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## Analysis of trends and growth rate of wheat crop and forecast of its production in Uttar Pradesh

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### Abstract

In the present study, an attempt has been made to find out the growth and trends of area, production and productivity of wheat in the State of Uttar Pradesh. The time series data pertaining to the period from 1970-71 to 2010-11 on area, production and productivity of wheat crop have been utilized to study the growth, trends and projection. 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.

**Keywords:** Area, growth rates, production, productivity and wheat

### 1. Introduction

Wheat (*Triticum aestivum* L.) is an important cereal crop in India occupying second place next to rice in production and it plays a critical role in food security. Wheat crop belongs to Graminae (Poaceae) family of the genus *Triticum* (Poonam *et al.*, 2017)<sup>[3]</sup>. Wheat is consumed in a variety of ways such as bread, chapatti, porridge, flour, suji etc. India has about 30.97 million hectares of land, under wheat crop and has production of 88.74 million tons with productivity of about 28.72 Q/ha during the year 2014-15 (Bulletin of Agricultural statistics of Uttar Pradesh, 2015-16). Crop yield is affected by technological changes and weather variables. The technological changes include use of improved qualities of seed, increased fertilizer applications, better irrigation facilities, improved management practices and pest control, etc.

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)<sup>[4]</sup>. Mohd. Jaslam *et al.* (2018)<sup>[6]</sup> studied the trend of growth of legumes in Haryana State. Wheat is cultivated mainly in temperate and sub temperate regions of the world. Wheat has distinct history in India. Considerable increase in wheat production during late sixties and early seventies led to green revolution in the country and makes the country self-sufficient in wheat production. This significant contribution of wheat ushered Green Revolution 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)<sup>[5]</sup>.

Uttar Pradesh is largest state in terms of population and second largest in terms of geographical area. Rice-Wheat is a major cropping system of the State. It produces about 20.36 million tonnes wheat covering the 9.85 million hectare (2014-15). It contributes about 25.91 per cent in the national production of wheat (2014-15) (Directorate of Economics & Statistics 2016-17). It is the Uttar Pradesh that can provide sufficient production of wheat to feed the increasing mouth of the country. Therefore, it is necessary to examine the present trend and growth of wheat production in the State in order to inject policy innervation for sustainable growth of wheat production in the State. In view of the above facts, an attempt has been made to analyse the trend and growth rates of wheat crop during the last four decades the State of Uttar Pradesh.

### 2. Material and Methods

#### Data

For the present study, secondary data on area, production and productivity of wheat crop covering the period 1970-71 to 2010-11 have been collected from the Bulletins of Directorate of Agricultural Statistics and Crop-Insurance, Krishi Bhawan, Lucknow, Government of Uttar Pradesh.

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**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:

- (i) Simple linear function  $Y_t = a + bt + u_t$  ... (1)
- (ii) Growth function/ semi log function  $\log_e(Y) = a + bt + u_t$  ... (2)
- (iii) Compound function  $Y_t = a(1+r)^t + u_t$  ... (3)
- (iv) Logarithmic function  $Y_t = a + b \log_e t + u_t$  ... (4)

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,...,n), r: average compound growth rate per annum,  $u_t$ : error term at t and is assumed to follow independently normally distributed with mean zero and variance  $\sigma^2$ .

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**

**(i) Growth rate for simple linear function**

The annual average linear growth rate is computed as follows

$$r = \frac{\hat{b}}{\bar{Y}} \times 100 \quad \dots (5)$$

Where,  $\bar{Y}$  is arithmetic mean of Y and  $\hat{b}$  is the estimate of b obtained through fitting (1) by least square (L.S.) technique.

**(ii) Growth rate for semi log function /growth function**

The annual average growth rate is computed as

$$r = \hat{b} \times 100 \quad \dots (6)$$

Where  $\hat{b}$  is the L.S. estimate of b in (2).

**(iii) 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 average compound growth rate is computed as

$$r = (\text{antilog of } \hat{b} - 1) \times 100 \quad \dots (7)$$

**(iv) Growth rate from logarithmic function**

The growth rate using this function has been computed for each year by applying the following formula

$$r_t = \frac{\hat{Y}_t - \hat{Y}_{t-1}}{\hat{Y}_{t-1}} \times 100 \quad \dots (8)$$

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.

