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TRENDS AND CHALLENGES IN PEARL MILLET PRODUCTION WITH SPECIAL REFERENCE TO EASTERN UTTAR PRADESH

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ABSTRACT

Millet, a resilient grain, has been a staple crop for centuries. In 2023, the UN declared the International Year of Millets to highlight its role in addressing food security, nutrition, and sustainable agriculture. This study analyzes trends in pearl millet production in Eastern Uttar Pradesh from 2017-18 to 2021-22, focusing on area, yield, and interaction effects across 20 districts.

***Purpose**: To assess production trends, identify spatial challenges, and recommend strategies for enhancing millet cultivation.*

***Design/Methodology/Approach**: Secondary data on area, yield, and production are analyzed using CAGR and decomposition analysis to evaluate growth and the contributions of area and yield changes.*

***Findings**: Significant variations in production trends are observed, with area and yield changes impacting output differently. Interaction effects highlight the need for targeted interventions.**Originality/Value**: This study offers valuable agricultural planning and policy insights, supporting efforts to promote millet cultivation for sustainable development and food security.*

KEYWORDS: *Pearl millet, Production trends, Sustainable agriculture, Food security, Climate Change.*
JEL Classification- Q10,Q12,Q13,Q18,Q56,R11,O13.

1.INTRODUCTION

Eastern Uttar Pradesh has been selected for studying millet production due to its strategic location in the Indo-Gangetic Plain, representing 35.63% of the state's land area and serving as a significant agricultural zone (**Shakeel,2013**). The region has a diverse cropping history but is transitioning from traditional coarse cereals to fine cereals and cash crops, driven by economic and market demands (**Shakeel,2013**). This shift underscores the importance of analyzing how evolving agricultural practices impact millet cultivation, an integral part of the region's

agricultural heritage and diet. Understanding these dynamics is critical for assessing food security and sustainability in the area, particularly declining millet production.

Pearl millet's drought resistance makes it highly relevant to this study, as the crop excels in arid conditions where water scarcity and poor soil challenge other crops. Its ability to conserve water by folding or withering leaves during drought, especially at critical growth stages like grain filling, ensures its survival and productivity (**Redmann, 1985; Kadioglu and Terzi, 2007**). This unique adaptation is vital for maintaining food security in regions like Eastern Uttar Pradesh, where agricultural practices are changing. The research aims to contribute valuable insights into agricultural resilience and sustainability by studying pearl millet's role in this evolving landscape.

2.REVIEW OF LITERATURE

Jukanti et al. (2016) highlighted pearl millet's resilience to drought, high temperatures, and poor soil, making it ideal for arid regions. Its rich nutritional profile, including energy, fiber, proteins, essential minerals, vitamins, and antioxidants, helps prevent diseases like diabetes and cardiovascular conditions. Despite its genetic variability and pest resistance, its potential remains underutilized due to limited genetic improvements and poor crop management. **Erler, Keck, and Dittrich (2020)** observed a shift in Bengaluru, where millets transitioned from traditional staples tolifestyle superfoods,driven by marketing and health-conscious consumers, reflecting class-based distinctions. **Satyavathi et al. (2021)** emphasized pearl millet's climate resilience and nutritional value, highlighting advancements in hybrid development, stress tolerance, and genomic technologies alongside supportive policies like India's micronutrient standards. **Chaudhary et al. (2023)** examined declining millet trends in India from 1950–2021, identifying yield improvements as drivers for bajra and ragi, while area expansion influenced jowar and small millets. Despite these trends, consumption declined, prompting calls for awareness, training, and policy support. **Deevi et al. (2024)** stressed pearl millet's global importance, noting its role as a gluten-free staple primarily in Africa and Asia, though cultivation areas declined from 35 to 32 million hectares (2007–2019). Rising Asian yields and growing global demand by 2050 suggest opportunities for expanded production, though challenges like yield instability and socio-economic constraints persist.

3.Objectives

1. To analyze the spatial challenges in pearl millet performance across districts in the Eastern Region of Uttar Pradesh.
2. To evaluate trends in pearl millet production across the eastern region of Uttar Pradesh.

4.RESEARCH METHODOLOGY

This study utilized secondary data to analyze the trends in pearl millet production in Eastern Uttar Pradesh. The data on area, production, and productivity were compiled from the Directorate of Economics and Statistics, Uttar Pradesh. The dataset covers the period from 2017-18 to 2021-22. This period was selected to provide a comprehensive overview of the trends and changes in pearl millet production over time. The data includes the area under cultivation, total production, and productivity.

