



# GROWTH RATE AND TREND ANALYSIS OF RICE CROP IN UTTAR PRADESH

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## Abstract

The growth and trends of area, production and productivity of rice crop in the state of Uttar Pradesh has been found in this study. The necessary time series data pertaining to the period from 1970-71 to 2009-10 on area, production and productivity of rice crop have been used to study the growth, trends and projection of rice crop in the state. Forecasting of rice production has also been done up to 2019-2020. The secondary data have been obtained from the Bulletins of Directorate of Agricultural Statistics and Crop-Insurance, Krishi Bhawan, Lucknow, Government of Uttar Pradesh. The results show that the growth rate area, production and productivity have increased during all the decades and during the entire period of the study.

**Key words:** Area, Growth rates, Production, Productivity and Rice.

## Introduction

Rice (*Oryza sativa*), one of the three most important food grain crops in world, forms the staple diet of 2.7 billion people. Rice belongs to the genus *Oryza*, sub tribe oryzineae of the family Gramineae. It is one of the few crop species endowed with richest genetic diversity. India has about 43.79 million hectares of the total area under wheat crop and has production 112.91 million tons with productivity is about 2578.0 kg/ha during the year 2018-19 (Anonymous, 2019). Among the rice growing countries in the world, India has the largest area under rice crop and ranks second in production next to China. Rice is grown in Uttar Pradesh during Kharif season from June to October/ November. Rice is grown in all type of soils (clay, clay loam and loamy) and are most suited for its cultivation. Rice is the major crop of Uttar Pradesh which covers about 36.5 per cent area of total gross-cropped area in Uttar Pradesh. Rice is most important food grains of India. Moreover, this country has the biggest area under rice cultivation, as it is the principal food crop. It is in fact the dominant crop of the country.

The growth and fluctuations of annual food production (consisting of rice, wheat, coarse grains, and also grams and pulses) have been examined by Gadgil *et al.* (1999). Zahra *et al.* (2015) estimated the situation of rice regarding its area and yield in Punjab, the estimation is based on time series data from 1980 to 2011. Laitonjam *et al.* (2018) studied the contribution of area, yield and their interaction to growth in production of rice as well as the compound annual growth rate in area, production and yield of rice in India. India stands second rank in production and consumption both next to china in the world. India's share in world wheat production is about 14.13 per cent (Gautam and Sisodia, 2018). In the present study, the growth rate analysis of rice crop for last four

decades in the state of Uttar Pradesh have been done using the data from the Bulletins of Directorate of Agricultural Statistics and Crop insurance, Government of Uttar Pradesh.

## Material and Methods

This section deals with materials and statistical methodologies to carry out the investigation undertaken. In order to study the trend, growth and projection of production of rice crop in Uttar Pradesh, some appropriate statistical methodologies have been used.

## Data

The study on growth in area, production and productivity of rice was purposively taken up in Uttar Pradesh. The necessary data on area, production and productivity of wheat crop was used to analysis of trends. The analysis was carried out for the period of 1970-71 to 2009-10. Time series data pertaining to area, production, productivity of wheat was collected from Bulletins of Directorate of Agricultural Statistics and Crop-Insurance, Krishi Bhawan, Lucknow, Government of Uttar Pradesh.

## Methodology

### Trend and Growth rate

The trend and growth rate in area, production and productivity of wheat crop have been worked out by fitting the following five different functions:

1. Simple linear function

$$Y_t = a + bt + u_t$$

2. Growth function/ semi log function

$$Y_t = e^{a+bt}u_t$$

$$\log_e(Y) = a + bt + u_t$$

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3. Compound function

$$Y_t = a(1+r)^t u_t$$

4. Logarithmic function

$$Y_t = a + b \log_e t + u_t$$

5. Exponential function

$$Y_t = ae^{bt} u_t$$

$$\log_e(Y_t) = \log a + bt + u_t$$

Where,

$Y_t$ : Time series data on area/production/productivity of wheat at time  $t$ ,  $a$  &  $b$  are parameters of the function to be estimated.

$t$ : Time index ( $t=1,2,\dots,n$ )

$r$ : Average compound growth rate per annum.