**Using these fitted functions, the production of wheat was forecasted for subsequent years.**

**3. Results and Discussion**

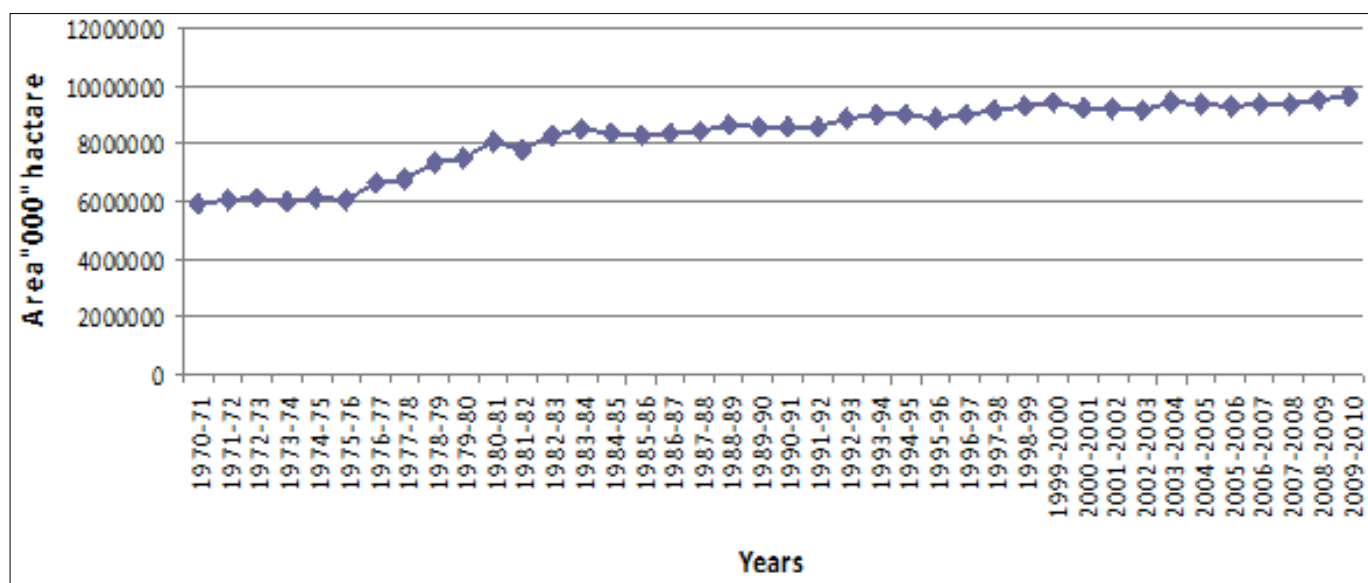
The results of growth trend and rates are presented and are discussed in this section.

**Growth trends and growth rates**

**3.1 Growth trends**

The three years moving average of area, production and productivity have been worked out. The line diagrams of these moving averages have been sketched over the years to find out the growth trends in area, production and the productivity of the wheat.

The Fig. 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 wheat since 1970-71 with some little fluctuation at certain years.



**Fig 1:** Trend in Area

Similarly, the production also shows an almost linear growth trend (Figure 2). However, there has been steep growth in the

production since 1970-71 with some fluctuations at certain years.

