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Rice and wheat production in India: An overtime study on growth and instability

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Abstract
Rice and wheat are the staple source of nourishment of billions of Indians. India is the second largest producer of rice and wheat after China, indicating the role of both the crop in food security of the nation. Both the crops played key role in transforming the nation from a food deficient nation to a food sufficient nation. The present study examines the growth and instability in in wheat area, production and productivity these two eminent crops over a period of 1950-51 to 2015-16 and also the study tries to decompose the major factors contributing to growth of production in India. The study revealed that throughout the whole period, there is positive significant growth rate in area, production and yield. The analysis over the sub periods showed variations in rate of growth. The analysis of instability showed that in both rice and wheat production recorded more variation as compared to area and productivity. Decomposition analysis showed that yield effect contributed more to rice production, whereas in wheat interaction effect was more dominant factor.

Keywords: Rice, wheat, India, CAGR, instability, decomposition

Introduction

Rice and wheat together make up for about 30% of the global calorie intake (FAO), making both the crops a predominant source of nourishment for billions of people across the globe. Both the crop had been among the earliest cultivated crops and has been the staples in the diet of many civilizations. Rice and wheat are grown widely almost in all the continents, making them globally important cereal crops. Rice is majorly grown in Asian, African and Latin American countries, whereas, wheat is majorly grown in North America, Southern European countries and Australia. Wheat is the most versatile crop of all cereal grains because of its high adaptability of different climatic regions, while rice is the chief and cheapest source of carbohydrate in majority of the developing nations. There has been a rise in global consumption of rice and wheat with subject to global population growth, raising the need to increase production with improvement in technology. India is the second largest producer of rice and wheat after China, as the country produces 101.29 million tonnes of wheat and 175.58 million tonnes of rice annually (FAOSTAT, 2018). Approximately 44 million ha and 29.5 million ha area are under rice and wheat production in India, symbolizing the importance of both the crop in Indian agriculture. The country has exported 2,26,225.00 MT of wheat for the worth of Rs. 424.94crores and 44,14,562 MT of basmati rice worth of Rs. 32.8crores and 75,99,596 MT of worth Rs. 21.18crores to the world during the year of 2018-19 (www.apeda.gov.in), thus rice and wheat production not only makes the country food sufficient nation but also strengthen its agrarian economy. Since, agriculture is the major source of income for a large population of the country, and rice and wheat being the majorly grown crops plays key role in enhancing income of the farmers. The study of growth and instability in both the crops is of higher significance as it would enable us to understand the nature of food security and income stability. The division of the whole study period into sub periods aims at better understanding of in which sub period there was growth and in which period there was lag. On viewing the importance of both the food crop in Indian economy, the study was aimed to analyze:

1. To analyze the growth and instability in the area, production, and productivity of rice and wheat
2. To study the relative contribution of area and yield in the production of rice and wheat to analyze which factors contributed to growth.

Methodology

The study was based on secondary data collected from India stat website. The study period for rice and wheat growth and instability analysis was from 1950 to 2016 for the variables area, production and productivity.

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The entire study period was further divided into seven sub-periods as: Period I (1950-51 to 1959-60), Period II: (1960-61 to 1969-70), Period III: (1970-71 to 1979-80), Period IV: (1980-81 to 1989-90), Period V: (1990-91 to 1999-00), Period VI: (2000-01 to 2009-10) and Period VII: (2010-11 to 2015-16).

Compound annual growth rate
Compound annual growth rate (CAGR) was estimated using the following functional form:

$$\ln Y = a + bt$$

Where, Y is the time series data of area, production or yield of wheat - for which growth rate is calculated, 't' is the trend term and 'a' is the constant coefficient. The slope coefficient 'b' measures the relative change in Y for a given absolute change in the value of explanatory variable 't'. Compound annual growth rate can be calculated from the value obtained for 'b' as:

$$CAGR = [antilog\ b - 1] \times 100$$

The values of compound growth rates obtained were also tested for their significance using student 't' test.

Co-efficient of Variation
Instability is the deviation from the trend. It can be measured by using the coefficient of variation. The standard deviation as a percentage of means is called as the coefficient of variation.

$$CV = (SD / MEAN) \times 100$$

Where CV is the Co-efficient of variation, SD is the standard deviation of the variable.