$u_t$ : error term at  $t$  and is assumed to fallow independently distributed

However, before the fitting above functions, the time series data on area and production were smoothed by three years moving-average method.

### Computation of growth rate

1. **Growth rate for simple linear function:** After fitting the first linear trend function by least-square method, we get the estimate of  $b$  denoted by  $\hat{b}$  (say). Then, annual linear growth rate is computed as follows

$$r = \frac{\hat{b}}{\bar{Y}} \times 100$$

Where,  $\bar{Y}$  is arithmetic mean of  $Y_t$ .

2. **Growth rate for semi log function /growth function:** Semi log function was fitted by least square method and estimate of  $b$  as  $\hat{b}$  was obtained. The annual growth rate is then computed as

$$r = \hat{b} \times 100$$

This growth function gives a constant rate & growth.

3. **Compound growth rate:** To obtain annual compound growth rate, the third function was first linearized by taking natural log on both side, i.e.

$$\log Y_t = \log a + t \log(1+r)$$

$$\text{or } Y_t^* = a^* + bt$$

where,  $Y_t^* = \log Y_t$ ,  $a^* = \log a$  and  $b = \log(1+r)$

The above linearized function was fitted by least square method and estimate of  $b$  as  $\hat{b}$  was obtained. The annual compound growth rate is then computed as  $r = (\text{antilog of } \hat{b} - 1) \times 100$

4. **Growth rate from logarithmic function:** The growth rate using this function has been computed for each year by applying the following formula

$$r_t = \frac{\hat{Y}_t - \hat{Y}_{t-1}}{\hat{Y}_{t-1}} \times 100$$

where  $\hat{Y}_t$  and  $\hat{Y}_{t-1}$  are estimated values of  $Y$  at time  $t$  and  $t-1$ , obtained from fitted logarithmic function.

5. **Growth rate from exponential function:** By fitted the exponential function with time series data, we get the estimate of  $b$  as  $\hat{b}$  and growth rate is computed as

$$r = \hat{b} \times 100$$

Note that the growth rates obtained from semi log function and exponential function will be exactly same. All growth rates are expressed in percentage. The best fitted function was judged on the basis of  $R^2$  (coefficient of determination) and root mean square error (RMSE) both.

### Forecast of rice production

Using these five fitted functions, the forecast of rice production for the years 2013-14 to 2019-20 have been made. For example, in case of fitted linear function

$$\hat{Y}_t = \hat{a} + \hat{b}t$$

we use  $t=41,42,\dots$  and so on, for forecasting the Rice production at  $t=41,42,\dots$  and so on, as forty years time series data on rice production have been used to fit the function.

An absolute relative prediction error (ARPE) in percentage has been computed to examine the performance of forecast value of production of rice by the following formula.

$$APRE(\%) = \left| \frac{\hat{q} - q}{q} \right| \times 100$$

where  $\hat{\theta}$  is the forecast value of  $\theta$ , and  $\theta$  is the value of actual production of rice in a particular year.

## Results and Discussion

An attempt has been made in this section to analyse the growth trends and growth rates of the wheat crop in Uttar Pradesh since 1970-71 onwards.

### Growth trends and growth rates

#### 1. Growth Trends

The trends in growth of area, production and productivity of rice have been found out by drawing line diagrams over the years. The Figure 1 shows the line diagram of the area. It is quite visible from this figure that there has been quite linear trend in the growth of area under rice since 1970-71 till 1989-90 with some little fluctuation at certain years. However, it shows that the area remained almost stagnant since 1989-90 with sudden steep downfall in certain years. This also shows that the area of rice in Uttar Pradesh has been stable during the last decade and, therefore these in little chance of growth under rice in time to come because of pressure on land for other development purposes like roads, infrastructures etc.

The growth trend of production of rice during the period 1970-71 to 2010-11 has been depicted by line diagram (Figure 2). It is obvious from this figure that there has been linear trend in the growth of rice production in the state up to the year 1989-90 with some fluctuations at certain years (1979-80, 1987-88). It is also very evident that the production has been quite unstable during the last decade. The trends in growth of productivity has been depicted by line diagram for the period

1970-71 to 2010-11 (Fig. 3) like production, trends in growth of productivity of rice have been found to be linear up to 1989-90. Similarly the productivity has also been unstable during the last decade with some upward trend during 2009-10 and 2010-11. It is very obvious from these three figures that since area under rice crop has been almost stable during the last decade, unstability in the production of rice has been clearly due to unstability in its productivity during this period.

