Economic Affairs, Vol. 68, No. 02, pp. 1063-1067, June 2023
DOI: 10.46852/0424-2513.2.2023.9

AESSRA

Research Paper

Growth and Decomposition Analysis: Major Cereal Crops in Uttar Pradesh

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Received: 23-01-2023 **Revised:** 07-05-2023 **Accepted:** 28-05-2023

ABSTRACT

Cereal grains viz., Wheat, rice, and maize are stapled foods across the globe. Given this, the goal of the current study was to estimate the growth in acreage, output, yield, and decomposition analysis of the state's principal cereal crops. For the period of 30 years, from 1991-1992 to 2020-2021, the secondary data were gathered from the DES, New Delhi, Agricultural statistics yearly data book, etc. These decades were broken further into four sections: Decade I (1991-2000), Decade II (2001-2010), Decade III (2011-2020), and overall (1991-2020). The annual growth rates and proportional contributions of components in the grain harvest output were quantified using exponential trend and decomposition model. The study examined that the growth rate for wheat reported positive, whereas rice and maize show mixed patterns. Rice was one of the crops which reported affirmative and significantly favorable growth at the value of 0.46 per cent throughout the entire study period. Decomposition analysis of wheat, rice, and maize revealed that the rise in output was caused by the yield effect, although the acreage effect for rice and maize was significant and positive for decade II.

HIGHLIGHTS

- The growth rates showed mixed patterns during the study period.
- Yield effects were superior for wheat, rice, and maize.

Keywords: Growth, decomposition, rice, harvest, Uttar Pradesh

The farming sector and its derivatives are the primary employers in India. The primary source of income for 70% of its rural residents is still farming, with 82% of farmers being small and marginal farmers (FAO, 2022). The high output of grain crops in India is due to favorable weather and well-designed irrigation facilities. Cereal was the foundation of human civilization. Cereal is taken from the Roman term *'Ceres,'* which signifies the goddess of grain. The most vital grains are wheat, maize, and rice. Wheat crop is the second most after rice therefore wheat is called as '*King of cereals*.' Maize has the highest yield potential among cereals hence it is known as the '*queen of cereals*. Cereals, which include a broad variety of cereal products, are cultivated in vast amounts because of their high nutrient and mineral content. However, many bowls of cereal contain fiber, proteins, and carbohydrates. Cereals are enriched with niacin, iron, riboflavin, and thiamine.

The majority of the world's populace now gets the bulk of their energy from wheat cereals. Cereals are the primary source of energy for the vast majority of the world's people, and they are especially essential in developing nations. As compared to industrialized nations, developing nations rely more heavily on cereal grains to meet their

How to cite this article: Joshi, A., Balai, H.K. and Malviya, P.K. (2023). Growth and Decomposition Analysis: Major Cereal Crops in Uttar Pradesh. *Econ. Aff.*, **68**(02): 1063-1067.

Source of Support: None; **Conflict of Interest:** None

dietary requirements (Ahmad *et al.* 2015). In 2020, cereals output for World was 3.00 million tonnes. In the period between 1971 to 2020, global cereal production grew at an average yearly rate of 1.79%, rising from 1.30 mt to 3.00 mt. As a result of the green revolution, India's grain production increased dramatically from 1950-51 to 1977-78, from 55-56 mt to 125 mt in 1978 (Kabra and Ittyerah, 2009).

In 2020-21, India produced 285.27 mt of grain from an area of 101.01 million hectares of land. Uttar Pradesh accounted for 17.70 % of the total land area, followed Bt Madhya Pradesh at 10.28% and Punjab accounted for 1.15% of the total harvest. Almost 72% of the land and 73.83% of the production in the nation are located in the states of Uttar Pradesh, Madhya Pradesh, Maharashtra, Rajasthan, Bihar, Punjab, West Bengal, Haryana, and Karnataka, which are also significant cereal-growing states (DES, 2020-21).

It is essential to measure the development in agricultural output to comprehend how outputs change over time. Variations in the harvested acreage and average yield of a crop are the primary determinants of the physical production of a crop. To quantify the proportional share of collected area and production, as well as their interplay in overall output, a decomposition analysis approach is used (Ayele *et al.* 2021). The purpose of this study was to acquire a deeper comprehension of the growth performance of major cereal grains in Uttar Pradesh as measured by acreage, output, and yield. Furthermore, estimate the decomposition analysis of major cereal crops in Uttar Pradesh. Similar studies in the growth and decomposition of crops were attempted by Balai *et al.* (2021), Sahu *et al.* (2021), Dey *et al.* (2020), Singh *et al.* (2020), Kumari *et al.* (2020).

MATERIALS AND METHODOLOGY

The study was mainly based on secondary data and information that was gathered from different sources including the Ministry of Agriculture and the Directorate of Economics and Statistics. For the proposed study, time series data of 30 years, from 1991 to 2020 were employed. The entire study period was further divided into four decades, namely Period-I (1991-2000), Period II (2001-2010), Period III (2011-2020), and Overall period (1991-2020). Appropriate tools were applied for the study viz., the Exponential trend model and the decomposition model. The study was constrained to the three main cereal crops: wheat, rice and maize.