The CAGR formula measures the annual growth rate of pearl millet production from 2017-18 to 2021-22.

Compound Annual Growth Rate

$CAGR = [Ending\ Value / Beginning\ Value]^{(1/n)} - 1$

Where:

- **The ending Value** is the Value at the end of the period.
- **The beginning Value** is the Value at the start of the period.
- **n** is the number of years.

Decomposition of Growth Components:

Decomposition analysis is used to understand the contributions of various factors, such as area, yield, and their interactions, to changes in pearl millet production between 2017–18 and 2021–22.

Overall change in Production (ΔP) = Area effect+ yield effect+ interaction effect

Yield effect

yield effect = $^{Ao \times \Delta Y}$

where Ao= Area in the base year

$\Delta Y = Y_n - Y_o$ (change in yield between the base year and nth year)

Area Effect

Area Effect = $Y_o \times \Delta A$

where Y_o=yield in the base year

$\Delta A = A_n - A_o$ (Change in Area between the base year and nth year)

Interaction Effect

Interaction Effect= $\Delta A \times \Delta Y$

Where: ΔA (Change in Area) = $A_n - A_o$ and ΔY (change in yield) = $Y_n - Y_o$

thus, the Total change in Production (ΔP) can be expressed as:

$\Delta P = A_o \times \Delta Y + Y_o \times \Delta A + \Delta A \times \Delta Y$

5.DATA ANALYSIS

The study analyzed district-wise data on the area, production, and productivity of pearl millet in Eastern Uttar Pradesh from **2017–18** to **2021–22.** Decomposition analysis was employed to calculate the area, yield, and interaction effects and determine their contribution to changes in production over the study period.

Additionally, the Compound Annual Growth Rate (CAGR) was calculated to assess the overall growth trends in pearl millet production. The decomposition and CAGR calculations were performed using standard statistical formulas, ensuring accurate attribution of the effects. The results are summarized in the table below for better understanding and interpretation.

Table 1. District-wise Area, production, and productivity of pearl millets in Eastern Uttar Pradesh

TABLE 1. DISTRICT-WISE AREA, PRODUCTION, AND PRODUCTIVITY OF PEARL MILLETS IN EASTERN UTTAR PRADESH

S. N.	Division	DISTRICTS	YEARS														
			2017-18			2018-19			2019-20			2020-21			2021-22		
			Total Area ('000 hectares)	Production(tonnes)	Productivity (q/ha)	Total Area ('000 hectares)	Production(tonnes)	Productivity(q/ha)	Total Area ('000 hectares)	Production(tonnes)	Productivity(q/ha)	Total Area ('000 hectares)	Production(tonnes)	Productivity (q/ha)	Total Area ('000 hectares)	Production(tonnes)	Productivity (q/ha)
1	AZAMGARH DIV.	AZAMGARH	112.00	216.00	19.29	105.00	218.00	20.76	112.00	242.00	21.61	118.00	283.00	23.98	115.00	251.00	21.83
2		BALLIA	1981.00	3825.00	19.31	1802.00	3749.00	20.80	460.00	993.00	21.59	1894.00	4610.00	24.34	1879.00	4079.00	21.71
3		MAU	48.00	93.00	19.38	22.00	46.00	20.91	48.00	104.00	21.67	42.00	106.00	25.24	47.00	100.00	21.28
4	DEVI PATAN DIV.	BAHRAICH	14.00	27.00	19.29	30.00	61.00	20.33	30.00	64.00	21.33	2.00	4.00	20.00	20.00	45.00	22.50
5		BALRAMPUR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6		GONDA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7		SHRAVASTI	10.00	19.00	19.00	0.00	0.00	0.00	2.00	4.00	20.00	7.00	17.00	24.29	0.00	0.00	0.00
8	FAIZABAD DIV.	AMBEDKAR NAGAR	8.00	16.00	20.00	9.00	19.00	21.11	9.00	19.00	21.11	2.00	5.00	25.00	3.00	7.00	23.33
9		AMETHI	458.00	904.00	19.74	385.00	796.00	20.68	426.00	921.00	21.62	396.00	946.00	23.89	412.00	901.00	21.87
10		BARABANKI	552.00	1089.00	19.73	641.00	1326.00	20.69	443.00	957.00	21.60	545.00	1289.00	23.65	573.00	1256.00	21.92
11		FAIZABAD	2.00	4.00	20.00	67.00	139.00	20.75	1.00	2.00	20.00	2.00	4.00	20.00	1.00	3.00	30.00
12		SULTANPUR	134.00	264.00	19.70	203.00	420.00	20.69	214.00	463.00	21.64	163.00	394.00	24.17	157.00	342.00	21.78
13	GORAKHPUR DIV.	DEORIA	148.00	286.00	19.32	186.00	412.00	22.15	139.00	305.00	21.94	155.00	372.00	24.00	148.00	322.00	21.76
14		GORAKHPUR	9.00	17.00	18.89	7.00	15.00	21.43	8.00	17.00	21.25	7.00	17.00	24.29	8.00	18.00	22.50
15		KUSHINAGAR	103.00	199.00	19.32	335.00	742.00	22.15	181.00	397.00	21.93	147.00	360.00	24.49	103.00	220.00	21.36
16		MAHRAJGANJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	VARANASI DIV.	CHANDAULI	4150.00	4770.00	11.49	4930.00	5636.00	11.43	4889.00	4394.00	8.99	4974.00	6930.00	13.93	4903.00	4410.00	8.99
18		GHAZIPUR	14763.00	15480.00	10.49	15845.00	28360.00	17.90	14566.00	19525.00	13.40	15140.00	24054.00	15.89	15161.00	10373.00	6.84
19		JAUNPUR	4937.00	5797.00	11.74	5957.00	7509.00	12.61	7093.00	11039.00	15.56	5997.00	9258.00	15.44	5922.00	7391.00	12.48
20		VARANASI	6195.00	5888.00	9.50	4916.00	8718.00	17.73	5544.00	8111.00	14.63	4784.00	5104.00	10.67	5504.00	10130.00	18.40