## 2. Annual average growth rate of rice crop

In the present study annual growth rates of area, production and productivity of rice crop have been worked out using five functions, viz., linear, compound, semi-log growth, logarithmic and exponential function for four decades, i.e 1970-71 to 1979-80 (I-decade), 1980-81 to 1989-90 (II-decade), 1990-91 to 1999-00 (III-decade), 2000-01 to 2009-10 (IV-decade) and also for the entire period (1970-71 to 2009-10, overall). The results are presented and are discussed for each decade separately.

**Annual linear average growth rate (%) of area, production and productivity of rice crop:** The annual growth rate of area, production and productivity of rice for four decades and for entire period (overall) has been computed and are presented in the Table 4.2.2.1. The value of  $R^2$  (coefficient of determined) are also given in this table.

**Area:** It can be seen from the Table 1 that area has increased at the rate of about 0.65 per cent annually since 1970-71 onwards. The first decade witnesses maximum growth rate of about 1.55 per cent. It was probably because of active green revolution phase during this period. The growth rates in other decades were quite nominal. Even it was negative to the tune of about 0.44 per cent during the last decade.

**Production:** The production of rice crop has also increased in the state at the annual growth rate of about 3.02 per cent since 1970-71 onwards. The first decade has recorded maximum growth rate of 6.44 per cent followed by 5.65 and 3.22 per cent during second and third phase, respectively. The growth rate during the last decade was almost close to 0.10 per cent it indicate that production of rice during the last decade has almost been stable, which is not in right perspective in view of ever increasing demand of rice in Uttar Pradesh and also in India.

**Productivity:** The productivity of rice crop has risen with an annual linear growth rate of 2.53 per cent since 1970-71 onwards. The maximum growth rate was found during the second decade (5.75%) followed by 4.81 and 2.20 per cent during first and third decade, respectively. The growth rate of productivity was quite nominal to the tune of about 0.50 per cent during the last decade. It is obvious from the results of the table that the growth of production of rice in the state has not taken place during the last decade due to negative growth rate in area and marginal growth rate in its productivity. Therefore, efforts have to make by policy makers, farm scientists and farmers to boost up the production of rice in time to come for feeding ever increasing population of the state as well as the country.

## 3. Annual average compound growth rate (%) of area, production and productivity of rice

The annual growth rates of area, production and productivity of rice for four decades (I, II, III and IV) and for entire periods have been computed and are presented in Table 2. The values of  $R^2$  (coefficient of determination) are also given in the table. The compound growth rate function have provided consistent estimate of growth rates.

**Area:** Almost similar results have been obtained for the growth rates in area during all the decades and for the overall periods as it were found by linear growth function.

**Production:** The annual average compound growth rate of production has been obtained to be 3.58% since 1970-71 onwards, which was a little higher than linear growth of about 3.02% (Table 2). The first decade accounted for about 6.23 per cent annual compound growth rate. The growth rates in other decades were found to be almost similar to linear growth rate.

**Productivity:** The annual compound growth rates of the productivity were also worked out to be almost similar to linear growth rate during all the decades and also for the entire period undertaken for the study.

## 4. Annual average growth rate (%) of area, production and productivity of rice based on semi-log growth function

The annual average growth rates of area, production and productivity of rice crop for different decades and for the entire period under study have been computed using semi-log function. The growth rates are given in the Table 3. Almost similar results have been obtained by semi-log function as it were obtained by compound growth function (Table 2) for the area, production and productivity. Thus, it needs no further explanation. The overall results of the Table 1, Table 2 and Table 3 revealed that growth rates obtained by linear growth function, compound growth function and semi-log function have been almost similar for area, production and productivity for the entire periods and for last four decades of the study.

