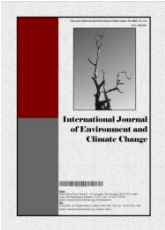


International Journal of Environment and Climate Change

12(11): 2607-2616, 2022; Article no.IJECC.92043
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Trend, Growth and Instability Analysis of Wheat Crop in Central India

Khemraj [a*], N. K. Chaure [b], G. Chandrakar [c], Ajay Tegar [b], Krishan Pal Singh [a], Rajshree Shukla [a], Purnima Haldar [a], Nootesh K. Thakur [a], Vedprakash [c] and Rudresh Kesharwani [c]

[a] College of Horticulture and Research Station, Jagdalpur, Bastar-494001, C.G., India.
[b] Barrister Thakur Chhedilal College of Agriculture and Research Station, Bilaspur, C.G., India.
[c] College of Agriculture and Research Station, IGKV, Raipur, C.G., India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2022/v12i1131253

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/92043

Original Research Article

Received 09 July 2022
Accepted 19 September 2022
Published 20 September 2022

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%).

**Corresponding author: E-mail: sahukhemraj54@gmail.com;*

Keywords: Compound growth rate; coefficient of variation; instability index; area; production; productivity.

1. INTRODUCTION

Wheat (*Triticum aestivum*) is one of the most important cereals crop belonging to the family Poaceae and having a chromosome number 2n = 6x = 42. It is originated in South West Asia. Wheat is the most widely grown crop in the world and provides food to 4.5 billion people. It provides 20% of the daily protein and about 340 kcal of energy per kg wheat flour. It is the second most important food crop in the developing world after rice [1-5]. Wheat is grown as a commercial crop because it generates a high yield per unit area, grows well in temperate climates and produces versatile, high-quality flour [6-9]. Wheat flour is mostly used to produce bread, pasta, cereal, pastries, cookies, crackers, muffins, tortillas, and pitas. India being the second-largest producer of wheat in the world, contributes around 14.14% of the world's total production (2020). It is grown in nearly 31.6 million ha of land with an average productivity of 3.40 t/ha which is less than the productivity of many countries. Major wheat growing states in India are Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan, Bihar and Gujarat. 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 of 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. Under wheat cultivation, Chattisgarh has an area of 102.19 thousand hectare, production of 141.64 thousand MT and productivity of 1386 kg/ha (as of 2017-18).A number of statistical techniques such as linear function, quadratic function, exponential function, compound growth rate, coefficient of variation have been used for the analysis. Shanker et al. [10] examined the compound growth rate and instability status of crops of Chhattisgarh during kharif and rabi season.Therefore, in view of the above consideration there is a need for developing an objective methodology to assess the variability in wheat crop, trend and growth rate an attempt has been made by using statistical methods like coefficient of variation, linear function, quadratic function, exponential function over a time period [11,12].

2. MATERIALS AND METHODS

2.1 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 cropfor 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.

2.2 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.

2.3 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 iserror term

2.4 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

2.5 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 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.

2.6 Compound Growth Rate Analysis

Compound growth rate (%) for area, production and productivity of wheat crop has been computed for the Chhattisgarh Plains for25 years (1990-91 to 2014-15) of Raipur, Durg, Rajnadgaon, 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 [13].

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

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

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

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

$$y = a + b * t$$

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) × 100 = (antilog b-1) × 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 × 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.

2.7 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:

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

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

2.8 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;

$$R^2 = \frac{\text{RSS}}{\text{TSS}}$$
$$= \text{coefficient of determination(Goodness of fit)}$$

RSS = Regression Sum of Square and TSS = Total Sum of Square.

3. RESULTS AND DISCUSSION

3.1 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.

3.2 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 0.05respectively.

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 0.01respectively.

