. Pulse production scenario of Bundelkhand region as compared to UP state and India (2019-20)

Crops	Bundelkhand region					Uttar Pradesh State					India	
	Area (Mha)	% area	Prod (MT)	% prod	Yield (t/ha)	Area (Mha)	% in Bund. region	Prod (MT)	% in region	Yield (t/ha)	Prod (MT)	% prod
Pigeon pea	0.06	4.6	0.07	5	0.88	0.28	19.86	0.28	24.43	0.98	3.83	1.77
Chickpea	0.44	36.5	0.63	46.6	1.43	0.62	70.79	0.85	74.10	1.37	11.35	5.55
Lentil	0.17	13.8	0.19	14.5	1.16	0.46	36.11	0.45	42.93	0.98	1.18	16.44
Mungbean	0.03	2.6	0.01	0.4	0.24	0.049	66.25	0.01	41.01	0.29	2.46	0.24
Field pea	0.23	19.8	0.42	31.1	1.47	0.34	68.56	0.56	74.53	1.65	1.5	28.06
Urdbean	0.28	22.7	0.03	2.4	0.24	0.52	53.48	0.21	14.90	0.41	2.04	1.57
Total/Average	1.21	100	1.35	100		2.28	53.01	2.37	56.93		23.15	5.84

Source: Authors calculation from secondary data

Table 2. Pulse area and production in Bundelkhand region of UP state (2019-20)

Crops	Head	Jalaun	Jhansi	Banda	Chitrakoot	Hamirpur	Lalitpur	Mahoba	Total
Pigeon pea	Area	4.743 (8.38)	0.495 (0.87)	16.942 (29.93)	17.404 (30.74)	13.428 (23.72)	0.006 (0.01)	3.591 (6.34)	56.609 (100)
	Production	4.713 (6.9)	.067 (0.1)	31.086 (45.6)	15.494 (22.7)	14.614 (21.4)	0.004 (0.0)	2.230 (3.3)	68.208 (100)
Chickpea	Area	44.225 (10.06)	73.306 (16.68)	94.201 (21.44)	44.040 (10.02)	84.227 (19.17)	20.504 (4.67)	78.961 (17.97)	439.46 (100)
	Production	65.600 (10.4)	135.35 (21.5)	124.380 (19.7)	43.400 (6.9)	99.430 (15.8)	32.191 (5.1)	130.413 (20.7)	630.76 (100)
Lentil	Area	25.607 (15.30)	26.348 (15.74)	27.227 (16.27)	18.368 (10.98)	24.763 (14.80)	17.979 (10.74)	27.055 (16.17)	167.34 (100)
	Production	34.518 (17.7)	36.782 (18.9)	28.234 (14.5)	14.162 (7.3)	25.357 (13.0)	25.494 (13.1)	30.031 (15.4)	194.57 (100)
Mungbean	Area	1.724 (5.32)	5.711 (17.62)	3.887 (11.99)	2.472 (7.63)	5.547 (17.11)	4.559 (14.06)	8.514 (26.27)	32.414 (100)
	Production	0.948 (16.5)	0.388 (6.7)	2.083 (36.2)	0.482 (8.4)	0.926 (16.1)	0.447 (7.8)	0.485 (8.4)	5.759 (100)
Field pea	Area	65.267 (27.71)	56.429 (23.96)	4.685 (1.99)	0.580 (0.25)	11.197 (4.75)	60.370 (25.63)	37.004 (15.71)	235.53 (100)
	Production	127.85 (830.3)	107.55 (425.5)	6.700 (1.6)	0.193 (0.0)	14.634 (3.5)	101.784 (24.2)	62.574 (14.9)	421.29 (100)
Urdbean	Area	9.576 (3.45)	48.255 (17.39)	4.941 (1.78)	1.651 (0.59)	15.688 (5.65)	155.602 (56.06)	41.829 (15.07)	27.754 (100)
	Production	4.855 (15.3)	3.426 (10.8)	3.315 (10.5)	0.193 (0.6)	2.636 (8.3)	15.871 (50.1)	1.380 (4.4)	31.676 (100)
Total	Area	151.1 (12.5)	210.5 (17.42)	151.9 (12.56)	84.5 (6.99)	154.8 (12.81)	259.0 (21.43)	196.9 (16.29)	1208.9 (100)
	Production	238.57 (17.6)	283.6 (21.00)	195.8 (14.5)	73.9 (5.5)	157.6 (11.7)	175.8 (13.0)	227.1 (16.8)	1352.8 (100)

