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Assessing the Growth Performance of Millet in Uttar Pradesh: A Decomposition Analysis

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ABSTRACT

Background: Uttar Pradesh is emerging as a driver of the nation's economy with its infrastructure and as an exporter of indigenous products. In the last few decades, it has become India's largest producer of food grains and has made a significant contribution to exports.

Methods: The log-linear exponential method has been used to estimate production, area and yield growth. Production was decomposed to area, yield and interaction effects; for Stability analysis, the coefficient of variation (CV) and Cuddy Dell and Coppock's instability index were employed and analysis was carried out for three specific millet crops- sorghum, pearl millet and small millets.

Result: In Uttar Pradesh, a region of significant millet production, there was a notable increase in the area, production and millet productivity over the entire period. Pearl millet, the most critical millet crop, accounted for a substantial portion of the area (46.93%) and (43.76%) of the total millet area and production in India, respectively. Growth indicated that the production and productivity of pearl millet have increased despite a decrease in the area under cultivation. The coefficient of variation (CV) and instability index suggested by Cuddy and Dell revealed that the production and productivity of pearl millet and sorghum millet showed a low degree of variation over the years. The decomposition of millet production indicates that it declined over the year. Regarding the interaction effect, the highest (2128%) was in the overall period of sorghum millet and the lowest. The highest interaction effect was observed overall compared to periods I and II.

Key words: Decomposition, Growth rate, Instability, Millets, Production.

INTRODUCTION

The United Nations General Assembly (UNGA) declared 2023 the International Year of Millets.

Millets are food crops adapted to dryland agroecologies of the arid and semi-arid tropics. In India, millets are produced in most regions with low to moderate precipitation (200-800 m rainfall). Major millet crops include sorghum, pearl, finger and small millet. India is the world's largest producer of sorghum and millet and shares around 19.1% of the total, while the USA produces 12.4%. The higher the nutrient content of millet, the more we should include them in our diet for a healthy life. However, the use of millet should be wise according to the conditions and requirements of humans. Millets provide many health benefits, like lower cholesterol and helpful with diabetes (Divya and Garg, 2024).

The production of pearl millet, sorghum millet and small millet is p(95.31, 40.34 and 4.29 lakh tonnes, respectively) during 2023-24 (2nd Advance Estimates, 2023-24, Agricultural and Processed Food Products Export Development Authority). India is the leading producer of millet, around 41% of the total millet globally (Gowari and Shivkumar, 2020). India is the largest producer of millet, sharing 37.5% of the total global (Meena *et al*., 2021). Millets are the most secure crops for small farmers as they are the hardiest, most resilient and climate-adaptable crops in hot and harsh regions (up to 50°C) and drought environments. Last standing crops in drought seasons and will be a sustainable future food source amidst worsening climatic conditions (Bhat *et al*., 2023). Millets are ancient grains domesticated by humans even before wheat and rice. Gradually, due to the accessibility of irrigation, modern inputs and high-yielding varieties, millets lost areas to wheat, rice and other commercial crops, making commercial crops more profitable during the Green Revolution (Das *et al*., 2019). Asia and Africa region are the major producers of millet in the world (FAO, 1996).

Uttar Pradesh is the heart of India. It is emerging as a driver of the nation's economy with its infrastructures and an exporter of indigenous products. It is India's largest producer of food grains and accounts for about 18.89% share (58.32 million MT) of the country's total food grains output in 2020-21. Major food grains produced in the state include rice, wheat, maize, millet, gram, peas and lentils (DES). Most inhabitants in the region depend on agriculture/ livestock-based activities and about 33% of the area is

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covered by degraded forest, grazing land and wasteland (Gupta *et al*., 2014). Africa and Asia produce and consume 97% of millet and contribute to 26.6% of the world's millet growing area, of which Asia covers 83%. In the above background, the present study aims to understand the current scenario of millet in India and Uttar Pradesh. It analyses the growth and instability in the area, production, productivity and decomposition of millet production in Uttar Pradesh.