3.3 Instability Analysis

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

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***

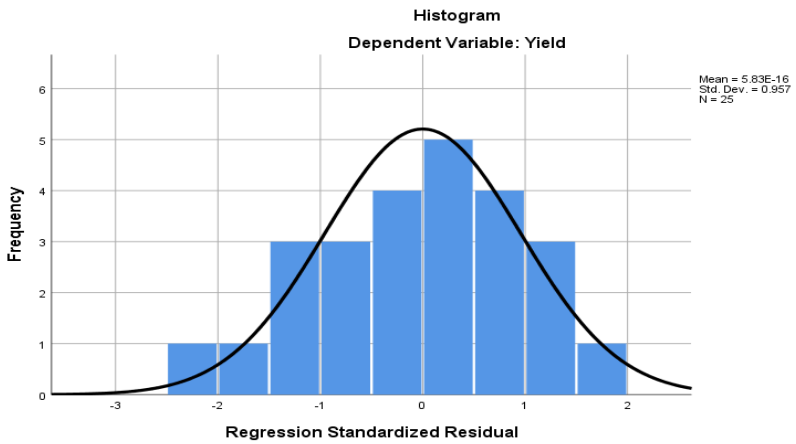
***P<0.001, **P<0.01,*P<0.05, $^{+}$P<0.1. Figures in parentheses are SE(b)

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

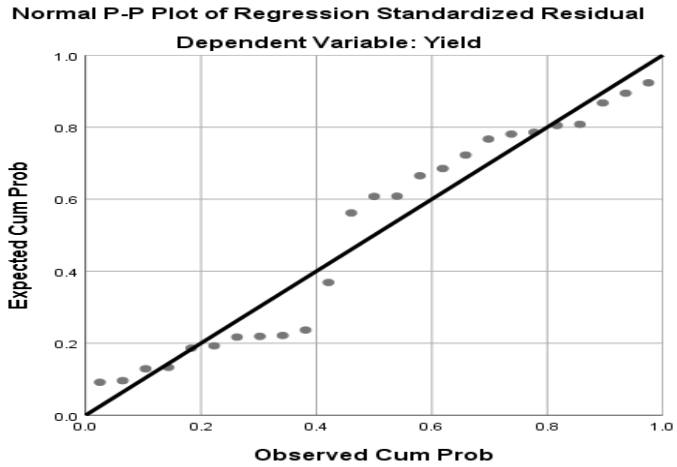
Districts	Aspects	CGR (%)	CV (%)	Instability Index
Raipur	A	-2.26*	22.03	0.021
	P	-0.32	21.43	0.045
	Y	1.59^{+}	20.29	0.026
Durg	A	1.72*	17.12	0.011
	P	4.00*	38.19	0.056
	Y	2.03*	20.96	0.024
Rajnandgaon	A	0.75	8.47	0.004
	P	3.29*	32.90	0.042
	Y	2.33*	25.56	0.032
Bilaspur	A	0.02	13.95	0.019
	P	2.25*	27.76	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



Graph 1. Histogram for Productivity (Yield) of Chhattisgarh Plains under Wheat from the year 1990-91 to 2014-15



Graph 2. Normal distribution fitted for Productivity (Yield) of Chhattisgarh Plains under Wheat from the year 1990-91 to 2014-15

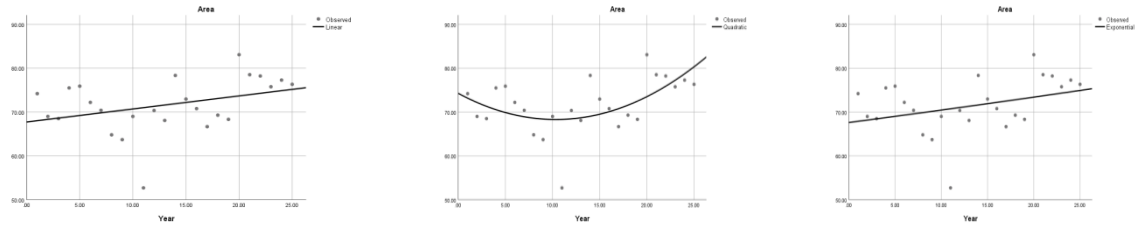


Fig. 1. Observed (linear, quadratic and exponential function) for area of Chhattisgarh plains under wheat from the year 1990-91 to 2014-15

