DoI: https://doi.org/10.58537/jorangrau.2024.52.4.13

J. Res. ANGRAU 52 (4) 118-126, 2024

RICE PRODUCTION IN UTTAR PRADESH: GROWTH, INSTABILITY AND DECOMPOSITION ANALYSIS

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Date of Receipt : 07-10-2024 Date of Acceptance : 05-12-2024

ABSTRACT

The present study investigated the association between growth rate and instability regarding to the production, area and yield of rice in Uttar Pradesh. The data was extracted from the (Directorate of Economics and Statistics, DES), Department of Agriculture and Farmers Welfare, (MoA, GoI), spanning from 1990-91 to 2021-22. The data has been segmented into four periods for analysis. The compound annual growth rate, Coppock's and Cuddy-Della Valle Instability Index have been estimated for the four periods.The growth rate analysis showed the rice crops for the area (0.56%), production (1.30%) and productivity (1.4%) overall, respectively. The highlights of the overall instability measures result of the CDVI Index in rice were observed to be low under area (4.09%) and low (9.59%) instability in production, respectively. In terms of Coppock's performed measure of instability was registered to be low (38.42%) under area cultivation and medium (42.93%) in the production, respectively. The results from the decomposition analysis revealed that the yieldeffect contributed the highest in production observed during period II (155.56%), which shows that there is a negative in-area effect (-65.56%), and an interaction effect was observed (7.78%). The study suggests that production should be prioritized and improving productivity to reach the future demand for rice; it also indicates that there is further potential for the enhancing production of rice in Uttar Pradesh by the adoption of advanced inputs technology.

Keywords: Decomposition,Growth Rate, Instability Analysis, Rice, Uttar Pradesh

INTRODUCTION

The rice crop is the only staple food crop for consumption by nearly half of the world's population. Therefore, rice production should be increased to connect the future demands of the growing global population. Uttar Pradesh accounted for around 12 per cent of the nation-leveltotal rice production and contributed significantly to the area cultivation during 2021-22 (MoA and FW, GoI, 2021-22). The consumption of rice is increasing daily intake due to the increase in population, which can be achieved only through the increase in yield. It has been achieved by introducing new high-yielding varieties and crop management techniques (Jambhulkar *et al.,* 2023).

Global rice production was projected to increase from 501.2 million tonnes to 510.6 million tonnes between 2017 and 2019, respectively. The variation in production from

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2018-19 over 2017-18 was only 1.3 percent in the world market (Food and Agriculture Organization, 2018). India has witnessed a tremendous rise in rice food production from 20.58 millionin 1950-51 to 129.47 mt in 2021-22 (Department of Agriculture, Cooperation and Farmers Welfare, 2022-23, Government of India). the rice growth was made possible by adapting high-yielding varieties due to expansion in irrigation, using modern inputs, and developing infrastructure and institutions, credit markets, and minimum support price policy. Agricultural credit in itself is not an input, but it helps create an environment for adopting modern production technology (Sidhu and Gill, 2006). India is the second largest producer globally, with 23.5 per cent of global rice production, next to China nation. The producers and consumers India is the world's second-largest country. Rice registered (41%) of total food grain production, occupies 35 per cent of the food gains area of the nation and persistently plays an essential importance in livelihood and food security (Nirmala *et al.,* 2019). Rice is an important staple food throughout the national crops. Among the major rice-producing states, West Bengal (13.79%), Uttar Pradesh (13.34%), and Andhra Pradesh, including Telangana (12.84%), are the top three in terms of their contribution to rice production in India (Singh *et al.,* 2021). The forecasted consumption demand for rice by 2025 in Asian countries means that rice consumption will increase more than the population. In India, rice consumption will rise by more than 47 per cent and 51 per cent in Asia (Papademetriou, 2000). The primary reason for the variability in wheat and rice is that the expansion of irrigation in rice was less than in wheat. Rice area under irrigation increased from 37 per cent to 43 per cent between 1965 and 1988. Additionally, food and agriculture production instability play a pivotal role in effective food management (Chand and Raju, 2009). Rice holds importance in Uttar Pradesh, with an area of cultivation of 5.90 million hectares, observed for 13.5 per cent of the total production in India (Ansari *et al.,* 2022). Agriculture was the most essential sector of the economy. However, the population growth in the past few decades has outpaced agricultural production, thereby creating a disparity in the availability and demand of the rice crop. Therefore, the present study considers rice a major staple in the world, particularly in India, whereit contributes overhalf of the worldwide calorie intake of all human beings. However, there is a demand to significantly enhance the average yields of rice; against this background, the study investigates the growth and trends in production, area,and productivity of rice along with instability in rice crops.