MATERIALS AND METHODS

The study was conducted on millet crops from 1999-2000 to 2022-23 in Uttar Pradesh. It was primarily based on secondary data for twenty-three years concerning the area, production and productivity of Millets in Uttar Pradesh obtained from the Directorate of Economics and Statistics (DES), Department of Agriculture and Farmers Welfare, Ministry of Agricultural (MoA), Government of India (GOI, 2023). Analysing the compound annual growth rates (CAGR) and estimating the impact of area, yield and their interaction on total millet production was achieved using log-linear growth models and a decomposition approach. Additionally, Coppock's Instability Index, Cuddy Della Valle Index (CDVI) and the coefficient of variation (CV) were calculated as the variability in area, production and productivity of millets. Pearl millet, sorghum millet and small millet were selected for the present study as these are the most widely cultivated millets in Uttar Pradesh in terms of area and production. Thus, secondary data concerning the area, production and productivity of pearl millet, sorghum millet and small millet were collected from 1999-2000 to 2022-23. The data was divided into three periods: 1999-2000 to 2009-10 (Period I), 2010-11 to 2022-23 (Period II) and 1999-2000 to 2022-23 (overall period) of Millets in Uttar Pradesh.

Growth analysis

The annual compound growth rate was estimated for the area, production and yield of millets as follows:

$$Y = ab^t$$

The equation takes the linear form by taking the logarithm of both sides.

$$\log Y = \log a + t \log b$$

$$Y = a + bt$$

Where;

Y = Dependent variable for which the rate of increase/decrease is estimated (Area, production and productivity of millets).

t = Time variable (2000 to 2010, 2010 to 2023 and 2000 to 2023).

r = Compound growth rate

a =Constant/intercept

b =Regression coefficient

e =Error term

$$CAGR \text{ or } (r\%) = \{Antilog (\ln b) - 1\} * 100$$

The significance of the estimated compound annual growth rate was tested with the help of a student's t-test.

Instability and its measure

Instability means deviation from the trend. In agriculture, instability is an inherent characteristic due to weather conditions, seasonal variation in area and crop production and productivity from year to year. The degree of variability in area, production and productivity was computed to measure the variability using the instability index given by the Cuddy-Della Valle (1978), which estimates variability in time series data. A low value of this index shows low instability in production and prices. Meanwhile, the coefficient of variation (CV) estimates the variability in time series data due to a trend.

Instability analysis

The coefficient of variation (CV) was computed using the following formula to study the variability in the area, production and millet productivity:

Coefficient of variation (CV%) =

$$\frac{\text{Stamdar deviation}}{\text{Mean}} \times 100$$

A linear trend was fitted to the time series data on area, production and productivity for 1999-2000 to 2022-23.

An instability index suggested by Coppock's Instability (1962) and Cuddy and Della (1978) was used to study the variability in the area, production and millet productivity.

Cuddy-della valle index

$$CVt = CV \times \sqrt{(1 - \bar{R})^2}$$

CV_t = Cuddy Della Valle Index (%).

CV = Coefficient of variation.

R^2 = Adjusted coefficient of determination.

CDVI = Cuddy Dell Valle index.

Low instability = between 5 to 15, Medium instability = 15 to 30, High instability = 30<CDVI>50, Very high instability = greater than 50.

This study calculated the Coppock Instability Index (CII) in addition to the Cuddy-Della Valle Index (CDVI).

Coppock's Instability Index = Antilog $\left(\sqrt{\log V - 1}\right) \times 100$

$$\text{Log } V = \frac{\left[\left(\log \frac{X_t + 1}{X_t}\right) m\right]^2}{n - 1}$$

X_t = Area/production/productivity of millet in the year 't'.

N = Number of years; m = mean of the difference between logs of Xt + 1, Xt.

Log V = Logarithmic variance of the series.

Decomposition analysis

Minhas and Vaidyanathan (1965) introduced the initial structure method for breaking down the growth trend. Several scholars have adopted and modified this decomposition technique model to estimate the relative contribution of area and yield and their interaction with millet in India (Malathi *et al*., 2016). They present it in the following format.

