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Trends in Area Production and Productivity of Sesame in Bundelkhand Region of Uttar Pradesh

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ABSTRACT

Sesame seeds are often referred to as *seeds of immortality.* Due to the root system, the crop does well under drought stress, making the Bundelkhand region more suitable for growing sesame than other districts in Uttar Pradesh. The coefficient of Variation and the Cuddy-Della-Valle Index were computed to determine the degree of instability. The relative importance of acreage and yield to the expansion of sesame production was determined by calculating the area effect, yield effect, and interaction effect. Results showed that in Jalaun, both the sesame area and production increased at a compound annual growth rate of 0.17 per cent and 0.20 per cent, respectively, while in other districts of Bundelkhand, they remained relatively stable or declined. On the other hand, it was found that productivity was falling across the seven districts of the region. According to the CDVI values, Chitrakoot had the highest variability in area (125.45) while Jalaun had the highest variability in production (181.7) as well as productivity (53.45). In the whole Bundelkhand, the strongest interaction effect between area and yield growth was found.

INTRODUCTION

The use of vegetable oils in both the food and industrial sectors has skyrocketed in recent years. India is now one of the world's largest importers of vegetable oils despite being the world's fifth-largest producer of oilseed crops (Reddy, 2013). Oilseeds are the second-most important crop in India. It accounts for 15.7 per cent of the gross cultivated area and 11 per cent of the total agricultural output value (Sri et al., 2022; Singh et al., 2019; Meena et al., 2023). Seven of the nine oilseed crops grown in the country are used for human consumption (soybean, groundnut, mustard, sunflower, sesame, safflower, and Niger), while the other two are used for industrial purposes (castor and linseed). The Indian ecological zone is the original home of most oilseeds. About of 5,500 years ago, the Indian subcontinent became the first place in the world where sesame was cultivated. The oilseeds crops have shown the significant growth in area and production during last three decades (Reddy & Immanuelraj, 2017). Sesame is considered to be the most valuable oilseed crop. Sesame seeds are held in high regard and are sometimes referred to as "the seeds of immortality" due to their high antioxidant content.

The estimated global area, production, and yield of sesame in 2018–19 were 128.21 million hectare, 65.49 million tones, and 510.8 kg ha^{-1}, respectively, reflecting the crop's significant role in human nutrition and the livelihood of millions around the world (FAO, 2019). Sudan has the largest area of 42.43 million hectares dedicated to the cultivation of sesame, followed by Myanmar (15.05 million hectares) and India (14.19 million hectares) (FAO, 2019). The top producers of sesame are Sudan, Myanmar, and India. As compared to Nigeria, Ethiopia, Tanzania, and Burkina Faso, India has the lowest productivity. While the average yield in India is only 485.4 kg ha^{-1}, Nigeria's is 818.4 kg ha^{-1}, making

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for a stark comparison (FAO, 2019). The total amount of sesame produced in India in 2019 is projected to be 399.16 million metric tonnes. Uttar Pradesh, with a total production of 99.76 million tonnes, accounted for 25 per cent of India's total output; this was followed by Madhya Pradesh (82.34 million tonnes), Rajasthan (78.08 million tonnes), and Gujarat (65.65 million tonnes), each of which accounted for 20 per cent. Eighty-two per cent of the country's output came from these four states. As a whole, the yield estimates for each state were as follows: Gujarat: 565 kg ha^{-1}; Rajasthan: 289 kg ha^{-1}; Madhya Pradesh: 262 kg ha^{-1}; and Uttar Pradesh: 239 kg ha^{-1}. An estimated 485.4 kg ha^{-1} was the average yield across the country (Directorate of Economics & Statistics, 2019)

The highest estimated yield in Uttar Pradesh was recorded in Unnao (798 kg ha^{-1}), while the lowest was in Mahoba (120 kg ha^{-1}). Jhansi, with the most land and the highest estimated yield, made up nearly 17 per cent of the state's total harvest. Estimates put the global sesame harvest at 99.76 million metric tonnes, with a yield per hectare of 239 kg ha^{-1} (Directorate of Economics & Statistics, 2019). The current study attempts to analyse the relative contribution of area, yield, and interaction effects in the expansion of sesame in Bundelkhand, the major sesame producing districts in UP, taking these factors into account.