Area in thousand ha Production in thousand tonnes

area and production figures indicated highest productivity in Jalaun (1.5 t/ha) followed by Jhansi (1.3 t/ha) and Banda (1.29 t/ha) districts. Chitrakoot district accounted the least share (7%) of the total area and production (5.5%) of pulses in the region (Table 2).

Lalitpur district alone contributed about 56 percent (155.6 thousand ha) of the total urd bean area and 50 per cent of total urdbean production in Bundelkhand region. District Mahoba had the distinction to share the highest percentage i.e., 26 per cent of mungbean area (8.5 thousand ha) under mungbean while it contributed only 8.4 per cent (0.48 thousand tonnes) of total mungbean production in the region. This reflected on the low yield of mungbean in the district. Interestingly, Banda district contributed about 36 per cent of total mungbean production in the region from about 12 per cent of the total area, reflecting on higher mungbean productivity in the district. With regard to pigeon pea crop, Banda, Chitrakoot and Hamirpur district contributed about 30, 31 and 23

per cent of total area and contributed about 45, 22 and 21 per cent of total pigeon pea production in the region, respectively. Besides pigeon pea, Banda district contributed significant area under chickpea (94.2 thousand ha), lentil (27.2 thousand ha) and mungbean (3.9 thousand ha) in the region. Jalaun (27.7%) and Lalitpur (25.6%) districts contributed highest area under field pea in the region and correspondingly produced about 30 and 25 per cent of total field production, respectively.

Jalaun district offer scope for area expansion under mungbean, urdbean, pigeon pea and lentil crops, while field pea emerged as the most potential pulse crop in the district. In Jhansi district, mungbean and urdbean crops reported high area coverage with low yield level. Banda district reported highest area under chickpea and lentil in the region with poor yield levels that indicate high potential for varietal intervention in chickpea and lentil crops in the district. In addition, high productivity of pigeon pea and urdbean crops in

the district calls for efforts directed towards area expansion under them. Chitrakoot district was observed to have highest area and yield of pigeon pea crop in the region; however the area coverage for most of the pulse crops was lowest in this district. Varietal replacement along with diffusion of matching production technologies in case of chickpea and mungbean could work towards higher pulse production in Hamirpur district. Lalitpur district reported to contribute more than half of the total urdbean area in the region; however the productivity level in the district was low. In addition, the district also contributed about one fourth of total field pea area in Bundelkhand region with higher productivity level. Thus, varietal interventions in urdbean crop may be suggested for the districts. In addition, efforts for area expansion of field pea need to be undertaken. Mahoba district contributed significant area under mungbean, chickpea, lentil, field pea and urdbean. However, in terms of productivity, the district performed better with respect to field pea and chickpea. Varietal intervention in mungbean, chickpea, urdbean and lentil are hence recommended for the district.

Temporal variations

Decadal variations in overall area coverage under pulse crops was observed to fluctuate between 1.05 million ha at TE 2010 and 1.15 million ha at TE 2020, with an increase by 8.8 per cent from TE 2010 to TE 2020, after witnessing a decline (0.76%) from TE 2000 to TE 2010. A steady decline in overall pulse area was observed during period I (-1.57%), period II (-0.60%) and overall study period (-0.64%) however, the pulse production and productivity witnessed a positive growth rate of 2.76 per cent and 2.37 per cent during 2010-2020 after registering decline by 2.59 per cent and 2.39 per cent during 2000-2010, respectively. This indicates an enhanced penetration of improved pulse production technology in the region during 2010-20. This may be attributed to many pulses development

programmes, schemes and policies executed by Government of India during this period.