(**Source:** Directorate of Economics and Statistics Uttar Pradesh)

Table 2. Calculation of Area Effect, Yield Effect, and Interaction Effect from 2017-18 to 2021-22 (in Quintals)

TABLE 2. CALCULATION OF AREA EFFECT, YIELD EFFECT, AND INTERACTION EFFECT FROM 2017-18 TO 2021-22 (IN QUINTALS)

DIVISION	DISTRICTS	YEILD EFFECT				AREA EFFECT					INT. EFF.
		Base year area(A0)	yield of base year(Y0)	Change in yield (▲Y)	A0×▲Y	yield of base year(Y0)	Base year area(A0)	area of current year (A nth year)	Change in area ▲A	Y0×▲A	▲A×▲Y
AZAMGARH DIVISION	AZAMGARH	112.00	19.29	2.54	284.52	19.29	112.00	115.00	3.00	57.86	7.62
	BALLIA	1981.00	19.31	2.40	4754.25	19.31	1981.00	1879.00	-102.00	-1969.46	-244.79
	MAU	48.00	19.38	1.90	91.28	19.38	48.00	47.00	-1.00	-19.38	-1.90
DEVIPATAN DIVISION	BAHARAICH	14.00	19.29	3.21	45.00	19.29	14.00	20.00	6.00	115.71	19.29
	BALRAMPUR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	GONDA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	SHRAVASTI	10.00	19.00	-19.00	-190.00	19.00	10.00	0.00	-10.00	-190.00	190.00
FAIZABAD DIVISION	AMBEDKARNAGAR	8.00	20.00	3.33	26.67	20.00	8.00	3.00	-5.00	-100.00	-16.67
	AMETHI	458.00	19.74	2.13	975.97	19.74	458.00	412.00	-46.00	-907.95	-98.02
	BARABANKI	552.00	19.73	2.19	1209.69	19.73	552.00	573.00	21.00	414.29	46.02
	FAIZABAD	2.00	20.00	10.00	20.00	20.00	2.00	1.00	-1.00	-20.00	-10.00
	SULTANPUR	134.00	19.70	2.08	278.98	19.70	134.00	157.00	23.00	453.13	47.88
GORAKHPUR DIVISION	DEORIA	148.00	19.32	2.43	360.00	19.32	148.00	148.00	0.00	0.00	0.00
	GORAKHPUR	9.00	18.89	3.61	32.50	18.89	9.00	8.00	-1.00	-18.89	-3.61
	KUSHINAGAR	103.00	19.32	2.04	210.00	19.32	103.00	103.00	0.00	0.00	0.00
	MAHARAJGANJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VARANASI DIVISION	CHANDAULI	4150.00	11.49	-2.50	-10372.85	11.49	4150.00	4903.00	753.00	8654.96	-1882.11
	GHAZIPUR	14763.00	10.49	-3.64	-53793.07	10.49	14763.00	15161.00	398.00	4173.30	-1450.22
	JAUNPUR	4937.00	11.74	0.74	3646.63	11.74	4937.00	5922.00	985.00	11565.82	727.55
	VARANASI	6195.00	9.50	8.90	55137.71	9.50	6195.00	5504.00	-691.00	-6567.57	-6150.15

(**Source:** Directorate of Economics and Statistics Uttar Pradesh).