The values of  $R^2$  for linear growth were little more than those of based on the compound and semi-log function. Therefore, it can be concluded that the linear growth function was best fitted model. This is also obvious from the Figure 1 to 3 where almost linear trend in area, production and productivity has been observed. It may also be noted from the results of these three Tables that the growth rate of production and productivity of rice have been maximum during the first and second decades, which have been active green revolution period. The first decade observed maximum growth rate in area which was start of green revolution period. It also reveals that there has been stagnation in the area as well as productivity of rice during the last decade (2000-01 to 2009-10). There is a little scope of bringing more area under rice but the productivity can be increased to increase the production of rice in the state, as it is still stand at about 21 q/ha which is comparatively less than Punjab and Haryana (about 45 q/ha).

Therefore, this needs attention of the policy makers, farm scientists, different NGO working in agriculture sectors and farmers too to develop an integrated approach to enhance the productivity of rice in the state.

**Forecast of rice production:** On the basis of fitted functions for the entire period under study, the rice production for the years 2010-11 to 2019-20 have been forecasted and are presented in the Table 4. It can be seen from the results of the Table 4 that forecast value of rice production based on compound, semi-log and exponential function have been found to be close to the actual rice production during the years 2010-11 to 2013-14. The coefficient of determination ( $R^2$ ) for these functions have been found quit high, *i.e.* 86.83 and 79.89 per cent for almost all the growth functions.

The forecast of rice production have also been made for the subsequent years, *i.e.* from 2010-11 to 2019-20. If this trend of growth rate of production of rice continued, the state would expect to produce rice only about 22 million tonnes by 2020. The absolute relative prediction errors (ARPE) in percentage have been computed for the forecast value of rice production based on various fitted growth function. The ARPE(s) have been found to be between 19-30% for compound, semi-log and exponential growth functions, which provided best forecast of rice production. However, the rice production in the state can further be increased if the efforts are made by policy makers, farm scientists and farmer to increase the productivity of rice in future for which there is still lot of scope as the average yield of rice of the state is still less than many states like Haryana and Punjab etc.

### Conclusion

An attempt has been made to find out the growth and trends of area, production and productivity of rice crop in Uttar Pradesh using secondary data for a period from 1970-71 to 2009-10. It is thus concluded that the area under rice crop remained almost same during last four decades in the State. The production of rice has increased during the last four decades. The maximum increase has been observed during eighties. The productivity of rice has also increased during the period 1970-71 to 2010-11. The maximum increase was found during eighties. On the overall, the results show that the

growth rate of area, production and productivity have increased during all the decades and during the entire period of the study. The state is expected to produce rice about 13 million tonnes by the year 2019-20, a forecast value have revealed. The overall results of the study indicate that scenario of rice production in the state has been very rosy. But, the stagnation in the productivity during last decade suggests that the efforts have to be made by policy makers, farm scientists, farmers and NGO(s) engaged in agriculture development programmes to increase the productivity of rice in times to come if the production of rice is to be increased in the state as there is no scope of brining more area under rice.

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**Table 1: Annual average linear growth rate (%) of area, production, and productivity of rice**

Period	Area		Production		Productivity	
	AAGR (%)	$R^2$ (%)	AAGR (%)	$R^2$ (%)	AAGR (%)	$R^2$ (%)
<b>I</b>	1.55	64.52	6.44	70.47	4.81	73.30
<b>II</b>	0.05	0.08	5.65	72.60	5.75	85.52
<b>III</b>	0.10	60.79	3.22	76.15	2.20	67.20
<b>IV</b>	-0.44	5.87	0.09	0.0008	0.49	4.97
<b>Overall</b>	0.65	67.52	3.02	86.83	2.53	87.45

**Table 2: Annual average compound growth rate (%) of area, production and productivity of rice:**

Period	Area		Production		Productivity	
	AACGR (%)	R <sup>2</sup> (%)	AACGR (%)	R <sup>2</sup> (%)	AACGR (%)	R <sup>2</sup> (%)
<b>I</b>	1.54	64.42	6.23	70.98	4.71	73.28
<b>II</b>	0.02	0.34	5.74	73.78	5.88	87.89
<b>III</b>	0.98	60.74	3.21	77.10	2.20	67.92
<b>IV</b>	-0.45	5.86	0.03	0.15	0.50	4.98
<b>Overall</b>	0.66	67.00	3.58	84.67	2.88	85.73