Crop wise analysis indicated that during period I, pigeon pea witnessed highest growth (4.6%) in area coverage but highest decline in its productivity level (-8.37%) in UP Bundelkhand region. In contrast, during period II, area coverage under pigeon pea registered a decline by 3.03 per cent with upward trend of productivity (1.11%) and production (0.78%). Further, chickpea registered highest decline in production (-7.06%) and area (-5.03%) and productivity (-1.02%) during period I. Despite registering a decline in chickpea area in all the three periods, the productivity registered an upward trend (5.32%) during period II and overall period III (0.57%). Alike chickpea, lentil also recorded a steady decline in area coverage in all the three periods (-0.51%, -4.37% and -2.66%, respectively) in the region, however, the productivity figures registered upwards trend. During period II, the rate of decline of area coverage under lentil was reported to be highest (-4.37%) among all the pulse crops. In contrast to chickpea and lentil, mungbean registered highest growth in area coverage in the region among all the pulse crops during period I (2.27%), period II (2.25%) and overall period (3.48%), while the productivity recorded a decline at 2.70 and 5.84 per cent in period I and period II, respectively. In similar lines, urdbean also registered growth in area coverage in all the three periods but decline in its productivity during all the three periods. Steady expansion of area under field pea was observed in the region during all the three period under study with an upward trend of productivity and production figures except during period I. The overall study period (2000-20), the area coverage in UP Bundelkhand region enhanced for mungbean (3.48%), urdbean (3.02%), field pea (0.33%) and pigeon pea (0.20%) while it declined for chickpea (-2.79%) and lentil (-2.66%) (Table 3). In similar lines, CAGR for productivity of all the pulse crops registered an upwards

Table 3. Decadal variations in area, production and productivity of pulses in Uttar Pradesh Bundelkhand region. Total area (ha)

Crop	TE			CAGR			Instability		
	1999-20	2009-10	2019-20	2000-10	2010-20	2000-20	2000-10	2010-20	2000-20
<i>Bundelkhand</i>									
Pigeon pea	54271	65327	52702	4.60	-3.03	0.20	16.01	8.54	16.68
Chickpea	463105	352026	383025	-5.03	-0.64	-2.79	12.54	25.16	19.44
Lentil	132623	212646	171584	-0.51	-4.37	-2.66	18.44	24.72	21.28
Mungbean	19567	22330	32473	2.27	2.25	3.48	17.78	9.84	13.39
Field pea	253718	186537	210338	0.94	0.81	0.33	31.49	17.73	25.01
Urd bean	137942	214284	296196	0.78	0.91	3.02	32.69	8.65	20.87
Total	1061227	1053150	1146318	-1.57	-0.60	-0.64	13.22	10.35	11.7
<i>Production</i>									
Pigeonpea	87475	45386.33	66507	-4.61	0.78	-1.72	20.32	40.68	31.06
Chickpea	389192	262563.67	475345	-7.06	5.00	-2.64	22.54	54.29	43.03
Lentil	106276.3	153486.0	174458.3	0.38	2.35	-2.05	26.95	47.61	36.72
Mungbean	5156.3	5249.0	9341.33	1.90	-4.83	3.61	49.23	22.64	37.65
Field pea	275140.3	252336.33	354730.3	-3.79	3.75	1.60	40.17	26.75	32.24
Urdbean	43004	71888.67	89946	3.70	-11.82	2.71	31.29	33.17	48.52
Total	906244.7	790910.00	1170328	-2.59	2.76	-0.36	24.63	31.57	30.31
<i>Productivity</i>									
Pigeon pea	1.41	0.71	0.98	-8.37	1.11	-2.80	21.28	36.37	31.53
Chickpea	0.84	0.79	1.26	-1.02	5.32	0.57	16.85	40.8	32.96
Lentil	0.63	0.70	1.02	0.67	7.42	0.33	26.49	35.64	33.41
Mungbean	0.29	0.25	0.36	-2.70	-5.84	1.00	18.31	24.84	41.03
Field pea	1.12	0.58	0.88	-0.21	2.29	1.96	32.56	25.68	23.21
Urd bean	0.29	0.51	0.76	-2.16	-6.52	-6.52	32.83	21.41	29.75
Total	0.76	0.59	0.88	-2.33	2.37	0.06	12.06	20.52	19.86