Table 3. Calculated Value of CAGR of Area, Production, and Productivity of Pearl Millet in districts of Eastern Uttar Pradesh.

TABLE 3. CALCULATED VALUE OF CAGR OF AREA, PRODUCTION, AND PRODUCTIVITY OF PEARL MILLET IN DISTRICTS OF EASTERN UTTAR PRADESH

NAME OF DIST.	CAGR OF AREA PERCENT%	CAGR OF PRODUCTION PERCENT%	CAGR OF PRODUCTIVITY PERCENT%
AZAMGARH	0.53	3.05	2.51
BALLIA	-1.05	1.29	2.37
MAU	-0.42	1.46	1.89
BAHRAICH	7.39	10.76	3.13
BALRAMPUR	0.00	0.00	0.00
GONDA	0.00	0.00	0.00
SHRAVASTI	-100.00	-100.00	-100.00
AMBEDKAR NAGAR	-17.81	-15.24	3.13
AMETHI	-2.09	-0.07	2.07
BARABANKI	0.75	2.89	2.13
FAIZABAD	-12.94	-5.59	8.45
SULTANPUR	3.22	5.31	2.03
DEORIA	0.00	2.40	2.40
GORAKHPUR	-2.33	1.15	3.56
KUSHI NAGAR	0.00	2.03	2.03
MAHRAJGANJ	0.00	0.00	0.00
CHANDAULI	3.39	-1.56	-4.79
GHAZIPUR	0.53	-7.69	-8.18
JAUNPUR	3.71	4.98	1.23
VARANASI	-2.34	11.46	14.13

Source**:** Directorate of Economics and Statistics Uttar Pradesh

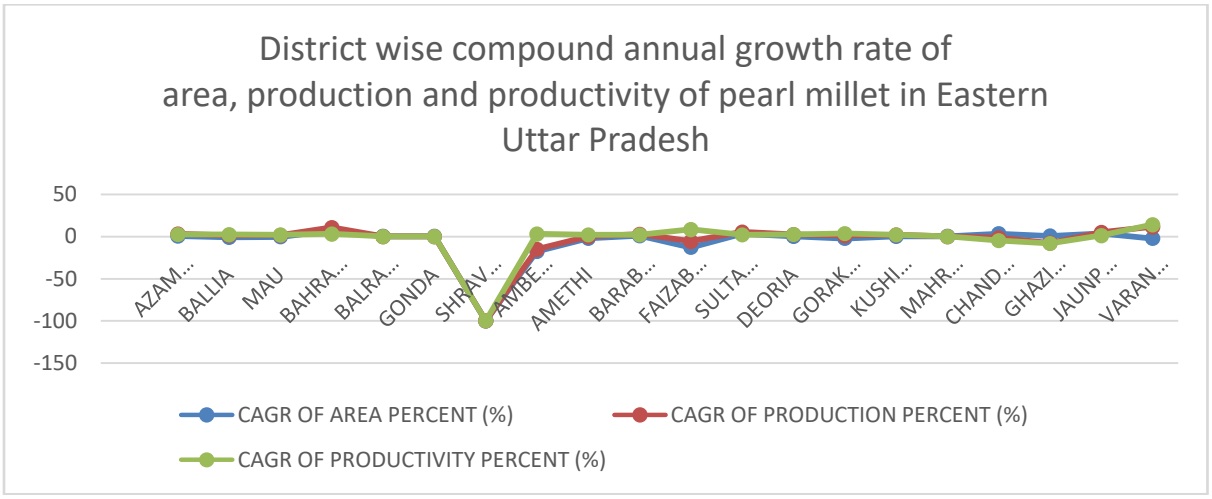

Figure 1 District wise compound annual growth rate of area, production and productivity of pearl millet in Eastern Uttar Pradesh