Decomposition analysis
Decomposition helps us to get to know about the constituent elements of a particular parameter. To estimate the contribution of area, productivity and interaction of the two in total production, following model was used.

$$\Delta P = A_0 \Delta Y + Y_0 \Delta A + \Delta A \Delta Y$$

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

Where, ΔP is change in production, A_0 is area in the base year, ΔA is change in the area and ΔY is the change in yield. $\Delta A \Delta Y$ corresponds to the interaction effect.

Results and Discussion
Growth in rice and wheat area, production and productivity
The growth in rice and wheat area, production and productivity are represented in table 1. The total area under rice cultivation in India grew from 30810 thousand hectares in 1950-51 to 43499 thousand hectares in 2015-16. There has been not much increase in the area under rice cultivation in India. The growth trend shows that the area under rice grew at a compound growth rate of 0.52 per cent. The study of the sub-periods shows that there has been positive growth rate in all the sub-periods except in the sixth sub period which shows negative growth rate i.e. -0.64 per cent. The overall area under wheat production in India has increased from 10010 thousand hectares to 30418 thousand hectares during 1950-51 to 2015-16 at a significant growth rate of 1.69 per cent. The sub-period wise compound growth trend analysis for the area under wheat shows a declining trend in the compound growth rate except in the fifth sub-period. Except fourth sub period all the sub periods showed significant growth in area.

India is the second leading producer of rice in the world, which is evident from the growth trend in rice production. The rice production of the country increased from 20576 thousand tonnes in 1950-51 to 104408 thousand tonnes in 2015-16. The production under rice grew at a compound growth rate of 2.5 per cent. The study of sub periods shows that first, fourth and fifth sub period recorded significant growth. In the sub periods increasing growth trend was observed till fourth sub period thereafter, decreasing trend was recorded. India has shown a tremendous growth in wheat production especially after the Green revolution in the 1960s. The wheat production increased from 6462 thousand tonnes in 1950-51 to 92288 thousand tonnes in 2015-16, which is approximately 14 times. Significant growth was observed in all sub periods except last sub period. The wheat production has recorded a significant growth rate of 4.11 per cent which is comparatively more than rice.

Table 1: Compound Annual Growth Rates of Area, Production and Yield of Rice & Wheat in India

Crop	Particulars	Periods							Over-all Period
		I	II	III	IV	V	VI	VII	
Rice	Area	0.936** (30810)	0.995** (34128)	0.474** (37592)	0.490** (40152)	0.565 (42687)	-0.644 (44716)	0.147 (42862)	0.5239
	Production	0.936** (20576)	0.577 (34574)	0.024 (42225)	3.212** (53631)	1.90** (74291)	0.474 (84976)	0.846 (95970)	2.491**
	Yield	3.441** (668)	0.577 (1013)	-0.445 (1123)	2.706** (1336)	1.331** (1740)	1.125* (1900)	0.696 (2239)	1.956**
Wheat	Area	2.947** (10010)	2.641* (12931)	1.907** (18293)	0.542 (22225)	1.414** (24045)	0.986** (25797)	0.758** (29069)	1.698**
	Production	4.796** (6462)	6.212** (10997)	2.936** (23832)	103.2** (36313)	3.311** (55135)	1.492** (69681)	1.012 (86874)	4.11**
	Yield	1.533 (663)	3.573** (851)	0.945* (1307)	102.6** (1630)	1.990** (2281)	0.473 (2708)	0.249 (2989)	2.331**

** at 1% significance level, *at 5% significance level
Digits in parenthesis in each row corresponds to area ('000 hectares), production ('000 tonnes) and yield (kg/ hectare) respectively in the starting year of the respective time period.

The per hectare yield of rice in India multiplied thrice during the period of 1950-51 to 2015-16. The productivity of the crop increased from 668 kg/ha in 1950-51 to 2400 kg/ha in 2015-16 at a compound growth rate of 1.9 per cent. Positive growth was observed in all sub periods except in third subperiod. First, fourth, fifth and sixth subperiod showed significant growth rate. Per hectare yield of wheat in the state increased from 663 kg/ ha to 3034 kg/ ha during 1950-51 to 2015-16. The growth trend analysis for wheat suggests that the yield was growing at a compound annual growth rate of 2.33 per cent from 1950-51 to 2015-16. An exceptional growth rate was observed in fourth sub period. Second, third, fourth and fifth subperiod recorded significant growth. For the overall study period significant growth was observed.