**Table 3: Annual average growth rate (%) of area, production, and productivity of rice based on semi-log function**

Period	Area		Production		Productivity	
	AASLGR (%)	R <sup>2</sup> (%)	AASLGR (%)	R <sup>2</sup> (%)	AASLGR (%)	R <sup>2</sup> (%)
<b>I</b>	1.53	64.43	6.05	70.98	4.61	73.28
<b>II</b>	0.02	0.34	5.58	73.78	5.71	87.87
<b>III</b>	0.98	60.75	3.15	77.10	2.17	67.91
<b>IV</b>	-0.45	5.86	0.03	0.14	0.49	4.98
<b>Overall</b>	0.66	67.00	3.51	84.67	2.84	85.73

**Table 4: Forecast of rice production (Million Tonnes)**

Year	Actual production	Linear function	Compound function	Semi log function	Logarithmic function	Exponential Function
<b>2010-11</b>	12.28	10.38(15.47)	15.96(29.96)	15.96(29.96)	11.52(6.19)	15.96(29.96)
<b>2011-12</b>	13.85	10.64(23.17)	16.54(19.42)	16.54(19.42)	11.60(16.24)	16.54(19.42)
<b>2012-13</b>	14.47	10.90(24.67)	17.13(18.38)	17.13(18.38)	11.68(19.28)	17.13(18.38)
<b>2013-14</b>	14.57	11.16(23.40)	17.74(21.75)	17.74(21.75)	11.76(19.29)	17.74(21.75)
<b>2014-15</b>	-	11.42	18.38	18.38	11.83	18.38
<b>2015-16</b>	-	11.68	19.04	19.04	11.90	19.04
<b>2016-17</b>	-	11.94	19.72	19.72	11.97	19.72
<b>2017-18</b>	-	12.20	20.42	20.42	12.04	20.42
<b>2018-19</b>	-	12.45	21.15	21.15	12.11	21.15
<b>2019-20</b>	-	12.71	21.91	21.91	12.18	21.91