MATERIAL AND METHODS

The study was conducted on rice crops from 1990-91 to 2021-22 in Uttar Pradesh. The study used secondary data for 32 years of year-to-year data regarding the productivity, production and area of ricein Uttar Pradesh obtained from the (DES, MoA&FW), Government of India, Agricultural Statistics at a Glance. The thirty-two-year data used for the analysis from 1990-91 to 2021-22 on the productivity, production and area, of rice crops in Uttar Pradesh. Analysing the growth rates using CAGR and estimating the impact of yield, the area, and their interaction on total rice production was achieved using log-linear growth models and a decomposition approach. Additionally, (CV), Coppock's Instability Index and (CDVI), were calculated as the variability in production, productivity and area.

The study was spanning into three periods (1990-91 to 1999-2000)-Period I, (2000-01 to 2009-10)-II, (2010-11 to 2021-22)-III, and (1990-91 to 2021-22)- Overall of rice crops in Uttar Pradesh.

Analysis of Data

The annual growth rate analysis was forecasted for the production and productivity and area of the rice crop 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 (Area, production and productivity)

t = time/year (independent variable)

a = constant/intercept

b = (regression coefficient)

CAGR = {Antilog (ln b) -1} *100

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

Instability Analysis in Rice

The extent and type of instability within the rice production, yield and area in Uttar Pradesh were estimated using the coefficient of variation (CV). However, the basic CV does not adequately capture the underlying trend in the year-by-year data. To address this issue, the degree of variability in production, yield and area was computed to estimate the variability using the instability index originally given by Cuddy and Valle (1978). A low value of this index shows low instability in production. The CV is measured by the formula with equation (1) to estimate the instability index of rice crops in Uttar Pradesh concerning production, area, and yield.

$$(CV\%) = \frac{\sigma}{\mu} * 100$$

CDVI in Rice

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

CDVI = (Cuddy Della Valle Index, %), CV = (Coefficient of Variation), $\overline{R^2}$=Adjusted Coefficient of Determination, CDVI = Cuddy Dell Valle Index, very low = 0 to 5, Low instability = between 5 to 15, Medium instability = 15<CDVI<30, High instability = 30<CDVI>50, Very high = greater than 50.

Coppock's Instability Index (CII)

The study measured variation using the (CV), which calculate the level of instability in continuous data characterised by long-term trends. The Coppock's Instability Index (CII) approximates the average year-to-year % variation adjusted for the trend to overcome this issue. The equation's algebraic form.

Coppock's Instability Index = $\left(\sqrt{logV} - 1\right)_{*100}$

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

X_t = area/production/productivity in the year 't'

N = number of years;m = (mean of the difference between logs) of X_{t+1}, X_t

Log V = Logarithmic variance of the series.

Decomposition Analysis

Minha 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 comparative contribution of yield of area and their interaction with rice (Devegowda, 2024), presenting 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- Ao)

ΔY = Change in Yield (Yn – Yo)

$$P = \frac{A_0 \Delta Y \times 100}{\Delta P} + \frac{Y_0 \Delta A \times 100}{\Delta P} + \frac{\Delta Y \Delta A \times 100}{\Delta P}$$

P (Production change) = Area effect + Yield effect + Interaction effect.

RESULTS AND DISCUSSION

Uttar Pradesh, often referred to as the "Rice Bowl of Central India has witnessed a remarkable contribution in cultivation in Uttar Pradesh since post-reforms in India. In terms of area under rice in Uttar Pradesh, it has consistently increased from 5.6 million hectares to 5.7 million hectares from (1990-2000). This growth has been accompanied by increased rice production with (10.3 MT in 1990-91 to 15.5MT) in 2021-22. Similarly, the productivity (yield) of rice in Uttar Pradesh has also experienced growth from1.8 t/ha in 1990-91 to 2.7 t/ha in 2021-22.These statistics are presented in Table 1, which outlines the production, productivity and area of rice in Uttar Pradesh during the period (1990-91 to 2019-20). This tremendous rise in production can be attributed to favourable climate conditions in different regions of the state. In addition, great production also supports significant scientific research in the rice crop.