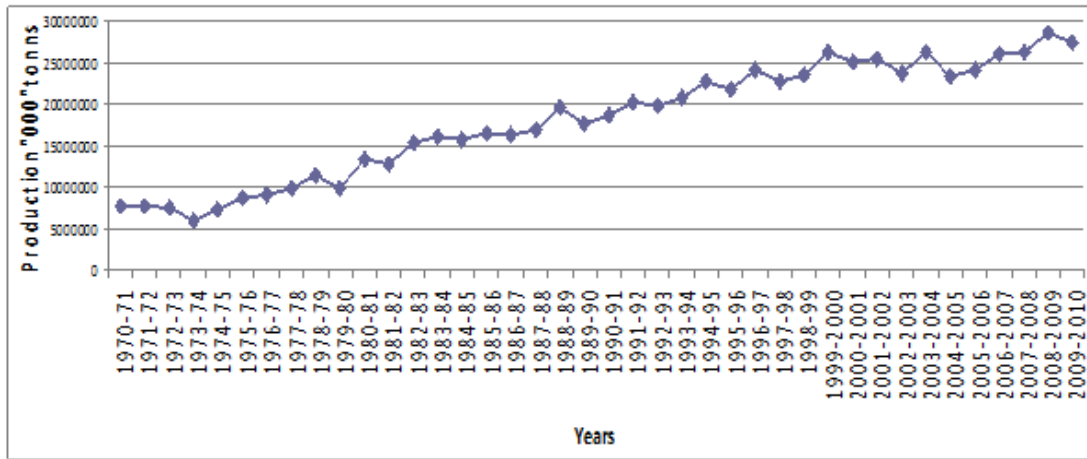


Fig 2: Trend in Production

The growth in the productivity of the wheat has witnessed more fluctuations than area and production (Figure 3).

However, an almost linear trend in the growth of productivity of wheat can be visualized from the Figure 3 up to 2010.

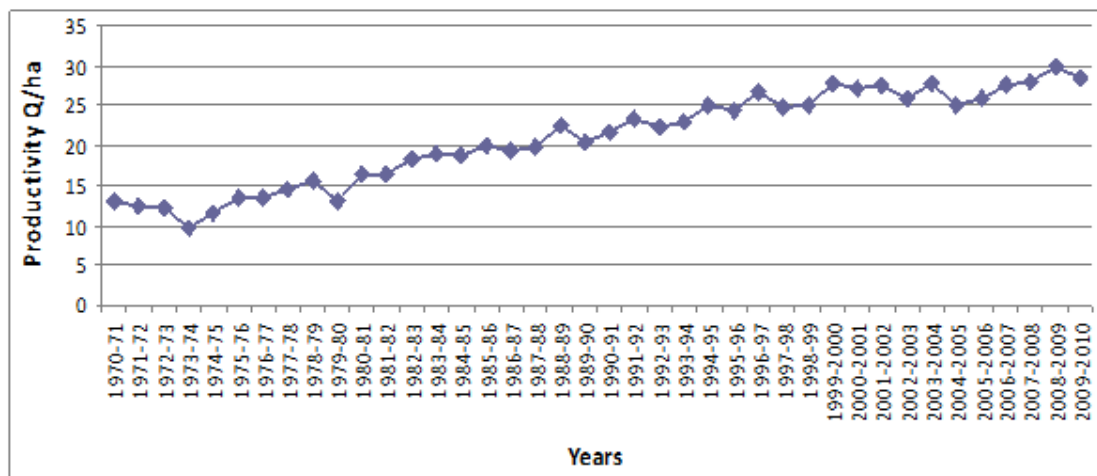


Fig 3: Trend in Productivity

**3.2 Annual average growth rate**

Annual growth rates of area, production and productivity of wheat crop have been worked out using the fitted functions, viz., linear, compound, semi-log growth, logarithmic for four decades, i.e. 1970-71 to 1979-80 (decade-I), 1980-81 to 1989-90 (decade-II), 1990-91 to 1999-00 (decade-III), 2000-01 to 2009-10 (decade-IV) and also for the entire period (1970-71 to 2009-10, overall) under study. The fitted functions are given in Appendix 1 to 3. The results are presented and are discussed for each decade separately.

**3.2.1 Annual linear average growth rate (%) of area, production and productivity of wheat crop:** The annual

growth rate of area, production and productivity of wheat for four decades and for entire period (overall) has been computed and are presented in the Table 1. The value of R<sup>2</sup> (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 1.13 per cent annually since 1970-71 onwards. The growth rate was higher (2.71%) during first decade as compared to that of about 0.85 per cent during second decade followed by 0.96 and 0.43 per cent during third and fourth decade, respectively.