6. RESULT AND DISCUSSION

The analysis of area effects, as shown in **Table 2**, reveals varying impacts on pearl millet production across districts in Eastern Uttar Pradesh. Districts like **Jaunpur (11,565.82 quintals)**, **Chandauli (8,654.96 quintals)**, and **Ghazipur (4,173.30 quintals)** exhibit positive area effects, which can be attributed to favorable climatic conditions, better market demand, or supportive government policies encouraging the expansion of cultivated land. On the other hand, districts such as **Amethi (-907.95 quintals)**, **Ballia (-1,969.46 quintals)**, and **Varanasi (-6,567.57 quintals)** show adverse area effects. These declines may result from a shift to other crops, declining profitability of millet cultivation, limited research and development efforts, weak market and demand linkages, and insufficient awareness about the benefits of millet. **Deoria (0.00)** and **Khushinagar (0.00)**recorded no changes in production despite changes in the area, suggesting that factors other than land expansion, such as farming practices or market factors, might be limiting production.

For yield effects, **Table 2** shows that districts like **Varanasi (55,137.71 quintals)**, **Ballia (4,754.25 quintals)**, and **Jaunpur (3,646.63 quintals)** experienced high positive yield effects, indicating that improved farming practices or the adoption of better crop varieties contributed to higher production. In contrast, districts like **Ghazipur (-53,793.07 quintals)** and **Chandauli (-10,372.85 quintals)** showed negative yield effects, which may be linked to challenges such as pest infestations, inadequate agricultural practices, or soil degradation. As for interaction effects, **Jaunpur (7,275.50 quintals)**, **Sultanpur (478.80 quintals)**, and **Barabanki (460.20 quintals)** benefited from simultaneous improvements in both area and yield, likely due to coordinated efforts in improving both aspects. In contrast, **Varanasi (-61,501.50 quintals)** and **Chandauli (-1,882.11 quintals)**had negativeadverse interaction effects, which might result from inefficiencies or poor management when both area and yield were expanded together.

The **CAGR** analysis in **Table 3** reveals varied trends in area, production, and productivity across districts. Positive growth in Areas such as **Bahraich (7.39%)**, **Sultanpur (3.22%)**, **Jaunpur (3.71%)**, and **Chandauli (3.39%)** can be attributed to favorable climatic conditions, better market demand, or supportive government policies. On the other hand, districts like **Shravasti (-100.00%)**, **Ambedkar Nagar (-17.81%)**, and **Faizabad (-12.94%)** experienced negative growth, reflecting a shift to other crops, declining profitability, or weak market linkages. For production, **Bahraich (10.76%)** and **Varanasi (11.46%)** showed positive growth, likely due to improved farming techniques or favorable conditions. Conversely, districts like **Faizabad (-5.59%)** and **Ghazipur (-7.69%)**observed declining production, possibly because of adverse weather or poor crop management. Productivity gains, particularly in **Varanasi (14.13%)**, **Faizabad (8.45%)**, and **Gorakhpur (3.56%)** indicate improvements in farming practices. In comparison, reductions in productivity in **Ghazipur (-8.18%)** and **Chandauli (-4.79%)** suggest challenges such as poor crop management or pest issues. These findings emphasize the need for targeted interventions to address the problems hindering production and productivity in certain districts.

7.CONCLUSION

Based on this analysis, it is concluded that the diverse impacts of increasing cultivated area, yield improvements, and their interaction on pearl millet production vary across districts in Eastern Uttar Pradesh. The findings reveal distinct patterns of outcomes, with districts like Jaunpur,

Chandauli, and Ghazipur benefiting significantly from expanded land use, while others, including Varanasi and Ballia, experienced substantial declines.

The variations in yield effects, ranging from highly positive in districts such as Varanasi to negative in Ghazipur and Chandauli, highlight the complexity of agricultural performance across the region. The interaction between area and yield also presents mixed results, with some districts achieving substantial gains and others suffering from inefficiencies when both factors increase simultaneously. This suggests that local conditions, such as farming practices, robust research and development efforts, effective market and demand linkages, and widespread awareness of the nutritional and environmental benefits, play critical roles in determining the effectiveness of land and yield enhancements.

The Compound Annual Growth Rate (CAGR) trends further emphasize the need for region-specific approaches. While some districts, like Bahraich and Jaunpur, show promising growth, others face stagnation ordecline, particularly Shravasti and Faizabad, which may require specific measures to boost performance.

This study underscores the need for tailored strategies to address each district's challenges and opportunities. Policymakers, agricultural experts, and local farmers must collaborate to implement region-specific solutions through improved farming practices, resource management, or investment in research and development. By doing so, Eastern Uttar Pradesh can fully harness its agricultural potential, ensuring future sustainable growth and food security.

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