

Trend, growth and instability analysis of wheat crop in Central India

ABSTRACT

Information about agricultural trends can help policymakers identify strategies that will result in a sustained rise in food output. The present investigation has been undertaken to study the Growth, Trend and Instability in Area, Production and Productivity of Wheat Crop in Chhattisgarh Plains. Time series data for wheat were collected for the period 1990-91 to 2014-15. The linear, quadratic and exponential functions are fitted in order to analyse the trend in area, production and productivity of wheat crop. Besides these compound growth rate, coefficient of variation, instability index of area, production and productivity of this crop have also been recorded. In the entire Chhattisgarh Plains, the average compound growth rate for wheat area is (0.41%). Dhamtari District has the lowest compound growth rate (-8.22%) while Raigarh District has the highest (3.4%) under wheat-growing areas. The negative growth rate under area of wheat in Dhamtari district is causing a switch from winter wheat to summer rice. The average compound growth rate of wheat production across the entire Chhattisgarh Plains is positive (2.42%), which is a good indicator of the rising trend in wheat production in the Chhattisgarh Plains. The highest compound growth rate of wheat production is found in Kawardha District (7.62%), while the lowest is in Dhamtari District (-4.33%). The average compound growth rate for wheat productivity across the entire Chhattisgarh Plains is (1.51%), with Kawardha District having the highest rate (5.00%) and Raigarh District having the lowest (0.60%).

Keywords: Compound growth rate, coefficient of variation, Instability Index, Area, Production, Productivity.

Introduction

Wheat is the most widely grown crop in the world and provides 20% of the daily protein and of the food calories for 4.5 billion people. It is the second most important food crop in the developing world after rice. Wheat is an important crop in India and grown in nearly 31.2 million ha of land in the country with an average productivity of 3.31 t/ha which is less than the productivity of many countries. Chhattisgarh, which came into existence as a new State on November 1, 2000 was formed by incorporating 16 districts of undivided Madhya Pradesh, with a geographical area is 137.90 lakh ha

(www.agridept.cg.gov.in) which is 4.15% of the country and net sown area of 46.51 lakh ha, which is 34% of its total geographical area.

Materials and Methods

Yield data

Time series data on area, production and productivity of wheat crop for 25 years (1990-91 to 2014-15) for Raipur, Durg, Rajnadgaon, Bilaspur and Raigarh Districts have been procured. These districts were then subdivided into distinct districts, and statistics on wheat crop area, production, and productivity were collected for a period of 17 years (1998-99 to 2014-15). The districts are Dhamtari, Mahasamund, Korba, Kawardha, Jashpur and Janjgir-Champa. Further, data for three years (2012-13 to 2014-15) was procured on area, production and productivity of wheat crop for Balodabazar, Gariyaband, Bemetara, Mungeli and Balod. All data have been collected from the published booklets and official website (<http://www.agridept.cg.gov.in>) of the Directorate of Agriculture, Government of Chhattisgarh, India.

Trend Analysis

In order to quantify the growth for area, production and productivity of wheat crop, zone level trend in area, production and productivity was worked out for the wheat crop of Chhattisgarh Plains from period (1990-91 to 2014-15). To analyse the trend in area, production and productivity of wheat crop the following different functional forms were fitted.

Linear function

The mathematical equation is given by

$$Y = a + bx + \epsilon$$

Where;

Y is the dependent variable *i.e.*, area or production or productivity

x is the independent variable, time in years

a is the intercept

b is the regression coefficient

ϵ is error term

Quadratic function

Quadratic function is given by the equation

$$Y = a + bx + cx^2 + \epsilon$$

Where;

Y is the dependent variable *i.e.*, area or production or productivity

x is the independent variable, time in years

a is the intercept

b and c is the regression coefficients

ϵ is error term

Exponential function

Exponential function is given by the equation

$$Y = a \times b^x + \epsilon$$

Where;

Y is the dependent variable *i.e.*, area or production or productivity

x is the independent variable, time in years

a is the intercept

b is the regression coefficient

ϵ is error term

The functional form having the highest coefficient of determination (R^2) is selected for fitting the trend. Similarly, the growth rate of area, production and productivity of wheat crop will also be computed.

Compound growth rate (CGR) is also computed for area, production and productivity of wheat crop based on the exponential function for the period. The Compound growth rate will be computed as follows.