trend (-2.33% to 2.37%) except for urdbean (-6.52%) and pigeon pea (-2.8%) crops.

The results also indicate the probable shifting of area under chickpea and lentil to other pulses or other crops. Heavy incidence of pod borer and wilt (*Fusarium oxysporum*) in chickpea could be the factor attributing the decline in its area. The results also reflect that the decrease in productivity of pigeon pea and urdbean crops in the region was compensated by increase in their area to meet the market demand. Further, the enhanced productivity level of majority of the pulse in the study period indicates the enhanced uptake of improved pulse cultivation technologies and the related packages. The fact gets support from the development of suitable varieties of pulses along with the matching production technologies for Bundelkhand region of UP state. As per the published reports of All India Coordinated Research Projects on Chickpea, MULLaRP and Pigeon pea of Indian Council of Agricultural Research, total of 35 varieties (chickpea-7; lentil-14 mungbean -6; field pea-8) were released during 2010-20 for the region. In contrast, only one variety each of pigeon pea and urdbean was developed for the region which may probably be attributed to lower productivity level of both the crops despite their large area share. Aggressive technological backstopping, hence, is suggested for urdbean and pigeon pea crops for improving productivity in the region. Better productivity figures for major pulses in the region during period II (2010-20) as compared to period I could also be attributed to the multipronged initiatives like National Food Security Mission-Pulse component (since 2010), Accelerated Pulse Production Program (2010-12), special initiatives for promotion of pulses in dry land area (2010-11), integrated development of 60000 villages in rainfed areas (2011-12), seed hub initiative (2016-17 onwards), enhancing breeder seed production program (2016-17 onwards), seed mini kits, Cluster front Line Demonstrations covering 31366 ha area annually (since 2016-17), seed village program, favourable exim policy decisions by the Government for pulses which supported the pulses production in the country.

Instability in area and production of pulse crops

High instability (30.31%) with respect to overall pulse production in this region was estimated over the study period (2000-20) with variations from 24.63 per cent in period I to 31.57 per cent in period II. However, the instability index for overall area coverage under pulse crops was observed to be low in both the period I (13.22%), period II (10.32%) and overall period III (11.7%). In similar lines, the instability index of productivity was notified to be low (12.06%) for period 2000-10. Instability index of area coverage as well as productivity of chickpea and lentil crop enhanced from period I (12.54%, 18.44%) to period II (25.16%, 24.72%), while it declined for all the other pulse crops during the two period (Table 3). The same trend was noticed for productivity of chickpea and lentil along with pigeon pea and mungbean. The unfavourable weather conditions like untimely rains, hail storms and drought, that prevailed during 2010-15 could be the reason for wide fluctuations in yield levels during period II. In contrast, the yield instability was highest for urdbean (32.83%) closely followed by field pea (32.56%) during period I, which declined during period II, indicating of better uptake of production technologies including improved seeds of urdbean and field pea in the region.