Compound Growth Rate

The annual compound growth rate was estimated to know the acreage, output, and yield of the crops over the study period and was calculated by using the exponential trend model (Balai *et al.* 2021).

Exponential trend equation: $Y = ab^t$

Using the logarithmic version of the equation for compound growth rate was computed as follows:

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

Where,

Y = acreage/output/yield; a = Intercept; b = regression coefficient / (1 + r); t = Year; r = Compound growth rate / (Antilog b) – 1

The per cent compound growth rate ® will be as,

$$R = [(Anti\ log\ of\ b) - 1] \times 100$$

Student 't' test was used for testing the significance level of growth in acreage, output, and yield of selected cereal crops (Balai *et al.* 2021).

$$t = \frac{CGR}{SE(CGR)}$$

Where,

't' = Student 't-test

CGR = Compound growth rate

$SE\ (CGR)$ = Standard error of the compound growth rate

The standard error of annual compound growth rate is calculated by using the following formula (Rao *et al.* 1981);

$$SE(CGR) = \frac{100b}{\ln 10} \times SE(\ln b)$$

Decomposition Analysis

To estimate the relative contribution of acreage, yield, and the interaction of acreage and yield

towards increasing cereal output in India. The following decomposition analysis model was used (Minhas and Vaidyanthan, 1965):

$$\Delta P = AB*\Delta Y + YB*\Delta A + \Delta A*\Delta Y$$

= (Yield effect) + (Acreage effect) + (Interaction effect)

Where,

$\Delta A = AC - AB$, $\Delta P = PC - PB$, $\Delta Y = YC - YB$

AB, *PB*, and *YB* are the acreage, output, and yield of cereals for the base year.

AC, *PC* and *YC* are the acreage, output, and yield for the current year.

ΔA = Change in acreage

ΔP = Change in output

ΔY = Change in yield

As a result, the overall change in output can be divided into three components: yield effect, acreage effect, and interaction effect due to changes in yield and acreage.

RESULTS AND DISCUSSION

The growth performance of wheat, rice, and maize over the period was divided into four decades and the annual compound growth rate was estimated, over the year presented in Table 1.

Table 1: Growth performance of Wheat in Uttar Pradesh (1991-2020)

Decade	Wheat		
	Acreage	Output	Yield
Decade-I (1991-2000)	1.62* (0.001)	6.66 (0.004)	4.71* (0.004)
Decade-II (2001-2010)	1.39** (0.002)	4.95** (0.007)	3.51** (0.006)
Decade-III (2011-2020)	0.02 (0.001)	5.44 (0.014)	5.44 (0.014)
Overall (1991-2020)	0.93 (0.001)	3.51 (0.002)	2.80 (0.002)

Source: *Computation of author's compiled time series data.*

Note: *Figures in Brackets indicate the standard error of the growth model.*

**Significant at the 1% level of significance, and **significant at the 5% level of significance.*

The table reveals that, during decade I, in Uttar Pradesh, the CAGR for wheat acreage and yield were observed significant and positive at the value of 1.62 and 4.71 per cent annually. While in output it was found positive at 6.66 per cent annually but insignificant. During decade II, CAGR in the acreage, output, and yield under wheat were found statistically significant as well as positive at the value of 1.39, 4.95, and 3.51 per cent annually, respectively. The table also revealed that, in decade III, the CAGR in the acreage, output, and yield were statistically insignificant with the magnitude of 0.02, 5.44, and 5.44per cent annually, respectively. Similar results were observed during the entire study period in acreage, output, and yield at the value of 0.93, 3.51, and 2.80 per cent annually, respectively as in decade III.

Also considering to the study period, the rice indicates significant growth performance in output and yield with the magnitude of 7.65 and 4.71 per cent annually, while the acreage was insignificant with 2.80 per cent annually, respectively, in decade I. While in the decade II, the acreage declined with increasing output and yield at the value of -0.46, 1.16, 1.62 per cent annually, respectively. During decade III, it showed a similar result as in decade-II. It was revealed from the table that acreage was statistically significant while output and yield were non-significant with the account of 0.46, 3.04, 2.57 per cent annually, respectively, during overall.

Table 2: Growth performance of Rice in Uttar Pradesh (1991-2020)

Decade	Rice		
	Acreage	Output	Yield
Decade-I (1991-2000)	2.80 (0.002)	7.65* (0.006)	4.71** (0.006)
Decade-II (2001-2010)	-0.46 (0.007)	1.16 (0.013)	1.62 (0.008)
Decade-III (2011-2020)	-1.14* (0.001)	3.04 (0.009)	3.99 (0.010)
Overall (1991-2020)	0.46** (0.001)	3.04 (0.002)	2.57 (0.002)

Source: *Computation of author's compiled time series data.*

Note: *Figures in Brackets indicate the standard error of the growth model.*

**Significant at the 1% level of significance, and **significant at the 5% level of significance*

In maize, it is found that CAGR is statistically significant in the acreage, while the performance of output and yield was insignificant with the magnitude being -3.84, 0.01, and 3.99 per cent annually, respectively, in decade I. During decade II, it was reported that, the acreage was significant but output and yield showed insignificant growth performance at -4.50, -2.95, 1.62 per cent annually respectively. During decade III similar results were reported as in decade-I as well as overall time was similar to decade II.

