The Pharma Innovation Journal 2022; SP-11(12): 476-479

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(12): 476-479

www.thepharmajournal.com
Received: 01-09-2022
Accepted: 05-10-2022

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A growth and instability analysis by using different available models of rice crop in Chhattisgarh state

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Abstract
The study conducted "A Growth and instability analysis by using different available models of rice crop in Chhattisgarh State". The study is based on secondary data which is present study covered a period from the year 2009-10 to 2018-19. The area of rice, among all the models of Chhattisgarh state, power and cubic models have shown best fit with highest R^2 value of 0.69 and 0.80, respectively. The production of rice, among all the models of Chhattisgarh state, quadratic and cubic models have shown best fit with highest R^2 value of 0.33 and 0.39 respectively. The yield of rice, among all the models of Chhattisgarh state, quadratic and cubic models have shown best fit with highest R^2 value of 0.33 and 0.39, respectively.

Keywords: Area, production, yield, quadratic and cubic models

Introduction
India's food production is increasing in every year and the country is one of the main producers of crops like wheat, rice, pulses, sugarcane and cotton. In addition, India accounted for 22% of rice production and 13% in the wheat production. India accounts for 25% of the total production along with being the second largest cotton. Agriculture has gained a dignified status national economy through various programs and efforts. About the 64% of the workers in the agriculture sector are employed. Agriculture is counted as the chief economic occupation of the Chhattisgarh. According to a government estimate, net sown area of the state is 4.828 million hectares and the gross sown area is 5.788 million hectares. About 80% of the population of the state is rural and the main livelihood of the villagers is agriculture and agriculture-based small industry. The majority of the farmers are still practicing the traditional methods of cultivation, resulting in low growth rates and productivity. The farmers have to be made aware of modern technologies suitable to their holdings. Providing adequate knowledge to the farmers is essential for better implementation of the agricultural development plans and to improve productivity.
The main crops are rice, maize, kodo-kutki and other small millets. Chhattisgarh is also called the "rice bowl of central India". In the mid-1990s, most of Chhattisgarh was still a mono crop belt. Only one-fourth to one-fifth of the sown area was double-cropped. Chhattisgarh State is ranked as the 17th-largest tea-producing state in India. In Chhattisgarh, rice, the main crop, is grown on about 77% of the net sown area. Only about 20% of the area is under irrigation; the rest depends on rain. The irrigated area available for double cropping is only 87,000 ha in Chhattisgarh plains and 2300 ha in Bastar plateau and northern hills. Due to this, the productivity of rice and other crops is low, hence the farmers are unable to obtain economic benefits from agriculture and it has remained as subsistence agriculture till now, though agriculture is the main occupation of more than 80% of the population.

Methodology
This study is based on secondary data which is obtained from the website of Government of Chhattisgarh Agriculture Development and Farmer Welfare and Bio – Technology Department (agriportal.cg.nic.in) and Directorate of Economics and Statistics, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, India (https://eands.dacnet.nic.in/). The present study covered a period from the year 2009-10 to 2018-19.

Model developing for the study of Growth and instability by using different available models

Different regression equations such as linear, quadratic, cubic, compound, exponential etc. are fitted for each major crop with respect to area, production and yield of Chhattisgarh state. The best fit models (regression equations) which are chosen for estimating the growth pattern is based on the R^2 values obtained. The model with highest R^2 value is considered as the best model.

Table 1: Different models used for developing the best fit models

Model Name	Equation	Description
Linear	$Y_t = b_O + b_1 t_i + e$	Y and t_i`s are yield and time/year period respectively. b_0 and b_i's are constants to be estimated and e is the residual term
Quadratic	$Y_t = b_O + b_1 t_1 + b_2 t^2 + e$	Y and t_i's are yield and time period respectively. b_0 and b_i's are constants to be estimated and e is the residual term
Cubic	$Y_t = b_O + b_1 t_1 + b_2 t^2 + b_3 t^3 + e$	Y and t_i's are yield and time period respectively.b_0 and b_i's are constants to be estimated and e is the residual term
Power	$Yt = bO\ t^b 1 + e$ or $\ln(Y) = \ln(b_0) + b_1 \ln(t)$	Y and t_i's are yield and time period respectively. b_0 and b_i's are constants to be estimated and ln is Natural Log and e is the residual term
Exponential	$Y = bO * e^{(b}1t) + \varepsilon$ or $\ln(Y) = \ln(b_O) + (b_1 t) + \varepsilon$	Y and t_i's are yield and time period respectively.b_0 and b_i's are constants to be estimated, ln is Natural Log and "e" is the exponential function and e is the residual term

The various growth models of area, production and yield in rice crop

Various growth models viz. linear, quadratic, cubic, exponential and power are suggested for describing trend analysis of rice crop in Chhattisgarh state. Parameters (regression coefficient) used for examination and tests for determining goodness of fit (R^2) statistics for every model mentioned above have been shown in Table 2 to Table 4. As a part of it nearly five models were tried and the suitable models were fitted to investigate the trend for selected crop.