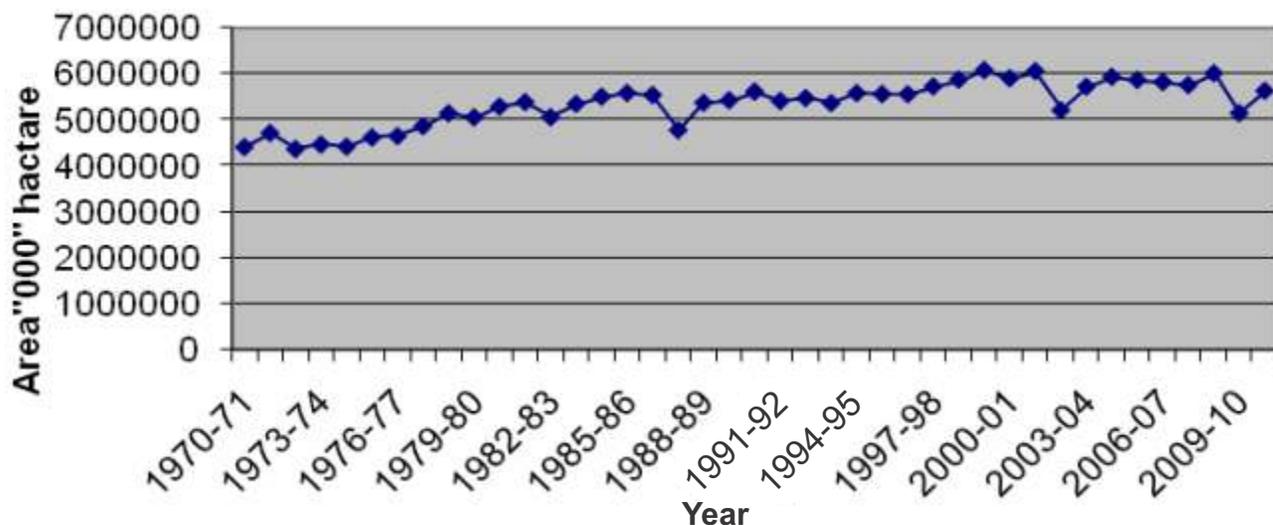


Figure 1: Trend in area of rice production in Uttar Pradesh

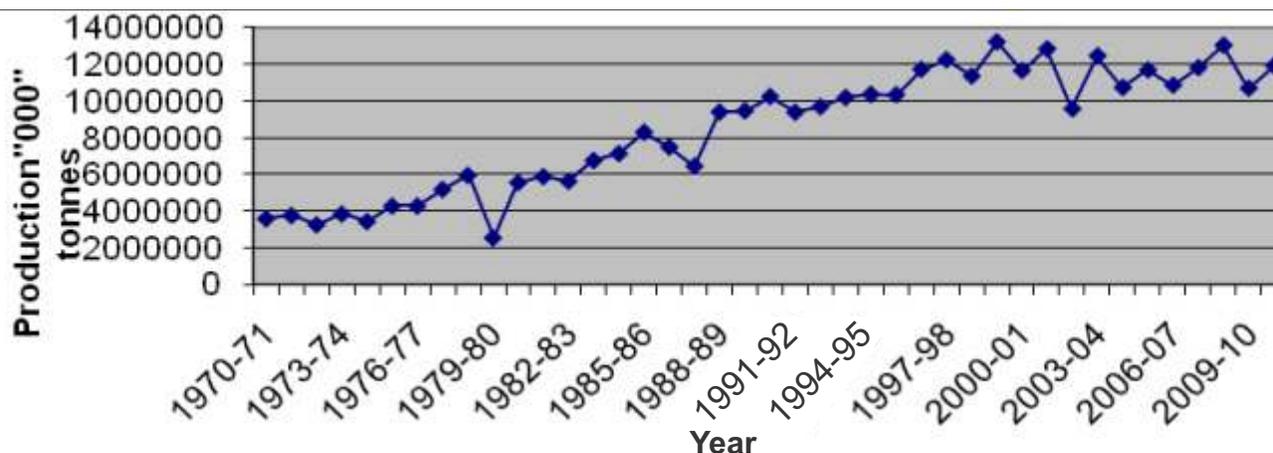


Figure 2: Trend in rice production in Uttar Pradesh

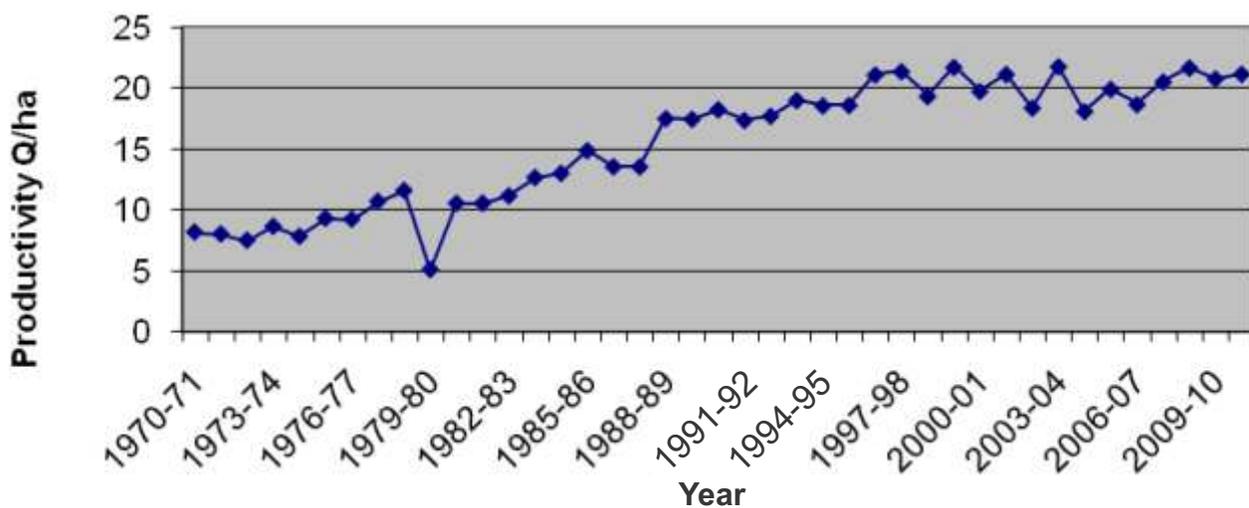


Figure 3: Trend in area of rice productivity in Uttar Pradesh