METHODOLOGY

This study is based on secondary information collected from various sources. The information was compiled from the Uttar Pradesh Department of Economics and Statistics, the Food and Agriculture Organization's Agricultural Statistics at a Glance 2019, and the FAO's Directorate of Economic and Statistical Research. Area, output, and harvest size for sesame in Bundelkhand have all been tracked for the past 30 years (1989-2019). The estimated changes in sesame area, production, and productivity were analysed using compound growth rates for the given time period, revealing some interesting trends. Explicit calculations of growth rates were derived in order to analyse whether a given variable tends to rise, fall, or stay about the same over time. The compound growth rate (CGR) is the rate of change of "Yt" per unit of time expressed as a function of the magnitude of "Yt" itself, and it was mathematically expressed as:

$$CGR = [(t)\ (dYt/dt)] = [(Yt+1-Yt/Yt)] \qquad \text{... (1)}$$

The compound growth rate of Yt was calculated in percentage form by multiplying the above expression by 100. Many different types of growth functions, such as linear exponential, modified exponential, Cobb-Douglas, etc., have been developed and were used in scientific inquiry. The following is the mathematical form of the log-linear function (also called the exponential function) that is employed:

$$Yt = Aebt \qquad \text{... (2)}$$

Instability was measured by using co-efficient of variation, Cuddy-Della Valle Index and Coppock's index to assess the variability in the production, area and yield of sesame, as followed by Sandeep et al., (2016) & Boyal et al., (2015). The standard deviation as percentage of means called as co-efficient of variation.

$$CV = \sigma/\mu \times 100$$

Where, CV = Co-efficient of variation
σ = Quantified in units of the variable's standard deviation
μ = Determining the average of a variable

To estimate the contribution of area, productivity and interaction of the two in total production, the following additive scheme of decomposition was used:

$$P = A0\ (Yn - Y0) + Y0\ (An - A0) + \Delta A \Delta Y$$
$$1 = [(Y\ \Delta A)/P] + [(A\ \Delta Y)/P] + [(\Delta A\ \Delta Y)/P]$$

Where, P = Change in production
A0 = Zone in the Foundational Year
An = Zone in current year
Y0 = Base Year Yield
Yn = Current Year's Yield
ΔA = Variation in region (An – A0)
ΔY = Variation in yield (Yn – Y0).

RESULTS AND DISCUSSION

Growth in sesame area, production and productivity

Sesame's area, production, and productivity in Bundelkhand were evaluated by fitting the compound growth trend equations. From 1989-2019, the amount of land used for growing sesame has increased in Bundelkhand from 27.46 thousand hectares to 219.44 thousand. A positive and statistically significant 0.07 per cent compound growth rate over time indicates a static growth rate supported by the findings of Debnath et al., (2015). When looking at the area planted with sesame on a district-by-district basis, it has showed an upward trend in the compound growth rate. From 1989 to 2019, Bundelkhand's sesame harvest increased from 33.55 million tones to 504.08 million tones, a compound growth rate of 0.09 per cent. Bundelkhand's sesame harvest slowed to a crawl this year. According to a breakdown of production growth by municipality, from 1989 to 2019, all regions saw an increase in output. From 1989 to 2019, Bundelkhand's average sesame yield per hectare rose from 1.22 to 2.29 tones. Growth trend analysis for sesame crop indicates a 0.02 per cent compound annual growth rate in yield from 1989 to 2019. When broken down by state, yield growth rates are positive in all but one district: Jhansi, where they are -0.009 per cent. All regions have experienced substantial expansion. Between 1989 and 2019, the Jalaun district saw a significant increase in population.

Instability in sesame area, production and productivity

Table 2 provides information for the entire period (1989-2019) and for individual districts on the fluctuations in Bundelkhand's sesame area, production, and yield. Bundelkhand saw the most variation in production compared to land area and crop yield over the 29-year study period. Differences in CDVI between production, area, and yield were 79.61, 53.54, and 27.15, respectively. According to district-by-district analyses, Chitrakoot's CDVI value of 125.45 is the highest, followed by the CDVI value of 181.87 for its area of production. In terms of yield, however, the 70.80 CDVI value observed in the Mahoba district represents the greatest instability. The consistent returns from growing sesame suggest that it is a major cash crop in all of Bundelkhand's

Table 1. Growth in area, production and productivity of sesame in Bundelkhand (1989-2019)

Sesame	Particulars	Jhansi	Lalitpur	Jalaun	Banda	Hamirpur	Mahoba	Chitrakoot	Total
Area	Beginning year area (000' ha)	6098	6397	454	1402	8144	4512	454	27461
	End year area (000' ha)	80152	7152	4622	11546	41913	31321	1134	219440
	No. of observation	30	30	30	30	30	30	30	30
	Coefficient	0.00017	0.0016	0.00025	0.0004	0.00038	0.0004	0.002	
	R^2 (%)	0.64*	0.31*	0.49*	0.40*	0.58*	0.63*	0.24*	0.66*
	Growth rate (%)	0.092	0.038	0.172	0.075	0.05	0.06	0.032	0.074
Production	Beginning year production (000' tonnes)	604	582	57	178	1458	450	26	3355
	End year production (000' tonnes)	6092	880	12572	3048	9221	18385	210	50408
	No. of observation	30	30	30	30	30	30	30	30
	Coefficient	0.00041	0.0043	0.0013	0.0017	0.0015	0.0015	0.009	0.00024
	R^2 (%)	0.42*	0.20*	0.54*	0.32*	0.48*	0.40*	0.20*	0.56*
	Growth rate (%)	0.082	0.014	0.204	0.10	0.06	0.13	0.074	0.097
Yield	Beginning year yield (q ha^{-1})	0.99	0.91	1.27	1.27	1.79	0.99	0.57	1.22
	End year yield (q ha^{-1})	0.76	1.23	2.71	2.63	2.20	5.86	1.85	2.29
	No. of observation	30	30	30	30	30	30	30	30
	Coefficient	4.76	4.44	3.78	5.95	6.37	3.18	12.02	9.77
	R^2 (%)	0.25*	0.088	0.16*	0.27*	0.14*	0.122*	0.43*	0.42*
	Growth rate (%)	-0.009	0.010	0.026	0.02	0.007	0.06	0.041	0.021