$P_o = A_o * Y_o$

$P_n = Y_o * Y_n$
$\Delta P = P_n - P_o$ (Production change)
A_o = Area (Base year)
A_n = Area (Current year)
Y_o = Yield (Base year)
ΔA = Change in area ($An - A_o$)
ΔY = Change in yield ($Y_n - Y_o$)

$$\Delta P = P_n - P_o = \frac{A_o \Delta Y \times 100}{\Delta P} + \frac{Y_o \Delta A \times 100}{\Delta P} + \frac{\Delta Y \Delta A \times 100}{\Delta P}$$

Change in production = Area effect + Yield effect + Interaction effect.

RESULTS AND DISCUSSION

Performance of mellet production in Uttar Pradesh

The area of millet under cultivation has drastically decreased over the last six decades in India, especially since the green revolution. Sorghum, pearl millet, and small millets comprising Kodo, little, proso and barnyard millet are the major millets in Uttar Pradesh. It may be seen from Table 1 that the state contributes an average of about 6.95 per cent of the total millet area and 11.54 per cent of the total millet production in Uttar Pradesh. Among the millet crops in the state, sorghum millet average area has accounted for 3.05 per cent (216 thousand ha) and 3.80 per cent (232 thousand tons) of the production in the state. Small millet occupied only 1.61 per cent of the total area and 1.67 per cent of the state's production. Sorghum millet and small millets occupied 21 per cent of the state's total production. The average productivity of pearl, sorghum millet, and total millet in the state was low (1.73, 1.10, and 3.52 t/ha). Pearl millet has the largest contribution in terms of average area (10.84%) and production (17.43%) in the state. The total millet average productivity at the state level (3.52 t/ha) is much less than the national level (57.05 t/ha).

The total millets (Shree Anna) production was 17.32 million tonnes during 2022-23. In Uttar Pradesh, the total production of sorghum (4.62 lakh tonnes), pearl millet (21.95 lakh tonnes), and small millet (0.41 lakh tonnes) were 4.62 lakh tonnes and area coverage under pearl millet, sorghum millet and small millet (2173 k/g, 1600 k/g and 869 k/g, respectively) during the 2023-24 (2nd Advance Estimates, APEDA, 2023-24). In Uttar Pradesh, sorghum is 159 kg/ha, which is less than the national level. Millets have better nutritional characteristics and health benefits than other cereals like rice and wheat (Rana and Dahiya, 2021).

Compound annual growth rate for area, production and productivity of millet

During the period I, among all the millets, pearl millet registered the highest growth rate in area (-0.10%), production (2.14%) and productivity (2.21%) and was statistically significant at 5% level of significance except the area in the state. Sorghum millet registered a negative growth rate area (-6.47%) and production (-6.40) except for productivity (0.12%), but statistically significant at 1% level of significance except for productivity in the state. Further, the small millet registered a negative growth rate in all three components, but area and production are statistically significant at 1% significance level.

During period II, sorghum registered the highest positive growth rate in productivity (3.77%), production (3.57%) and area growth rate, which was negative. Further, the growth rate of area coverage under pearl millet during Period II was 0.11 per cent and production registered the highest growth rate of 1.99 per cent and 1.90 per cent of productivity. The area's growth rate under small millet was positive and production and productivity observed a negative growth rate during the same period. Area growth was positive and significant from 1960 to 1970 and has been negative and significant in each of the subsequent four decades since the 1980s (Jena and Mishra, 2022).

During the overall study period, the positive and the highest growth rate was registered in pearl millet in the area (0.43), production (3.04) and productivity (2.60). Furthermore, the growth rate of the coverage area under small millets increased from (-12.19 to 0.60) in I to II, respectively. Compound annual growth rates (CAGR) for the area, as well as the production and productivity of pearl millet, sorghum and small millet, were analysed using the exponential growth function. The compound annual growth rate analysis showed that the pearl millet area, production and productivity have increased from 1999-2000 to 2022-23 compared to the periods I and II.