District wise CAGR of area, production and productivity

During overall study period (2000-20), district wise CAGR of area and production of pulses in Bundelkhand region of UP state reflected declining trends in all the districts except for Lalitpur. In Jalaun district, during overall study period (2000-20), area and production of pigeon pea (-3.26%, -7.03%), chickpea (-5.10%, -4.75%), lentil (-3.70%, -2.40%) and urdbean (-7.49%, -3.57%) recorded a decline, whereas, same for mungbean (3.62%, 7.65%) and field pea (2.92%, 3.84%) registered an upward trend (Table 4). Similar trend was observed in Jhansi district also for mungbean with exception of field pea. Area and production of lentil and chickpea recorded a declining trend in Banda district. In contrast, pigeon pea, mungbean and field pea demonstrated the positive growth in area (1.34%, 4.06% and 6.83%, respectively) as well as production (0.02%, 7.31% and 7.63%, respectively) in Banda district. Lalitpur witnessed highest rate of decline in area under pigeon pea (-14.47%), chickpea (-7.63%) and lentil (-4.54%). The district also recorded highest rate of increase in area (6.73%) and production (5.85%) for urdbean as compared to the rest of the districts in the region. In similar line, district Mahoba also recorded highest growth rate of area (4.99%) and production (0.89%) of urdbean crop followed by mungbean, while for all other pulse crops decline in area was registered during overall study period. Hamirpur district witnessed decline in area of all the pulse crops except mungbean and correspondingly decline in production of all pulse crops except mungbean and urdbean. During the overall study period, mungbean recorded highest increase in area (5.14%) and production (5.04%) in Chitrakoot district. In the same district, all pulse crops registered increase in area except chickpea (-1.11%). It could be inferred that mungbean and field pea registered area expansion coupled with their enhanced production levels while chickpea and lentil crops were losing ground in almost all the districts of the UP Bundelkhand region. Pigeon pea also seems to lose area coverage in majority of the districts of region except, Chitrakoot, Banda and Hamirpur districts. Biotic stresses like pod borer pest infestation and wilt disease lead to poor yield levels could be the reason for chickpea and pigeon pea for decline in their area in the region, Similar findings were reported by Kumbhare et al., (2014); Nain et al., (2014) and Nain et al., (2015).

CONCLUSION

The region witnessed a consistent decline in overall pulse area and production during 2000-20. Among all the pulse crops, chickpea and lentil registered highest decline in overall area and production in the region while mungbean and urdbean recorded highest growth in area and production. The overall pulse productivity registered marginal upward trend during the same period with highest growth in productivity in field pea. In contrast, urdbean registered highest decline in productivity during the said period. The results reflect on the need for technological intervention focused on improving pulse productivity in the region. Promotion of improved pulse production technologies including improved varieties, judicious use of nutrients and water resources with integrated crop management need to be undertaken for the enhanced productivity levels in the region. Effective delivery mechanisms for transfer of pulse

Table 4. District wise variation in area, production and productivity of pulses in Uttar Pradesh Bundelkhand region