(*significant at 1% level and **significant at 5% level)

Table 2. Instability in area, production and productivity of sesame in Bundelkhand region (1989-2019)

Particulars		Districts							
		Jhansi	Lalitpur	Jalaun	Banda	Hamirpur	Mahoba	Chitrakoot	Bundelkhand (Total)
Area	CV	108.63	46.38	93.57	145.30	95.46	91.21	143.90	91.824
	CDVI	65.16*	38.53*	68.11*	112.55*	61.87*	55.48*	125.45*	53.54*
	Instability	High	High	High	High	High	High	High	High
Production	CV	146.37	83.80	110.44	190.60	127.10	154.53	203.34	120.02
	CDVI	111.47*	74.95*	74.90*	157.18*	91.65*	119.70*	181.87*	79.61*
	Instability	High	High	High	High	High	High	High	High
Yield	CV	50.26	38.29	58.32	51.02	34.93	75.56	43.66	35.65
	CDVI	43.53	36.56*	53.45*	43.59*	32.39*	70.80	32.96*	27.15*
	Instability	High	High	High	High	High	High	High	High

(*significant at 1% level and **significant at 5% level)

Table 3. Relative contribution of area and yield in the growth of sesame in Bundelkhand region (1989-2019)

Particulars	Districts							
	Jhansi	Lalitpur	Jalaun	Banda	Hamirpur	Mahoba	Chitrakoot	Bundelkhand (Total)
Area effect $\Delta A.Y0$ (%)	133.5	23.08	46.65	45.00	77.90	14.80	21.00	49.90
Yield effect $\Delta Y.A0$ (%)	-2.5	68.79	0.5	6.67	4.3	12.3	31.5	6.4
Interaction effect $\Delta A.\Delta Y$ (%)	-31	8.13	52	48.33	17.8	72.9	47.5	43.7

districts. Study period was characterized by high levels of area and production instability supported by the findings of Nayak (2021). Changes in the cropping pattern of sesame crop in all the districts of Bundelkhand may have been caused by the introduction of the programme green revolution, technological advancement, and the availability of high yielding verities during the study period from 1989 to 2019. Similarly, in case of legumes the instability was attributed to adoption gap (Nain et al., 2014) as such the efforts for adoption of technologies might have effected positively.

Relative contribution of area and yield in the growth of sesame

For the time period 1989–2019 and district wise, separately, the study conducted a decomposition analysis to determine the area, yield, and their interaction effect on growth of sesame production in Bundelkhand. A summary of the findings is shown in Table 3. According to the data, in Bundelkhand, the area effect was 49.90 per cent, the yield effect was 6.40 per cent, and the interaction effect was 43.70. This indicates that the increase in

Bundelkhand's sesame output was due to a combination of factors, including both land area and yield; similar findings were reported by Kumar et al., (2020) and Kalia et al., (2021). Analysis by district indicates that during the study period, area had a positive effect on sesame production in the Jhansi district by 133.5 per cent, while yield had a negative effect. Comparatively, during the study period, the area and yield of the sesame crop produced were found to be positively correlated in the other Bundelkhand districts (Lalitpur, Jalaun, Banda, Hamirpur, Chitrakoot & Mahoba).

CONCLUSION

Sesame crop area increased at an annual growth rate of 0.007 per cent in Bundelkhand, but district-by-district analysis revealed a stagnant growth trend throughout the study period whereas yearly growth rate of 0.02 per cent in productivity. All Bundelkhand districts except Jhansi (-0.009%) showed a rising trend in productivity and Bundelkhand as a whole was experiencing a significant uptick in production. In Bundelkhand, the production instability (79.61%) was found to be higher than the area instability (53.154%) and the yield instability (27.15%). Decomposition analysis showed that the interaction effect was crucial to the development of sesame in Bundelkhand between 1989 and 2019. Reduced yields can be attributed to a lack of HYV seed input, seed replacement and the reluctance of farmers to implement improved agronomic practices requiring cutting-edge technology, as well as the careful identification of problem areas to optimize the output.

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