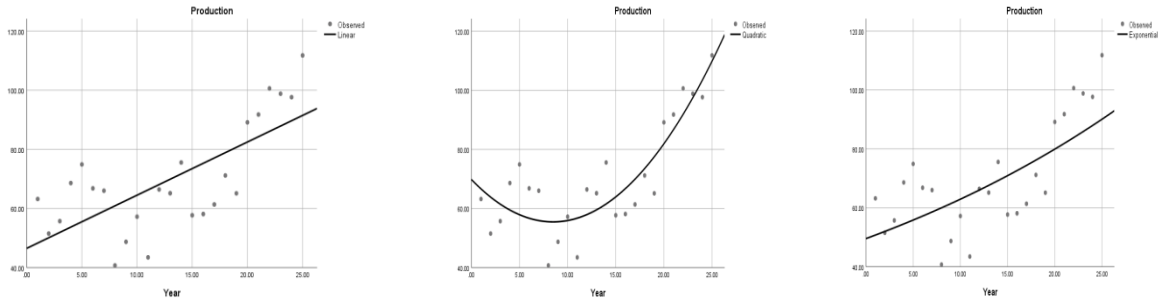


Fig. 2. Observed (linear, quadratic and exponential function) for production of Chhattisgarh plains under wheat from the year 1990-91 to 2014-15

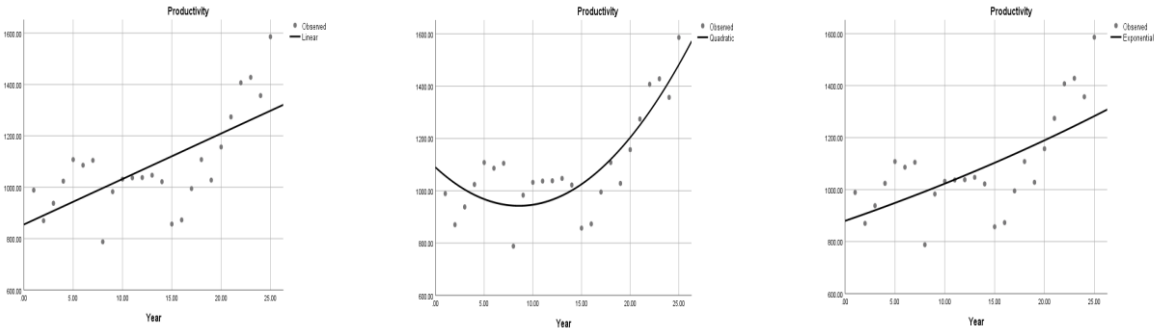


Fig. 3. Observed (linear, quadratic and exponential function) for productivity of Chhattisgarh plains under wheat from the year 1990-91 to 2014-15

Model diagnostic plot: The model diagnostic plots have been depicted in Fig. 4-12.