Crop	Area CAGR			Production CAGR		
	2000-20	2000-10	2010-20	2000-20	2000-10	2010-20
<i>Jalaun</i>						
Pigeon pea	-3.26	1.88	-6.61	-7.03	-6.26	-7.87
Chickpea	-5.10	-11.72	-2.48	-4.75	-13.30	0.28
Lentil	-3.70	-3.08	-4.92	-2.40	-2.81	-0.27
Mungbean	3.62	4.92	1.74	7.65	7.03	4.07
Field pea	2.92	4.78	1.56	3.84	-4.76	-0.27
Urad bean	-7.49	-5.93	0.99	-3.57	-1.96	2.84
Total Pulses	-2.20	-4.24	-0.91	-0.24	-4.88	1.66
<i>Jhansi</i>						
Pigeon pea	-5.53	0.95	-14.70	-9.42	-15.31	-22.90
Chickpea	-2.34	-11.98	-1.48	-1.47	-12.72	5.45
Lentil	-2.29	1.27	-5.53	-0.71	4.81	2.59
Mungbean	1.43	-0.32	2.03	2.11	-3.51	-13.24
Field pea	-0.91	-2.44	1.91	-0.78	-9.11	5.09
Urd bean	-0.65	-4.05%	3.77	0.15	-9.32	-11.56
Total Pulses	-0.98	-4.69	0.13	-0.62	-5.78	3.72
<i>Banda</i>						
Pigeon pea	1.34	4.95	-1.84	0.02	-5.78	4.80
Chickpea	-4.64	-1.94	-2.69	-5.23	-5.75	4.12
Lentil	-2.57	-2.63	-2.13	-2.53	-4.03	6.48
Mungbean	4.06	1.98	-2.56	7.31	-6.99	1.12
field pea	6.83	7.31	5.48	7.63	1.13	9.88
Urd bean	-0.41	0.70	-1.66	2.72	-5.94	4.96
Total Pulses	-1.88	-1.27	-1.31	-2.04	-5.37	5.51
<i>Chitrakoot</i>						
Pigeon pea	1.42	5.21	0.65	-3.33	-3.96	6.16
Chickpea	-1.11	-1.63	-1.21	-0.96	-3.63	4.08
Lentil	0.68	5.66	1.39	-2.15	1.22	10.11
Mungbean	5.14	7.77	7.81	5.04	-1.58	3.12
Field pea	3.49	5.68	4.80	3.05	4.29	-7.87
Urd bean	1.79	1.68	-0.35	3.22	-1.28	-7.21
Total Pulses	-0.05	1.19	0.03	-1.34	-2.8	5.22
<i>Hamirpur</i>						
Pigeon pea	-0.62	4.31%	-6.22	-1.32	-2.98	-4.48
Chickpea	-1.64	-3.77%	1.22	-1.72	-6.00	5.87
Lentil	-4.00	0.34%	-8.33	-3.41	-0.18	-0.40
Mungbean	4.85	0.15%	5.30	8.55	-9.84	2.95
Field pea	-4.48	-5.11%	-1.53	-3.12	-9.93	3.22
Urd bean	-1.47	-11.46%	-0.58	0.84	-20.76	-2.59
Total Pulses	-2.07	-2.92	-1.77	-1.69	-4.92	2.84
<i>Lalitpur</i>						
Pigeon pea	-14.47	-1.02	-3.90	0.69	-5.18	0.00
Chickpea	-7.63	-7.25	-2.06	-5.91	-4.80	3.28
Lentil	-4.54	-1.13	-4.47	-2.06	3.67	1.89
Mungbean	3.62	-1.10	0.92	3.37	9.42	-11.73
field pea	1.94	9.67	-1.52	4.38	10.65	2.63
Urd bean	6.73	4.49	0.98	5.85	13.83	-14.09
Total Pulses	2.12	2.38	-0.18	1.86	6.87	-2.74
<i>Mahoba</i>						
Pigeon pea	0.17	8.62	-3.41	-1.13	1.88	-0.15
Chickpea	-2.70	-1.21	-2.32	-2.62	-1.38	3.53
Lentil	-1.05	-1.53	-4.60	-2.16	-0.72	0.87
Mungbean	3.66	6.16	1.96	-0.59	5.13	-11.64
Field pea	-2.34	-8.37	1.92	-2.82	-10.23	7.28
Urd bean	4.99	10.43	-0.86	0.89	7.11	-16.11
Total Pulses	-0.13	0.05	-0.82	-1.01	-1.48	3.56

technologies to pulse growers with use of ICT coupled with need based capacity building and skill enhancement programs for better uptake of pulse production technologies by pulse growers of the region. Pulse production in the region could be incentivized through government procurement with subsequent linking it to mid-day meal scheme, public distribution system and similar others schemes. In addition, simple innovative efforts like establishment of custom hiring facilities at block level for farm machinery and promotion of farmer managed seed hubs may be explored for area expansion of pulse in the region.