Compound growth rate analysis

Compound growth rate (%) for area, production and productivity of wheat crop has been computed for the Chhattisgarh Plains for 25 years (1990-91 to 2014-15) of Raipur, Durg, Rajnandgaon, Bilaspur and Raigarh Districts. Seventeen year (1998-99 to 2014-15) for Dhamtari, Mahasamund, Korba, Kawardha and Janjgir-Champa.

The compound growth rate has been computed by fitting the exponential function given by Raguhuwanshi and Awasthi (2000).

$$Y_i = A \times B^t$$

Where;

Y_i = dependent variable like area, production and productivity in the year 't'

A = constant

B = regression coefficient

t = time element which takes the value 1,2,3,.....n

After transforming the model into a linear form by taking logarithms, we get

$$\text{Log } Y = \log A + t \cdot \log B$$

On writing $\log Y_i = y$, $\log A = a$ and $\log B = b$ this becomes

$$y = a + b \cdot t$$

Which is a linear relationship between y and t, hence can be fitted by the method of ordinary least squares (OLS) technique. The compound growth rate (r) was obtained by the formula $r = (B-1) \times 100 = (\text{antilog } b-1) \times 100$.

The significant of growth rate was tested by applying student 't' test statistics.

$$t = r/S.E.(r)$$

Where;

r = Compound growth rate (CGR)

S.E. means Standard Error and $S.E.(r) = 100 B \times S. E.(\log B)/\log_{10} e$

Which follows 't' distribution with (n-2) degree of freedom, n is number of year considered under study.

Methodology for variability in area, production and productivity of wheat crop

The statistical tool which is used to measure the variability for area, production and productivity of selected crop is coefficient of variation (CV). The coefficient of variation represents the ratio of the standard deviation to the mean, and it is a useful statistical parameter for comparing the degree of variation from one data series to another, even if the

means are drastically different from each other. It is expressed as percentage, where the CV is multiplied by 100.

The coefficient of variation is calculated by using the formula as follows:

$$CV (\%) = \frac{\text{Standard deviation}}{\text{Mean}} \times 100$$

To measure the magnitude of variability in area, production and productivity for the study period, the coefficient of variation will be computed.

Instability index

Further the instability index will also be calculated to examine the instability in area, production and productivity of wheat crop in Chhattisgarh Plains over the time period by using the formula

$$\text{Instability Index (I)} = (1 - R^2) \times CV^2$$

Where;

$$R^2 = \text{RSS/TSS} = \text{Goodness of fit}$$

RSS = Regression Sum of Square

TSS = Total Sum of Square.

Results and Discussion

Linear trend analysis

The linear trend of area, production and productivity of wheat computed for the Chhattisgarh Plains from the year (1990-91 to 2014-15) are shown in Table 1. It revealed that the Chhattisgarh Plains has a positive linear trend in area ($R^2 = 12.38\%$), production ($R^2 = 50.09\%$) and productivity ($R^2 = 45.87\%$) of wheat crop during the year (1990-91 to 2014-15). The increase in area, production and productivity was found highly significant at probability level 0.1, 0.001 and 0.001 respectively.

Quadratic trend analysis

The quadratic trend of area, production and productivity of wheat computed for the Chhattisgarh Plains from the year (1990-91 to 2014-15) are shown in Table 2.

Table 2 revealed that for Chhattisgarh Plains, the regression coefficients b_1 and b_2 were found significant ($R^2 = 30.52\%$) for area of wheat crop in Chhattisgarh Plains during the year (1990-91 to 2014-15). These regression coefficients were found highly significant at probability level of 0.1 and 0.05 respectively.

The regression coefficients b_1 and b_2 were found significant ($R^2 = 75.52\%$) for production of wheat in Chhattisgarh Plains during the year (1990-91 to 2014-15). These regression coefficients were found highly significant at probability level of 0.01 and 0.001 respectively.

The regression coefficients b_1 and b_2 found significant ($R^2 = 70.08\%$) for productivity of wheat in Chhattisgarh Plains during the year (1990-91 to 2014-15). These regression coefficients were found highly significant at probability level of 0.01 and 0.01 respectively.

Instability analysis

Table 3 revealed that the coefficient of variation for area under wheat crop in Chhattisgarh Plains is very low which indicates that the wheat crop is being grown in Raipur, Durg, Rajnandgaon, Bilaspur, Raigarh, Dhamtari, Mahasamund, Korba, Kawardha and Janjgir-Champawith almost same area.