Growth Performance for Area, Production and Yield of Rice Crops

In Uttar Pradesh, the compound annual growth rates analysis of production, area and rice productivity for three periods and the entire study period have been estimated and presented in Table 2. Analysis results revealed that the compound annual growth rates of production, productivity and yield fluctuated throughout each period.The finding of the growth analysis showed that the compound annual growth rates of production, area and yield varied throughout the three periods.

The growth rate analysis showed that the highest growth rates were recorded in production (3.18), which was significant during period I. However, positive growth rates were registered for the area, production and productivity during period I. During period II, the compound annual area growth rate was (-0.44) negative and non-significant, while production and yield growth rates were observed positive but non-significant.This may be due to diversifying rice cultivation areas to non-agricultural and commercial crops and purposes during the period.

During Period III, the growth rate in terms of area was observed to be negative (-0.24) and positive and significant growth rates registered in production(1.67) at a 10 per cent level, while productivity (0.34) was significant at a 1% significance level.

Examining Uttar Pradesh as a whole, the period I growth rates in production, area and productivity of rice were 3.18,0.94 and 2.21 per cent, respectively. In terms of area, production and yield in all components were observed statistically non-significant in UP during period II. In periods II and III, the growth rates of area, production, and productivity of Uttar Pradesh were less than in Period I. In the entire period, compound growth rates for the area (0.56), production (1.30***), and productivity (1.14***) of Uttar Pradesh registered positive in all three components and statistically significant at 1 per cent level, except in the area. The growth rate analysis observed a decline in the area in periods II and III could be characteristics of drought, dry spells, low farm-level technical efficiency, and low profitability. In the state, the requisiteis to expand research to increase rice productivity and ensure a sustainable solution for food security and rice production growth.

Table 1. Production, area and productivity (yield) of rice crop in Uttar Pradesh (1990-91 to 2019-20).

Year	Area (Mha)	Production (Mt)	Yield (t/ha)
1990-91	5.6	10.3	1.8
1991-92	5.4	9.4	1.7
1992-93	5.5	9.7	1.8
1993-94	5.4	10.2	1.9
1994-95	5.6	10.4	1.9
1995-96	5.6	10.4	1.9
1996-97	5.5	11.8	2.1
1997-98	5.7	12.2	2.1
1998-99	5.9	11.4	1.9
1999-00	6.1	13.2	2.2
2000-01	5.9	11.7	2.0
2001-02	6.1	12.9	2.1
2002-03	5.2	9.6	1.8
2003-04	6.0	13.0	2.2
2004-05	5.3	9.6	1.8
2005-06	5.6	11.1	2.0
2006-07	5.9	11.1	1.9
2007-08	5.7	11.8	2.1
2008-09	6.0	13.1	2.2
2009-10	5.2	10.8	2.1
2010-11	5.7	12.0	2.1
2011-12	5.9	14.0	2.4
2012-13	5.9	14.4	2.5
2013-14	6.0	14.6	2.4
2014-15	5.9	12.2	2.1
2015-16	5.9	12.5	2.1
2016-17	6.0	13.8	2.3
2017-18	5.8	13.3	2.3
2018-19	5.7	15.5	2.7
2019-20	5.7	15.5	2.7
2020-21	5.7	15.5	2.7
2021-22	5.7	15.3	2.7