REFERENCES

- Cuddy, J. D. A., & Della Valle, P. A. (1978). Measuring the instability of time series data. *Oxford Bulletin of Economics and Statistics*. <https://doi.org/10.1111/j.1468-0084.1978.mp40001006.x>
- Joshi, P. K., & Saxena, R. (2002). A profile of pulses production in India: Facts, trends and opportunities. *Indian Journal of Agricultural Economics*, 57(3), 326-339. DOI: 10.22004/ag.econ.297890
- Kalia, A., Shukla, G., Mishra, D., Mishra, B. P., & Patel, R. R. (2021). Comparative trend analysis of mustard in Bundelkhand Region, Uttar Pradesh and India. *Indian Journal of Extension Education*, 57(1), 15-19.
- Kumar, A., & Jain, R. (2013). Growth and instability in agricultural productivity: A district level analysis. *Agricultural Economics Research Review*, 26(Conference), 31-12. DOI: 10.22004/ag.econ.158490
- Kumar, R., Singh, S. K., & Sah, U. (2017). Multidimensional study of pulse production in Bundelkhand region of India. *Legume Research*, 40(5), 2046-52. DOI: 10.18805/LR-3502
- Kumbhare, N. V., Dubey, S. K., Nain, M. S., & Bahal, R. (2014). Micro analysis of yield gap and profitability in pulses and cereals. *Legume Research-An International Journal*, 37(5), 532-536.
- Maurya, O., Reddy, A. A., & Kumar, H. (2016). Growth and decomposition analysis of pigeonpea in India. *International Journal of Agriculture and Statistical Sciences*, 12(1), 189-191. http://www.connectjournals.com/file_full_text/2579401H_189-191.pdf
- Nain, M. S., Bahal, R., Dubey, S. K., & Kumbhare, N. V. (2014). Adoption gap as the determinant of instability in Indian legume production: Perspective and implications. *Journal of Food Legumes*, 27(2), 146-150.
- Nain, M. S., Kumbhare, N. V., Sharma, J. P., Chahal, V. P., & Bahal, R. (2015). Status, adoption gap and way forward of pulse production in India. *Indian Journal of Agricultural Science*, 85(8), 1017-1025.
- Narayan, P., & Kumar S. (2015). Constraints of growth in area production and productivity of pulses in India: An analytical approach to major pulses. *Indian Journal Agriculture Research*, 49(2), 114-124. DOI: 10.5958/0976-058X.2015.00017.7
- Pandey, N. K., Dikshit, A., Tewari, D., Yadav, N. K., & Somvanshi, S. P. S. (2019). Pulses production in Lalitpur district of Bundelkhand region: Constraints and opportunities. *Indian Journal of Extension Education*, 55(2), 35-39.
- Pichad, S. P., Wagh, H. J., & Kadam, M. M. (2014). Growth in area, production and productivity of chickpea in Amravati district. *International Research Journal of Agricultural Economics and Statistics*, 5(2), 289-292. DOI:10.15740/HAS/IRJAES/5.2/289-292
- Sah, U., Dixit, G. P., Kumar, N., Pal, J., & Singh N. P. (2021). Status and strategies for development of pulses in Bundelkhand region of India: A review. *Legume Research*, DOI: 10.18805/LR-4518
- Samra, J. S. (2008). Report on drought mitigation strategy for Bundelkhand region of Uttar Pradesh and Madhya Pradesh. NRAA, New Delhi.
- Sharma, M. K., & Sisodia, B. V. S. (2018). Pulses area out of reach-a regional study of Uttar Pradesh. *International Journal of Agriculture Sciences*, 10(5), 5335-5342.
- Shrivastava, P., Shrivastava, K. K., & Verma, A. (2021). Contribution of characteristics of panchayat leaders towards their attitude as evident from the multiple regression analysis. *Indian Journal of Extension Education*, 57(1): 73-77.
- Singh, S. (2020). Farmers' perception of climate change and adaptation decisions: A micro-level evidence from Bundelkhand region, India. *Ecological Indicators*, 116, <https://doi.org/10.1016/j.ecolind.2020.106475>