In Chhattisgarh Plains, coefficient of variation of area under wheat crop is only 8.69%, which indicates that area under wheat crop remains almost similar during the study period. While, compound growth rate of production and productivity of wheat in Chhattisgarh Plains is positive and coefficient of variation is slightly higher which shows that there is variability in production and productivity of wheat.

Summary and Conclusion

Dhamtari District has the lowest compound growth rate (- 8.22%) and Raigarh District has the highest (3.4%) under wheat-growing areas. In the entire Chhattisgarh Plains, the average compound growth rate for wheat area is (0.41%). The negative growth rate under area of wheat in Dhamtari district is causing a switch from winter wheat to summer rice.

The average compound growth rate of wheat production across the entire Chhattisgarh Plains is positive (2.42%), which is a good indicator of the rising trend in wheat production in the Chhattisgarh Plains. The highest compound growth rate of wheat

production is found in Kawardha District (7.62%), while the lowest is in Dhamtari District (-4.33%).

The average compound growth rate for wheat productivity across the entire Chhattisgarh Plains is (1.51%), with Kawardha District having the highest rate (5.00%) and Raigarh District having the lowest (0.60%).

The compound growth rate of area in Chhattisgarh Plains is found non-significant. There is an ample need to increase the area under wheat crop in Chhattisgarh Plains. The compound growth rate of production and productivity of wheat in Chhattisgarh Plains is found positive and significant at probability level of 0.05 and 0.1 respectively, which indicate the increasing trend of production and productivity of wheat in Chhattisgarh Plains.

Table 1: Linear trend for area, production and productivity of wheat in Chhattisgarh Plains.

Chhattisgarh Plains	b_0	b_1	R^2
Area	67.730	0.297 ⁺ (0.165)	12.380 ⁺
Production	46.486	1.800*** (0.375)	50.090**
Yield / Productivity	855.220	17.712*** (4.012)	45.871***

***P<0.001, **P<0.01, *P<0.05, +P<0.1. Figures in parentheses are SE(b).

Table 2: Quadratic trend for area, production and productivity of wheat in Chhattisgarh Plains.

Chhattisgarh Plains	b_0	b_1	b_2	R^2
Area	74.277	-1.15756 ⁺ (0.6252)	0.0560* (0.0232)	30.52**

Production	69.80779	-3.382** (1.117)	0.199*** (0.042)	75.520***
Yield / Productivity	1089.190	-34.281* (12.695)	2.000*** (0.474)	70.081***

***P<0.001, **P<0.01, *P<0.05, +P<0.1. Figures in parentheses are SE(b).

Table 3: Compound growth rate (%),coefficient of variation(%) and instability index for area, production and productivity of wheat in Chhattisgarh Plainsand it's constitute Districts.

Districts	Aspects	CGR (%)	CV (%)	Instability Index
Raipur	A	-2.26*	22.03	0.021

	P	-0.32	21.43	0.045
	Y	1.59 ⁺	20.29	0.026
Durg	A	1.72*	17.12	0.011
	P	4.00*	38.19	0.056
	Y	2.03*	20.96	0.024
Rajnandgaon	A	0.75	8.47	0.004
	P	3.29*	32.90	0.042
	Y	2.33*	25.56	0.032
Bilaspur	A	0.02	13.95	0.019
	P	2.25*	27.76	0.055
	Y	1.75*	20.70	0.029
Raigarh	A	3.45*	33.95	0.033
	P	4.80*	51.71	0.073
	Y	0.60	13.32	0.015
Dhamtari	A	-8.22*	53.16	0.129
	P	-4.33*	50.88	0.206
	Y	3.99*	22.57	0.010
Mahasamund	A	-2.48*	31.16	0.078
	P	-1.50	28.62	0.074
	Y	0.84	23.52	0.053
Korba	A	0.29	9.91	0.009
	P	2.73*	23.84	0.038
	Y	2.09*	20.35	0.029
Kawardha	A	2.33*	20.65	0.023
	P	7.62*	46.00	0.062
	Y	5.00*	29.68	0.030
Janjgir-Champa	A	0.46	32.45	0.104
	P	2.64*	27.90	0.063
	Y	1.99*	17.64	0.021
C.G. Plains	A	0.41	8.69	0.006
	P	2.42*	26.78	0.039
	Y	1.51 ⁺	17.72	0.017

***P<0.001, **P<0.01, *P<0.05, ⁺P<0.1

A= Area, P= Production, Y= Yield/Productivity

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