The compound annual growth rate for the area and the production and productivity of sorghum, pearl millet and small millet were analysed using the exponential growth function. From Table 2, it can be observed that pearl

Table 1: Average production of millets in Uttar Pradesh and India (Mean of 2000 to 2023).

Millets	India			Uttar Pradesh		
	Area	Production	Yield	Area	Production	Yield
Sorghum	7095	6116	19.16	216 (3.05)	232 (3.80)	1.10 (5.72)
Pearl millet	8256	8943	22.68	895 (10.84)	1559 (17.43)	1.73 (7.64)
Small millet	851	547	15.22	14 (1.61)	9 (1.67)	0.69 (4.51)
Total millets	16201	15606	57.05	1125 (6.95)	1801 (11.54)	3.52 (6.16)

Source Author calculation from secondary data: Area- '000' thousand hectares, Production-'000' thousand tonnes, Yield (Productivity)- t/ha. Figures in parentheses indicate percentages.

millet under area registered the highest growth over the year. The production also had a positive growth rate (2.60%), which is statistically significant. In comparison, productivity showed a positive growth rate and was statistically significant at a 1% significance level (2.60%) from 1999-2000 to 2022-23. Compound growth rates for the area, production and productivity of sorghum registered a negative growth rate except for productivity (1.94) and was statistically significant. Small millet registered the highest negative rate under area (-5.88%) but was statistically significant at a 1% significance level.

Instability analysis

Data in Table 3 show the variation in stability across different parameters, specifically area, production and productivity. In the initial Period I, the highest level of variability was identified in production, accounting for 51.02%, followed by 22.73% and the area, with 46.02% and 23.03% noticed in small millet and sorghum, respectively. When examining the Cuddy Della Valle Index (CDVI), production at 23.03, productivity at 16.10 and area at 12.70 were observed in small millet during Period I. Medium instability was registered under production and productivity of small millet. Low instability was observed in the area, as well as in the production and productivity of sorghum, pearl and small millet. Coppock's instability indices observed the highest instability in the area and production of small millet during Period I.

During the subsequent period II, a similar pattern was observed: the highest instability in production stood at 26.92%, while productivity showed a variation of 22.22% of sorghum millet and a similar pattern in small millet. CDVI values for this period were medium instability, 23.46 for production and 17.22 for the productivity of sorghum millet. Also registered medium instability in small millet, 18.15 for the area and 24.03 for production. Coppock's instability indices revealed low instability in all three parameters of millets during period II. The overall period also noticed instability in small millet production, which displayed a higher degree of variation compared to production from 1999-00 to 2022-23. The production of pearl millet also displayed a higher degree of variation compared to area and productivity. In the case of total millet production, a higher degree of variation was observed from 2000 to 2023.

Table 2: The growth rates of area, production and productivity of millets in Uttar Pradesh.

Crop	Period	Area	Production	Productivity
Sorghum Millet	I	-6.47***	-6.40***	0.12
	II	-0.17	3.57	3.77**
	Overall	-2.97***	-1.10	1.94***
Pearl Millet	I	-0.10	2.14**	2.21**
	II	0.11	1.99***	1.90***
	Overall	0.43***	3.04***	2.60***
Small Millet	I	-12.19***	-13.49***	-1.53
	II	0.60	-0.71	-1.34
	Overall	-5.88***	-4.79***	1.07*
Total Millet	I	-1.86***	0.55	0.89**
	II	0.07	2.14***	1.82**
	Overall	-0.50***	2.37***	2.10***

***Significant at 1% level, **Significant at 5%, *Significant at 10% level of significance.

Table 3: Instability of area, production and productivity of millets in Uttar Pradesh.