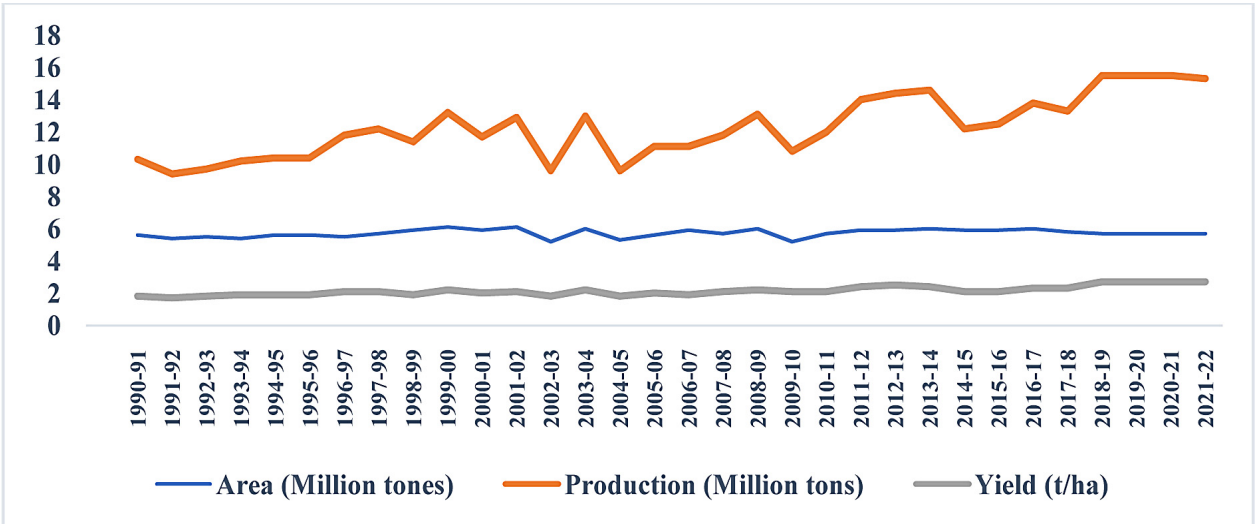

Fig. 1. Area (Mha), production (Mt) and yield (t/ha) of rice in Uttar Pradesh (1990-91 to 2019-20).

Table 2. Growth rates Analysis of production, areaand yield of rice crop in Uttar Pradesh(1990-91 to 2021-22)

Period	(CAGR%)		
	Area	Production	Yield
I	0.94**	3.18***	2.21***
II	-0.44	0.08	0.52
III	-0.24	1.67**	0.34***
Overall	0.56	1.30***	1.14***

*** and ** indicatesignificant at 1% and 10% significance level.
Note: A- area, P- production, Y-yield

Instability Analysis in Rice

Instability indices measuring in regarding of production and area rice productivity from 1990-91 to 2021-22 were computed using the CV, Coppock's Instability Index (CII), and Cuddy-Della Vale index methods. The results of the analysis are presented in Table 3. The instability measure determines whether the growth progress of the variable under study was unstable or stable entire period.

Coppock's Instability Index

Table 3 shows that CII is another measure of instability that approximates the average year-to-year per cent variation. The estimation of variation in rice crops shows that more variation was observed in production than in productivity and area. Table 3 describes the results of the Coppock's instability analysis revealing the rice's production, productivity and area. The discussion was period-wise, including the overall period. The instability analysis revealed that periods I, II, and II observed low instability for the area, production, and productivity in Uttar Pradesh. The entire period also showed low variability for the three components: production, productivity, and area. The analysis of the

Table3. Instability analysis ofproduction, area and yield of rice in Uttar Pradesh

Period	Area			Production			Yield		
	CV%	CDVI	CII	CV%	CDVI	CII	CV%	CDVI	CII
Period I	3.84	2.65	38.21	11.10	5.72	40.99	8.22	3.2	39.89
Period II	6.0	2.6	39.1	11.25	12	41.25	6.89	7.11	39.45
Period III	2.01	1.9	37.54	9.45	7.72	40.41	10.14	7.75	40.74
Overall	4.27	4.09	38.42	15.45	9.59	42.93	13.44	7.94	41.91

CV, CDVI and CII: (Coefficient of variation), (Cuddy Della Vally Index) and (Coppock's Instability Index)

instability index for the state of Uttar Pradesh revealed that all components were unstable for all periods of the study.

Cuddy Della Valle Index in rice

Table 3 indicates that the results of the period (I), the instability for production, area and yield was found to be very low (2.65), low (5.72), and very low (3.2), respectively. The instability measures vary from very low to low, and the area is less stable. During the period (II), low variability for production and productivity was recorded (12.0 and 7.11), respectively. The instability measures vary from 7.11 to 12 per cent for production and productivity. In period (III), the low instability index for production and productivity was registered (7.72 and 7.75), respectively. Overall, Uttar Pradesh had low production (9.59) and productivity (7.94).