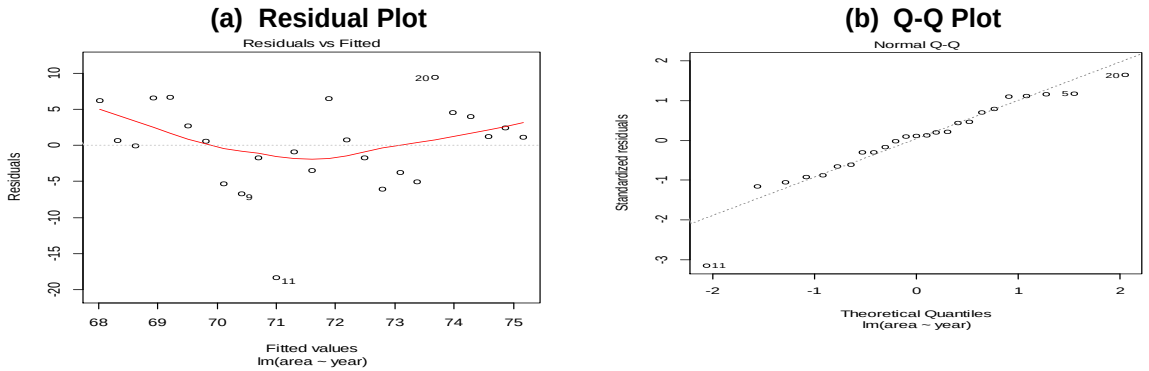


Fig. 4. Linear function for area of chhattisgarh plains under wheat from the year 1990-91 to 2014-15 (a) residual plot (b) Q-Q plot for normality test

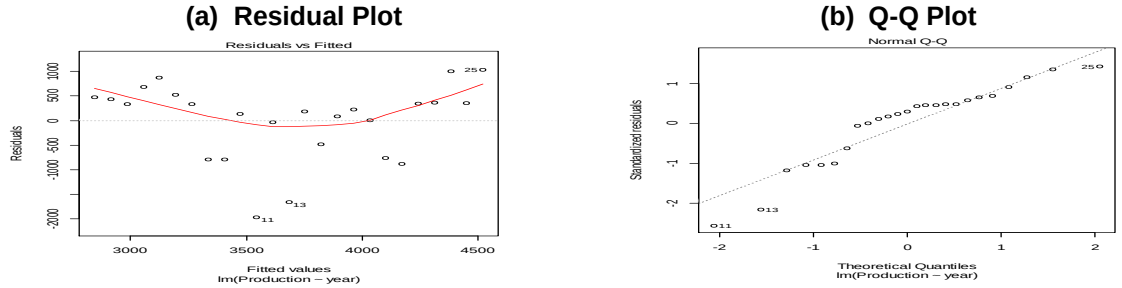


Fig. 5. Linear function for production of Chhattisgarh plains under wheat from the year 1990-91 to 2014-15 (a) residual plot (b) Q-Q plot for normality test

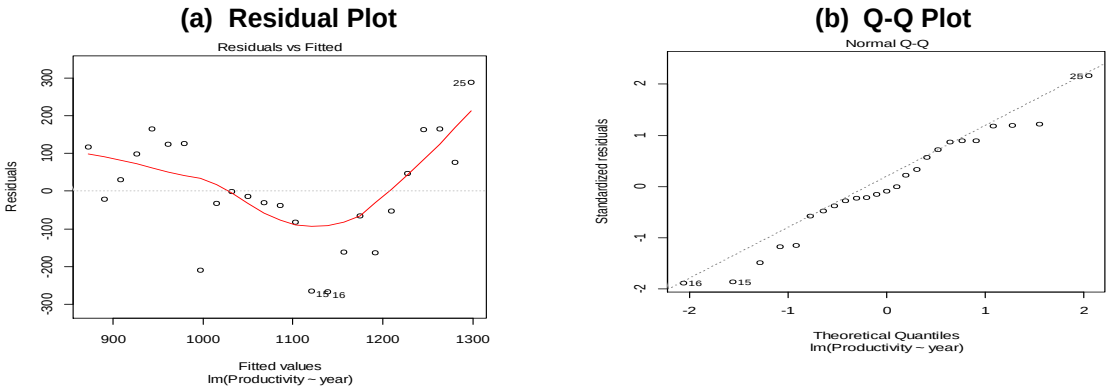


Fig. 6. Linear function for productivity of Chhattisgarh plains under wheat from the year 1990-91 to 2014-15 (a) residual plot (b) Q-Q plot for normality test