So, the best model criteria were selected based on R-square value.

Trend analysis of rice crops for area in Chhattisgarh state

Trend analysis and fitted models of rice crop for area in Chhattisgarh state were presented in the Table 2 and fig. 1. It is observed that different growth models are fitted well with the rice area data set. However, it is selection of best model criteria on the basis of R^2. The area of rice, among all the models of Chhattisgarh state, power and cubic models have shown best fit with highest R^2 value of 0.69 and 0.80 respectively. Also not much variation is observed among the models except linear and exponential models with respect to R^2 (Table 2). The results obtained are compared using the goodness of fit statistics such as R^2. Power and cubic model may be considered for the describing the trend of the rice area of Chhattisgarh state.

Table 2: Different statistical models with their regression coefficients for the rice area in Chhattisgarh state

Crop	Equation	Parameter Estimates				R^2
		Constant	b_1	b_2	b_3	
Rice	Linear	3866.80	21.517	-	-	0.65
	Quadratic	3849.40	30.228	-0.79	-	0.66
	Cubic	3709.60	154.21	-27.67	1.62	0.80
	Exponential	3867.90	0.0054	-	-	0.65
	Power	3848.70	0.0229	-	-	0.69

Trend analysis of rice crop for production in Chhattisgarh state

Trend analysis and fitted models of rice crop for production in Chhattisgarh state were presented in the Table 3 is observed that different growth models are fitted well with the rice production data set. However is selection of best model criteria on the basis of R^2. The production of rice, among all the models of Chhattisgarh state, quadratic and cubic models have shown best fit with highest R^2 value of 0.33 and 0.39 respectively. Also not much variation is observed among the models except linear and power model with respect to R^2 (Table 3). The results obtained are compared using the goodness of fit statistics such as R^2. Quadratic and cubic model may be considered for the describing the trend of the rice production of Chhattisgarh state.

Table 3: Different statistical models with their regression coefficients for rice production in Chhattisgarh state

Crop	Equation	Parameter Estimates				R^2
		Constant	b_1	b_2	b_3	
Rice	Linear	6025.60	112.08	-	-	0.06
	Quadratic	3983.10	1133.30	-378.20	-	0.33
	Cubic	2499.30	2449.40	-92.84	17.29	0.39
	Exponential	5863.30	0.01	-	-	0.07
	Power	5342.20	0.13	-	-	0.20

Trend analysis of rice crop for yield in Chhattisgarh state

Trend analysis and presented in the Table 4 with the rice yield data set. However, it is selection of best model criteria on the basis of R^2. The yield of rice, among all the models of Chhattisgarh state, quadratic and cubic models have shown best fit with highest R^2 value of 0.33 and 0.39 respectively. Also not much variation is observed among the models except Exponential and power model with respect to R^2 (Table 4). The results obtained are compared using the goodness of fit statistics such as R^2. Quadratic and cubic model may be considered for the describing the trend of the rice production of Chhattisgarh state.

Table 4: Different statistical models with their regression coefficients for rice yield in Chhattisgarh state

Crop	Equation	Parameter Estimates				R^2
		Constant	b_1	b_2	b_3	
Rice	Linear	1.55	0.02	-	-	0.03
	Quadratic	1.04	0.276	0.02	-	0.33
	Cubic	0.70	0.57	-0.08	0.003	0.39
	Exponential	1.51	0.13	-	-	0.04
	Power	0.10	1.38	-	-	0.15