Table 3: Growth performance of Mazie in Uttar Pradesh (1991-2020)

Period	Maize		
	Acreage	Output	Yield
Decade-I (1991-2000)	-3.84* (0.004)	0.01 (0.018)	3.99 (0.017)
Decade-II (2001-2010)	-4.50** (0.008)	-2.95 (0.018)	1.62 (0.012)
Decade-III (2011-2020)	-0.92 (0.007)	9.40* (0.008)	10.41 (0.004)
Overall (1991-2020)	-4.50 (0.001)	-0.46 (0.004)	4.23 (0.003)

Source: *Computation of author's compiled time series data.*

Note: *Figures in Brackets indicate the standard error of the growth model.*

**Significant at the1% level of significance, and **significant at the 5% level of significance.*

Decomposition Analysis

Decomposition is the effect of acreage, output, and their interplay between these three factors on the output of the concerned crops, table 2 represents the result as shown. It was examined for wheat that; the proportional contribution of yield effect was the highest at 77.34 per cent, followed by the contribution of the acreage effect at 22.41 per cent and their interplay effect on output was 0.25 per cent for the overall. During decade I, the variation in output was caused by the yield effect, which contributed 71.08 per cent of the total output. In addition to the growth acreage and the interplay effect each contributed 28.90 and 0.02 per cent correspondingly. During decade II, the yield effect was the most significant contributor to the overall production growth, accounting for 73.5 per cent of the increase. This was followed by an acreage effect of 23.36 per cent of the increase and their interplay effect which accounted for 3.06 per cent to the total output growth. During period III, the yield effect contributed the highest at 90.30 per cent of total output growth whereas the acreage effect was 11.62 per cent and the interplay effect showed a negative impact of -1.92 per cent. The output growth was mainly improved due to the yield effect for wheat in Uttar Pradesh.

Table 4: Acreage, Yield, and their interaction impact on the output of wheat in Uttar Pradesh (1991-2020) (In per cent)

Decade	Crop	Acreage effect	Yield effect	Interaction effect
Decade-I (1991-2000)	Wheat	28.90	71.08	0.02
Decade-II (2001-2010)		23.36	73.58	3.06
Decade-III (2011-2020)		11.62	90.30	-1.92
Overall (1991-2020)		22.41	77.34	0.25

Source: *Computation of author's compiled time series data.*

Rice: The decomposition analysis of rice for the overall period shows that the rise in output was predominantly due to the yield effect of 85.12 per cent, followed by the interplay effect of 15.97 per cent, while the acreage effect accounts negative effect on output with -1.09 per cent.

Table 5: Acreage, Yield, and their interaction impact on the output of rice in Uttar Pradesh (In per cent)

Decade	Crop	Acreage effect	Yield effect	Interaction effect
Decade-I (1991-2000)	Rice	43.25	56.06	0.69
Decade-II (2001-2010)		147.17	50.18	-97.35
Decade-III (2011-2020)		-45.67	144.01	1.66
Overall (1991-2020)		-1.09	85.12	15.97

Source: *Computation of author's compiled time series data.*

During decade I, it was observed that the yield contributed positively to an increase in the output of rice and its effect was 56.06 per cent, followed by an acreage effect of 43.25 per cent, while a contribution

of interplay effect with regards to increased output of rice was only 0.69 per cent. It shows that an increase in output contributes more in comparison with the acreage and interplay effect. During decade II, the acreage accounts for 147.17 per cent which was more than yield, and their interplay effect is negative with the order of magnitude 50.18 and -97.35 per cent correspondingly. Decade III registered similar results as for the overall period.

Maize: The relative contribution of maize examined similar findings found in rice in all aspects during all the periods except the acreage effect for maize in period-I and interaction effect in decade III were found negative based on the magnitude of -69.50, -7.19 per cent correspondingly.

Table 6: Acreage, Yield, and their interaction impact on the output of maize in Uttar Pradesh

Decade	Crop	Acreage effect	Yield effect	Interaction effect
Decade-I (1991-2000)	Maize	-69.50	168.83	0.67
Decade-II (2001-2010)		84.49	42.07	-26.56
Decade-III (2011-2020)		-5.96	113.15	-7.19
Overall (1991-2020)		-118.12	200.47	17.65

Source: *Computation of author's compiled time series data.*

CONCLUSION

Throughout the study period, it can be estimated that the expansion rates in acreage, output, and yield in wheat were reported as positive but insignificant. While it revealed a mixed growth pattern for rice and maize. In all decades, except decade II, where acreage impact was the dominant factor in increasing output of rice and maize, while yield was a key factor in the growth of wheat, rice, and maize output. The yield effect was primarily accountable for wheat output growth for Uttar Pradesh, followed by the acreage effect and interaction effect.

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