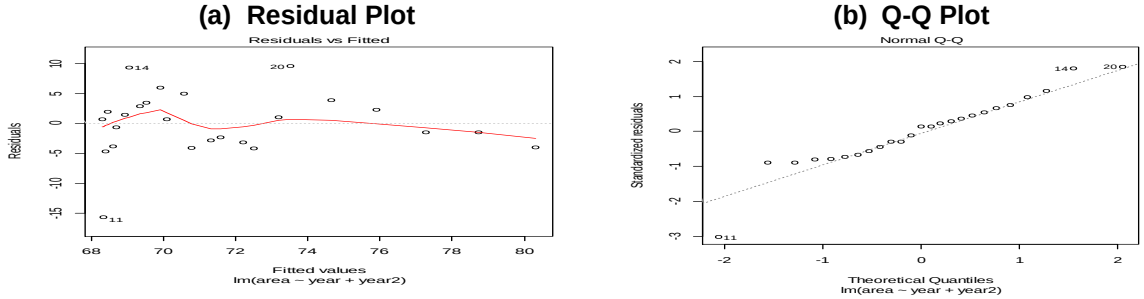


Fig. 7. Quadratic function for area of Chhattisgarh plains under wheat from the year 1990-91 to 2014-15 (a) residual plot (b) Q-Q plot for normality test

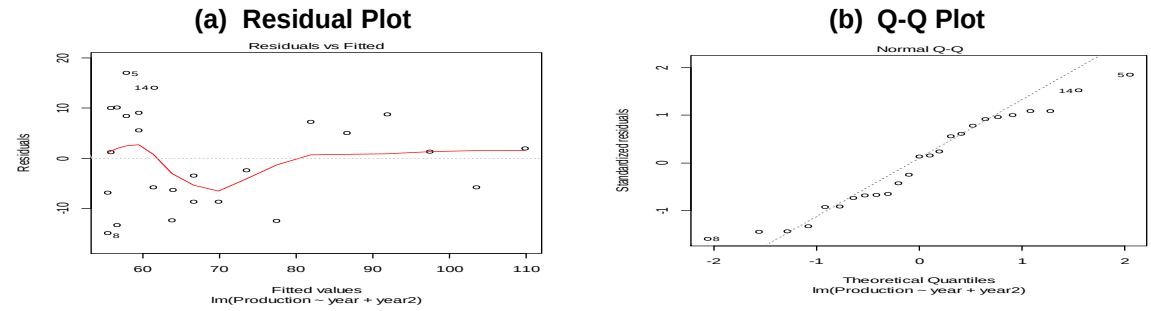


Fig. 8. Quadratic function for production of Chhattisgarh plains under wheat from the year 1990-91 to 2014-15 (a) residual plot (b) Q-Q plot for normality test

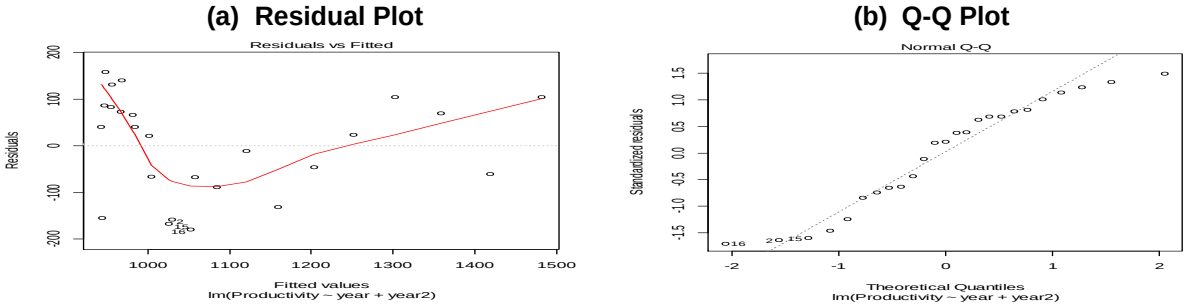


Fig. 9. Quadratic function for productivity of Chhattisgarh plains under wheat from the year 1990-91 to 2014-15 (a) residual plot (b) Q-Q plot for normality test