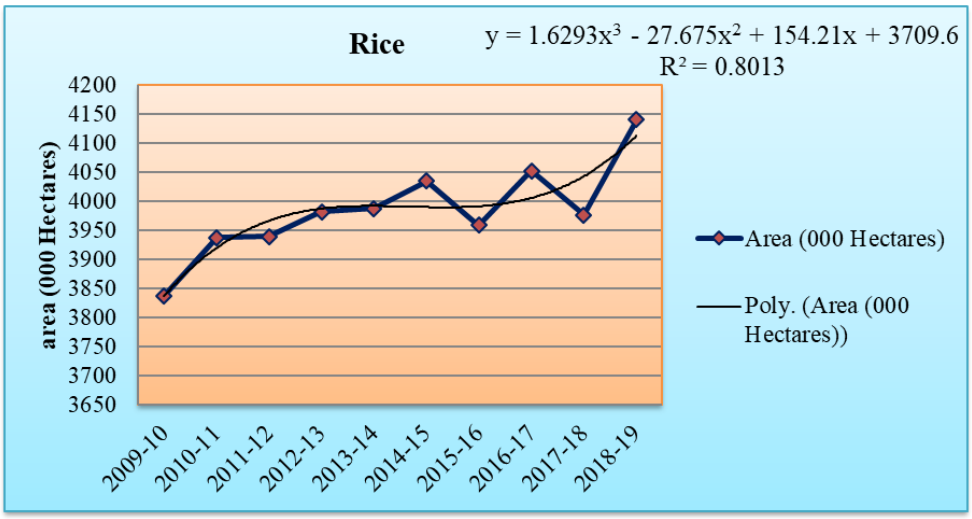

Fig 1: Best fitted modes (cubic) of rice area in Chhattisgarh state

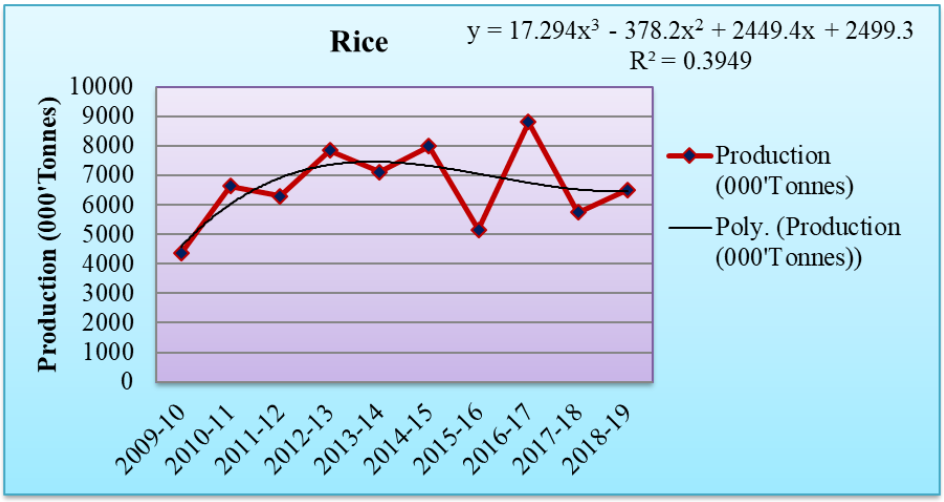

Fig 2: Best fitted modes (cubic) of rice production in Chhattisgarh state

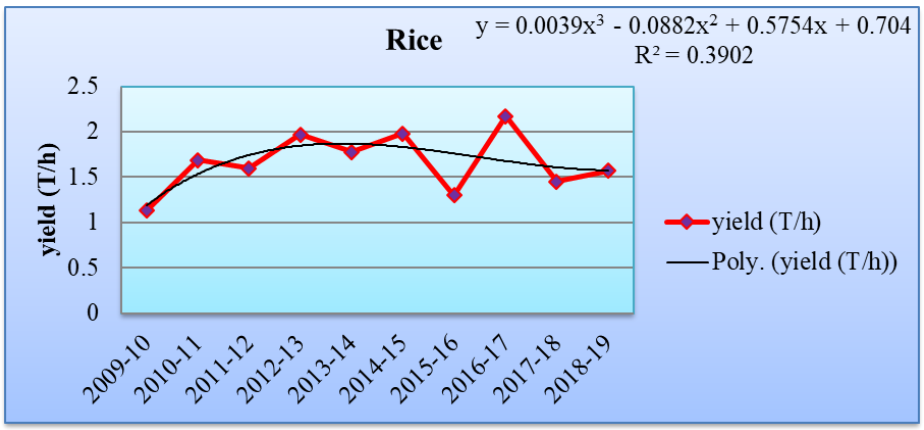

Fig 3: Best fitted modes (cubic) of rice yield in Chhattisgarh state

Conclusion

A brief summary of the findings of the study is presented below.

- Different growth models were fitted to study the trend of rice crop area, production and yield. Where cubic and quadratic model were best fit for the area production and yield.
- An effort was made to study the components responsible for increase of rice production. The result of Hazells decomposition analysis was indicated that mean area change was main factor contributing for the total change in production.

Suggestions

Based on the present study the following suggestions / implication are worth considering while forming policies for crop production in Chhattisgarh state.

- The growth rates should be calculated using different models not only the simple quadratic, cubic or simple linear regressions. This is because some other models like logarithmic, exponential, growth etc. suits very well for some data where these simple regression models do not fit.
- We have to make sure that whatever the behavior of production of cereal may be but there should be stable consumption pattern. Because the production is dependent on consumption also.
- The average cereal production is increasing due to the change in the increased area hence it is suggested that average yield for cereal should be increased.
- Inter crop variability is found in case of production and yield of cereal crops. Hence it is suggested that the region specific varieties of particular cereal crops should be developed.

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