Decomposition Analysis in Rice

The decomposition analysis of the rice crops' area yield and interaction. However, this analysis did not measure the exact contribution of area and productivity towards rice production growth. Decomposition analysis measured the contribution of area and yield and their interaction effects on production variability. The contribution of area and yield, as well as the impact of their relationship, on production variability, is examined using decomposition analysis. Three effects—area, yield, and interaction effects—were identified as the basis of production growth. In period III, the area effect was the most critical driver of change in rice production in Uttar Pradesh (Table 4). In the rice production in the state during periods (I and II), the yield effect was responsible for the most significant change in rice production. The highest yield effect was observed during II (155.56 per cent), with an area and interaction effect of -65.56 and 7.78 per cent. In the (I and III)- the yield effects were 31.03% and 6.36%, respectively, with area effects (77.24 and 103.64 per cent, respectively) and interaction effects (6.90 and 1.80 per cent). In the overall period, area, yield, and interaction effects were 100.8, 3.60 and 1.80 per cent, respectively.

CONCLUSIONS

Rice is the staple food crop of Uttar Pradesh. It provides more than 50% of the daily energy requirement and plays a significant role in the solution of food and nutritional security of the state. The results revealed a 5.6 million ha area and 10.3 million tonnes of total rice production during 1991-92, which was increased to 0.1 million ha and 4 million tonnes during 2021-22. The highest growth rates in area, production, and yield were registered during period I, where as the lowest was during period II. The lowest variability was observed

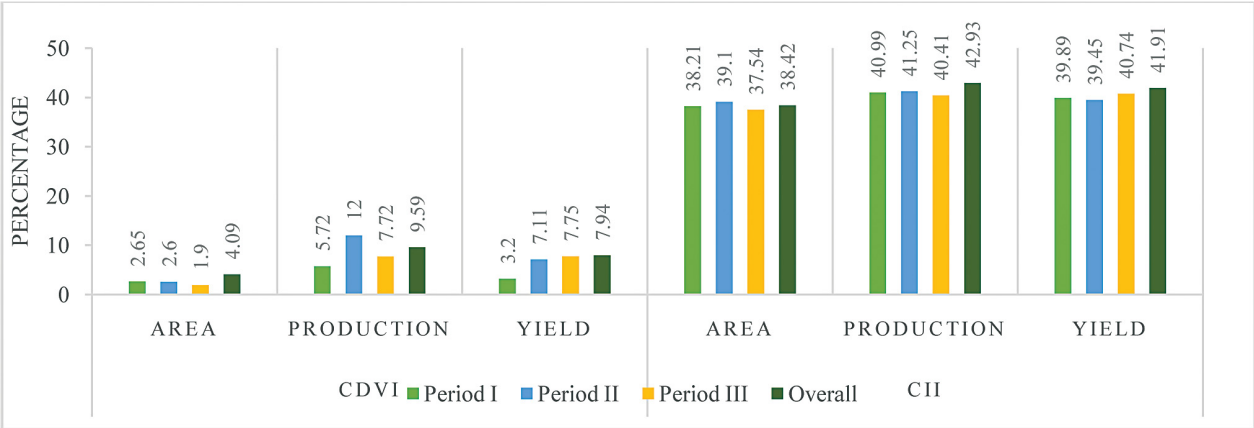

Fig.2. Instability for the production, areaand yield of rice during three periods in Uttar Pradesh, I (1990-91 to 1990-2000); II- (2000-01-2009-10); III-(2010-11 to 2021-22) and overall (1990-91 to 2021-22).

Table 4. Decomposition analysis in production, area and yield of rice in Uttar Pradesh (1990-91 to 2021-22)

Period	Decomposition Analysis (%)		
	Area Effect	Yield Effect	Interaction Effect
I	77.24	31.03	6.90
II	-65.56	155.56	7.78
III	103.64	6.36	1.82
Overall	100.8	3.60	1.80

in all the periods I to III for production, area and yield results from Coppock's indices. The decomposition analysis confirmed that the yield effect is higher in the rice for period II compared to the negative in-area effect and the interaction effect of rice was lowest. improving productivity to meet future demand for rice in Uttar Pradesh. There is assistance for policy emphasis on enhancing rice production through appropriate modern technology, enabling consistent production growth. Also, fluctuations in area and production under rice crops should be addressed, and diversified cultivation patterns should be adopted.

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