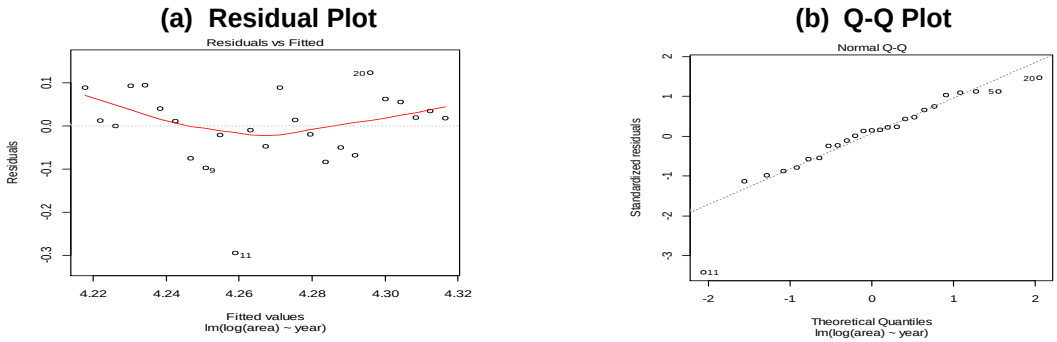


Fig. 10. Exponential function for area of Chhattisgarh plains under wheat from the year 1990-91 to 2014-15 (a) residual plot (b) Q-Q plot for normality test

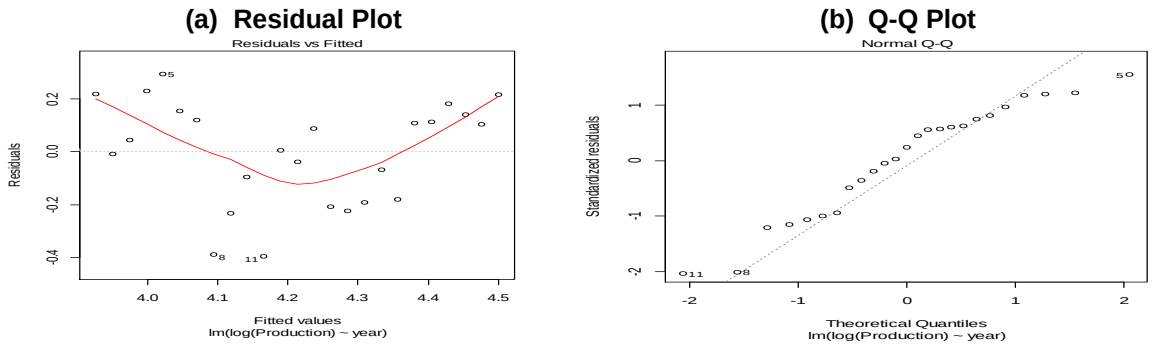


Fig. 11. Exponential function for production of Chhattisgarh plains under wheat from the year 1990-91 to 2014-15 (a) residual plot (b) Q-Q plot for normality test

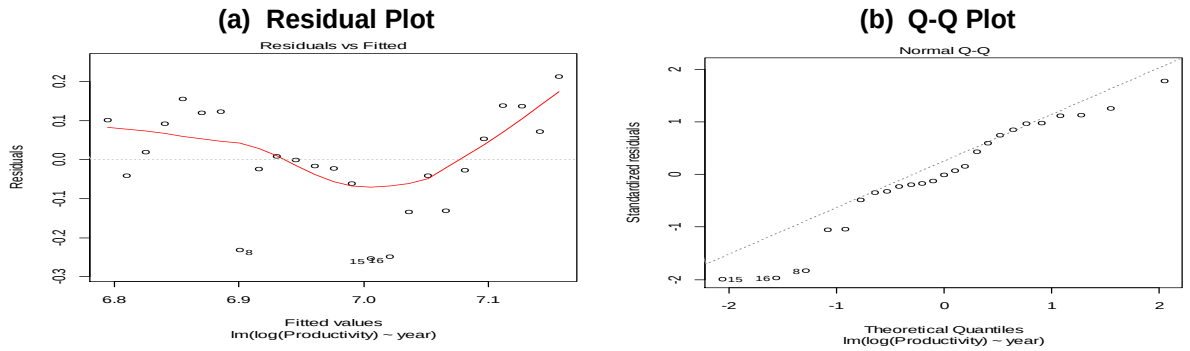


Fig. 12. Exponential function for productivity of Chhattisgarh plains under wheat from the year 1990-91 to 2014-15 (a) residual plot (b) Q-Q plot for normality test

In Chhattisgarh Plains, coefficient of variation of area under wheat crop is only 8.69%, which indicate 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 [14-17].