Crop	Parameters	Period I			Period II			Overall period		
		CV	CDVI	CII	CV	CDVI	CII	CV	CDVI	CII
Sorghum	Area	23.03	6.42	46.20	9.69	10.10	40.57	28.05	16.11	47.44
	Production	22.73	8.68	46.63	26.92	23.46	49.24	25.53	24.96	48.44
	Productivity	7.74	8.14	39.81	22.22	17.22	46.72	21.82	4.04	45.41
Pearl Millet	Area	3.67	3.85	38.16	3.00	3.10	37.91	4.71	3.69	38.57
	Production	10.91	7.94	40.97	8.93	4.75	40.22	21.72	6.81	46.05
	Productivity	10.31	7.33	40.93	8.91	5.34	4022	18.82	3.49	44.64
Small Millet	Area	46.02	12.70	61.46	17.70	18.15	43.83	65.7	39.03	64.83
	Production	51.02	23.03	67.80	23.10	24.03	46.00	61.13	41.29	62.95
	Productivity	15.66	16.10	44.23	14.10	13.41	42.13	18.49	3.43	44.79
Total Millet	Area	7.03	3.52	39.48	3.06	3.18	37.94	5.5	4.86	38.85
	Production	6.58	6.71	39.39	9.33	5.52	40.55	18.15	7.32	44.07
	Productivity	4.73	3.90	38.56	11.41	9.33	41.32	17.03	3.16	43.44

Table 4: Decomposition of change in the production of millet crops in Uttar Pradesh to area, yield and interaction effects.

Crop	Parameters	Period I	Period II	Overall period
Sorghum millet	ΔP, '000 MT	-151.07	1007.8	-5.4
	Area Effect	0.00	104.49	-4749.7
	Yield Effect	98.88	-3.05	2706.29
	Interaction Effect	0.00	-1.66	2128.54
Pearl millet	ΔP, '000 MT	223.49	488.6	880.3
	Area Effect	89.67	95.70	72.09
	Yield Effect	8.53	3.99	17.82
	Interaction Effect	1.46	1.20	9.67
Small millet	ΔP, '000 MT	-19.36	1.5	-15.1
	Area Effect	14.22	23.43	-46.85
	Yield Effect	97.04	68.78	111.86
	Interaction Effect	-11.71	3.82	34.72
Total millet	ΔP, '000 MT	53.05	598.0	860.0
	Area Effect	395.13	210.66	235.18

The instability index for area coverage of the pearl millet crop was recorded to be low during periods I, II and overall. In contrast, the instability index for production and productivity of pearl millet for period I (7.94% and 7.33%) was low instability. It also registered low instability during the overall period. The Coppock's instability index was high for the area and production of small millets during all study periods. The CDVI instability index also registered the highest instability for area and production during the overall period.

Decomposition analysis

Data in Table 4 show the decomposition of the production of sorghum, pearl millet, small millet and the total millet crop in Uttar Pradesh from 2000 to 2023. It shows the area, yield and interaction effects of production change on selected millet crops. For sorghum millet, a production change negative was noticed for Period I. The highest yield effect (98.88%) was observed in sorghum and the lowest 80.53% in pearl millet for Period I, whereas, for Period II, the yield effect was highest (68.78%) in small millet and the lowest yield effect was (-3.05%) in sorghum millet. For the overall period, the highest yield effect (2706%) was in sorghum and the lowest (18%) in Pearl millet. In the case of the Interaction effect, the highest (2128%) in the overall period of sorghum millet and the lowest (9.67%). The highest interaction effect was observed overall compared to periods I and II. The production of small millets declined due to area effects and interactions (Malathi *et al*., 2016).

CONCLUSION

The study found that pearl millet area, production and productivity have increased over time. In the case of sorghum millet, both areas under cultivation and production have decreased, but productivity has increased. The small millet production and productivity have decreased over time. Instability analysis found a low degree of variation in pearl millet, sorghum and small millet production and productivity. The Coppock's instability index was recorded to be high for the area and production of small millets during all study periods. Coppock's instability indices revealed low instability in all three parameters of millets during period II. The CDVI instability index is also registered to be the highest instability for area and production during the overall period. The highest yield effect (98.88%) was observed in sorghum and the lowest, 80.53%, in pearl millet for Period I. In the case of the Interaction effect, the highest (2128%) in the overall period of sorghum millet and the lowest (9.67%). The highest interaction effect was observed overall compared to periods I and II. The positive trend in millet production over the overall period reflects the improvement in modern production technology.

Conflict of interest

All authors declared that there is no conflict of interest.

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