Instability in rice and wheat area, production and productivity
Details of instability in rice and wheat area, production and yield in India for the overall period (1950-51 to 2015-16) and sub-periods is presented in Table 2. During the entire period, highest variation was noticed for production in comparison to area and yield. The variation in rice production was 43.8 per cent, while the variation in area and yield were 11 per cent and 35.3 per cent respectively, while in wheat the variation in production was 65.3 percent and the variation in area and yield were 30 percent and 45.5 percent respectively. The stability in the area under rice and wheat cultivation implies that both the crops holds a significant portion in cropping pattern of the country.
During subperiod analysis in rice highest variation was

noticed in first subperiod, it was 4 per cent variation in area, 14.6 per cent and 11.3 per cent variation in production and yield respectively. The instability was higher in the starting subperiods. Fourth subperiod observed high instability in both production and yield, it may due to launch of various development schemes in that decade by the government to improve Indian agriculture.
The subperiod analysis of wheat showed that early subperiods noticed high instability, production observed the highest instability as compared to area and productivity. Second subperiod showed high instability in production and productivity, it was 27 per cent variation and 17.5percent respectively, it may be due to launch of Green Revolution program in 1965-66, which brought changes in the cropping pattern.

Table 2: Instability in Area, Production and Yield of Rice and Wheat in India

Crops	Particulars	Periods							Overall Period
		I	II	III	IV	V	VI	VII	
Rice	Area	4.1635	2.9608	3.2022	3.2799	2.4197	3.3542	1.4423	11.174
	Production	14.647	10.106	11.553	13.394	6.766	8.797	3.777	43.881
	Productivity	11.305	8.3636	8.7120	10.998	4.6980	6.8224	3.1685	35.3749
Wheat	Area	12.731	9.795	8.328	3.246	5.518	4.230	2.629	30.106
	Production	16.647	27.84	15.681	11.764	11.161	7.3845	4.391	65.378
	Productivity	7.448	17.559	8.092	9.673	6.332	3.876	5.398	45.573

Instability is measured in percent

Relative contribution of area and yield in the growth of rice and wheat in India
Decomposition is done to find out the area, yield and interaction effect on growth of rice and wheat production in India for the overall period (1950-51 to 2015-16), and then in each sub-period separately. Results are presented in Table 3. The analysis of rice and wheat for the overall period shows that the area effect was 11.6 per cent and 17.1 percent, yield effect was 60.7 percent and 26.5 per cent and interaction effect was 27.5 per cent and 56.3 per cent respectively. From the table, it's evident that yield effect (60.7percent) was

important factor to increase production in case of rice, whereas, in wheat the interaction effect (56.3 percent) was more prominent.
The sub-period wise analysis in rice suggests that yield effect was key factor in increase production in all subperiods except in seventh sub period where area effect was comparatively more. In wheat, it was observed that though in the sub periods the area effect and yield effect were more prominent but for the overall period the interaction effect was more as compared to area effect and yield effect.

Table 3: Area, yield and interaction effect on the production of rice and wheat in India

Crops	Particulars	Periods							Overall Period
		I	II	III	IV	V	VI	VII	
Rice	Area effect	26.85	45.671	37.522	8.695	30.173	3.0933	50.289	11.691
	Yield effect	66.75	51.116	58.245	88.988	66.529	96.483	48.909	60.735
	Interaction effect	6.39	3.211	4.231	2.315	3.296	0.422	0.801	27.572
Wheat	Area effect	73.321	29.033	52.911	16.213	49.645	58.722	-515.9	17.103
	Yield effect	20.894	60.115	40.056	80.234	44.320	37.676	593.05	26.542
	Interaction effect	5.783	10.850	7.031	3.552	6.033	3.601	22.860	56.353

Conclusion
From the analysis of growth in rice and wheat, it was found that area, production and productivity observed an increasing trend, they increased at a growth rate of 0.5 percent, 2.4 percent and 1.9 percent in rice, and 1.6 percent, 4.1 percent and 2.3 percent in wheat respectively. Significant growth was observed in both crops over the whole study period. Instability analysis sowed that in both the crops production recorded more variations in growth followed by productivity and area respectively. The stability in the area under rice and wheat cultivation implies that both the crops holds a significant portion in cropping pattern of the country. Comparatively earlier sub periods observed more instability than the later sub periods, it may be due to Green revolution and various other development schemes launched by government to increase production and improve Indian

agriculture. In rice yield effect was the key contributor to increased production, whereas in wheat the interaction effect contributed more than area and yield effect. This study enables us to understand the production pattern of two major staple crops of the country.

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