4. 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 Pains 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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Sharma A. Trends in area, production and productivity of food grain in the North-eastern States of India. Economic Affairs. 2013;58(1):57-68.
2. Singh RP, Rupam R. Growth of production and productivity of different pulses in Jharkhand.J. of economics and Social Development. 2009;(12):35-43.
3. Singh SP, Gangwar AC. Trends and variability in area, production and productivity of coarse grains and pulses in Harayana.Agricultural Situation in India. 1986;412:81.
4. Tegar A, Banafar KNS, Gauraha AK, Chandrakar MR. An analysis of growth in area, production and productivity of major vegetables of Bilaspur District of Chhattisgarh State, India. Plant Archives, 2016;16 (2):797-800.
5. Tewari H, Singh HP, Tripathi U. Growth and instability in wheat production: A region wise analysis of Uttar Pradesh. Int. J. Curr. Microbiol. App. Sci. 2017; 6(9):2537-2544.
6. Acharya SP, Basavaraja H, Kunnal LB, Mahajanashetti SB and Bhat ARS Growth in Sci. area, production and productivity of major crops in Karnataka. Karnataka J. Of Agril. 2012;25(4):431-436.

7. Choudhary K, Kulkarni VS, Yeledhalli RA and Patil C. Study on the trends in area, production and productivity of mustard in India.Intern at. J. agric. Sci. 2011;7(2):362-365.
8. Devraj Singh SK, Prakash A. Growth and instability analysis of chickpea production in Maharashtra: A district-wise analysis.Current Advances in Agricultural Sci. 2014;6(2):169-172.
9. Ganjeer PK, Kaushik D and Lakhera ML. A review on trend in area, production and productivity of wheat crop in different Districts of Northern Hills of Chhattisgarh State.Bull. Env. Pharmacol. Life Sci. 2017;6(1):302-304.
10. Shanker G, Shrivastava A, Saxena RR. Growth and Instability: An Inter-Zonal analysis of kharif and rabi crops in Chhattisgarh. Res. J. Engineering and Tech. 2010;1 (1):18-23.
11. Pichad SP, Wagh HJ, Kadam MM. Growth in area, productionand productivity of chickpea in Amravati district. Int. Res. J. Agric. Eco. & Stat. 2014;5(2):289-292.
12. Sahu A, Lakhera ML, Pandey KK. Predictive models for the area, production and productivity of the major pulse crops in different districts of northern hills of Chhattisgarh. Int. J. of Applied Mathematics& Statistical Sci. 2015;4(6): 45-52.
13. Raguhuwanshi RS, Awasthi PK. Growth of chickpea production in Bundelkhand region. Indian J. of Pulses Res. 2000; (13):70-71.
14. Kaur R, Malhi M, and Sandhya Kiran G. Analysis of trends in area, production and yield of impor ant crops of India. International Journal of Agronomy and Agricultural Research. 2015;7(1):86-92.
15. Kumar S, Singh S. Trends in growth rates in area, production and productivity of sugarcane in Haryana. International J. of Advanced research and social sci. 2014; 3(4):117-123.
16. Kumrawat M and Yadav M. Trends in Area, Production, and Yield of Mustard crop in Bharatpur Region of Rajasthan. International Journal of Engineering Development and Research. 2018;6(1): 2321-9939.
17. Mech A. An analysis of growth, trend, instability and determinants of rice production in Assam. Indian J. Agric. Res. 2017;51(4):355-359.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/92043