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

Period	Area		Production		Productivity	
	AAGR (%)	R <sup>2</sup> (%)	AAGR (%)	R <sup>2</sup> (%)	AAGR (%)	R <sup>2</sup> (%)
I	2.71	80.9	4.99	61.3	2.27	27.0
II	0.85	63.1	3.62	79.3	2.88	79.2
III	0.96	85.8	3.19	86.3	2.23	76.5
IV	0.43	69.4	1.30	37.9	0.86	24.1
Overall	1.13	85.2	3.17	95.32	2.28	93.9

**Production**

The production of wheat crop has also increased in the state at the annual growth rate of about 3.17 per cent since 1970-71

onwards. First decade has witnessed maximum growth rate of 4.99 per cent as against 3.62 per cent during the second

decade followed by 3.19 and 1.30 per cent during third and last decade, respectively.

### Productivity

The productivity of wheat crop has risen with an annual linear growth rate of 2.28 per cent since 1970-71 onwards. The maximum growth rate was found during the second decade (2.88 %), which was peak period of green revolution. The growth rate in the productivity was maintained at the level of 2.23 per cent per annum during nineties, where the effect of green revolution has started shading during late nineties. This effect has been clearly visible during the last decade (2000-01 to 2009-10) where growth rate was plunged to 0.86 per cent.

It is very evident that positive growth rate in area as well as productivity has contributed to the high growth rate of production of the wheat in the State during the entire period of the study. It was found by Gautam and Sisodia (2018) [5]

that the contribution of increases in the productivity of wheat in the differential production of wheat was almost 75 per cent and the rest because of increase in area and simultaneous increase in area and productivity. This shows that increase in productivity has mattered much in fetching high production of wheat in the State.

### 3.2.2 Annual average compound growth rate (%) of area, production and productivity of wheat

The growth rates of area, production and productivity of wheat have been worked out by using compound growth function. The results are given in the Table 2. By comparing the results of the table 1 and the Table 2, we find that growth rates of area, production and productivity were almost similar. The values of  $R^2$  were also almost same. This shows that linear growth function and compound growth function provided almost similar growth rates.

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

Period	Area		Production		Productivity	
	AACGR (%)	$R^2$ (%)	AACGR (%)	$R^2$ (%)	AACGR (%)	$R^2$ (%)
I	2.68	82.1	4.96	57.5	2.20	27.0
II	0.85	62.3	3.75	79.4	2.87	80.3
III	0.96	85.7	3.24	87.6	2.26	77.2
IV	0.40	69.5	1.28	36.6	0.85	23.1
Overall	1.21	81.5	3.74	89.0	2.51	89.8

The growth rates of area, production and productivity based on semi-log function were found exactly similar to those obtained by compound growth function. Thus, the result based on semi log function is not presented here.

### 3.2.3 The annual growth rates (in %) of area, production and productivity based on logarithmic function

The annual growth rates of area, production and productivity of wheat crop for entire time period under the study have been computed using logarithmic function and are presented in Table 3.

**Table 3:** The annual growth rates (in %) of area, production and productivity based on logarithmic function.

Year	Area (%)	Production (%)	Productivity (%)
1970-71	19.08522		93.3349
1971-72	9.374916	91.34157	28.23981
1972-73	6.081476	33.87025	15.62422
1973-74	4.446732	19.62483	10.48144
1974-75	3.478562	13.40412	7.751493
1975-76	2.842214	9.993482	6.082323
1976-77	2.393996	7.870237	4.966666
1977-78	2.062283	6.435548	4.173615
1978-79	1.807499	5.408714	3.58385
1979-80	1.606052	4.641719	3.129818
1980-81	1.443035	4.049587	2.770586
1981-82	1.30858	3.580273	2.479982
1982-83	1.195907	3.200238	2.24054
1983-84	1.100205	2.886961	2.040182
1984-85	1.017973	2.624794	1.870305
1985-86	0.946603	2.402553	1.724626
1986-87	0.884112	2.212042	1.598453
1987-88	0.828969	2.047129	1.488218
1988-89	0.779973	1.903141	1.391161
1989-90	0.736168	1.776458	1.305116
1990-91	0.696786	1.664237	1.228359
1991-92	0.6612	1.564214	1.159504
1992-93	0.628897	1.474566	1.097424
1993-94	0.59945	1.39381	1.041192
1994-95	0.572504	1.320728	0.990042
1995-96	0.547759	1.254311	0.943333
1996-97	0.524961	1.193717	0.900528
1997-98	0.503892	1.138236	0.861168
1998-99	0.484367	1.087268	0.824867
1999-00	0.466225	1.040303	0.79129

2000-01	0.449327	0.996901	0.760151
2001-02	0.433551	0.956685	0.731199
2002-03	0.418791	0.919328	0.70422
2003-04	0.404955	0.884545	0.679023
2004-05	0.391959	0.852088	0.655443
2005-06	0.379731	0.821738	0.633332
2006-07	0.368205	0.793303	0.612561
2007-08	0.357325	0.766614	0.593016
2008-09	0.347037	0.74152	0.574594
2009-10	0.337297	0.717885	0.557204

For every year, growth rates have been computed and are presented in the Table 3. It can be seen from the table that growth rates in area, production and productivity have decreased steadily over the years since 1970-71. However, it was substantially high during first decade and yearly years of the second decade, which were the period of active green revolution.

### 3.3 Forecast of wheat production

On the basis of fitted function for the entire period under study, the wheat production for the years 2010-11 to 2019-20 have been forecasted and are presented in the Table 4. The absolute per cent deviation of the forecast from actual was computed by formula as follows.

$$\text{Absolute per cent deviation} = \frac{\text{forecast value} - \text{Actual value}}{\text{Actual value}} \times 100$$

**Table 4:** Forecast of wheat production (million tonnes)

Year	Actual Production	Linear function	Compound function	Logarithmic function
2010-11	30.49	29.79 (2.29%)	26.42 (13.34%)	29.13 (4.46%)
2011-12	32.15	30.36 (5.56%)	27.23 (15.30%)	30.03 (6.59%)
2012-13	31.48	30.94 (1.71%)	28.06 (10.86%)	30.75 (2.31%)
2013-14	30.38	31.51 (3.71%)	28.91 (4.83%)	31.47 (3.58%)
2014-15	20.36	32.08 (57.56%)	29.79 (46.31%)	32.19 (58.10%)
2015-16	26.87	32.66(21.79%)	30.70 (14.25%)	32.91 (22.50%)
2016-17	31.28	33.23 (6.23%)	31.64 (1.15%)	33.63 (7.51%)
2017-18	*	33.80	32.60	34.35
2018-19	*	34.37	33.59	35.07
2019-20	*	34.95	34.62	35.79

**Note-** The figures in parentheses indicate per cent deviation of forecast from actual production.

It is obvious from the result of the Table 4 that the forecast production of wheat based on linear and logarithmic function were almost close to the actual production in most of the years since 2010-11 onwards except in the year 2014-15 and 2015-16, which were probably abnormal years in terms of production of wheat in the State. It has been forecasted that the State can achieve about 35 million tonnes of wheat production by the years 2019-20.

### 4. Conclusion

In this study, an attempt was made to find out the growth and trends of area, production and productivity of wheat crop in Uttar Pradesh using secondary data for a period from 1970-71 to 2010-11. The trends in growth of area, production and productivity have been found almost linear with little bit fluctuations in certain years. The growth rates of area, production and productivity during the last four decade have been found to be 1.13, 3.17 and 2.28 per cent annually (based on linear growth function). However, the maximum growth rates in area and production, i.e. 2.71 and 4.99 per cent respectively have been observed in the first decade, while the productivity was 2.27 per cent. Almost similar growth rate in area, production and productivity have been obtained on the basis of growth function like compound and semi-log functions. Since trends in area, production and productivity were found to be linear in nature, the linear growth function was found to be best fitted. Thus, the results based on linear growth function were more reliable as compared to compound growth function. With this trend of growth in production, the State can achieve the production of about 35 million tonnes wheat by the year 2019-20.

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