The Andhra Agric. J 59 (3):500-505, 2012

Growth Trends of Paddy in Guntur District of Andhra Pradesh

Ch Karthik Sudha, V Srinivasa Rao, D Vishnu Sankar Rao, and G Raghunadha Reddy
Department of Statistics and Mathematics, Agricultural College, Bapatla 522 101, Andhra Pradesh

ABSTRACT

The present investigation was carried out to study the growth rates and trends of paddy area, production and productivity in Guntur district of Andhra Pradesh for the period 1970 to 2011 and to estimate the future projections upto 2020 AD by using the growth functions like linear, logarithmic, inverse, quadratic, cubic, compound, power and exponential. Statistically most suited growth model is selected based on the criteria *viz.,* significant adjusted R^2 and least Residual Mean Sum of Squares (RMSS).

Key words : Adjusted R^2, Coefficient of variation, Future projections,Growth rates, Growth trends, RMSS

Growth models are common in scientific fields which have been developed and used successfully for specific situations. The growth models are used to describe how something grows with changes in the regressor variable. Growth models are useful in drawing inferences like the exact relationship between time and growth, the rate of growth at each point of time, the turning points in the growth, etc. Aparna *et al*., (2008) analyzed growth rates of major vegetables in Visakhapatnam district with the help of compound growth by using exponential function. Borthakur and Bhattacharya (1998) analyzed trend of area, production and productivity of potato in Assam for the period of 1951 to 1993 using three different functional forms (linear, quadratic and exponential). Growth models can provide a convenient data summary and be useful for prediction. Devraj *et al.,* (2007) analysed the growth of chickpea area, production and productivity in Madhya Pradesh by using compound growth rates. Srinivasa Rao and Srinivasulu (2006) analyzed growth rates of Turmeric and estimated the future projections upto 2020 AD by using the regression equations like linear, quadratic, exponential, logarithmic and compound growth models. Martin and Yeh (1965) predicted the yield of Wheat, Oats and Barley in Manitoba for 1965. Ahuja (1987) calculated the future projections for the production of various crops like rice, maize, jowar, gram and groundnut.

Paddy (*Oryza sativa*) is one of the most important staple food crops grown in India. India is the home country for paddy and it is staple food for more than 65 per cent of its population. Andhra Pradesh is an important paddy-growing state in India. Therefore, it is often called Rice Bowl of India. With a paddy area of about 4 million ha, it produces 13 million tonnes of rice annually. The Guntur region is one of the most fertile areas in India. With the River Krishna flowing to the North of the district, growing wide varieties of rice, other food grains, and other various crops.

MATERIAL AND METHODS

In this paper an attempt has been made to assess the growth rates in area, production and productivity of paddy crop in Guntur district by using 42 years of time series data from 1970 to 2011. Besides, growth rates the projections were also estimated upto 2020 AD.

The data of the study for a period of 42 years (1970 to 2011) in Guntur district pertaining to area, production and productivity of paddy were collected from the Chief Planning Office, Guntur District.

The future projections of area, production and productivity of paddy crop in Guntur district upto 2020 AD were estimated upon the best fitted growth model used for fitting the trend equations. The linear and compound growth rates were calculated to know the trend of area, production and productivity of selected crops during the study period (1970-2011).

The trend equations were fitted by using different growth models. Among these models which was having significant adjusted R^2 and least Residual Mean Sum of Squares (RMSS) was selected as appropriate model for the projections. Growth models are nothing but the models that describe the behaviour of a variable overtime.

A) GROWTH MODELS:

The functions of the growth models taken under consideration are as follows.

1. Linear function $Y_t = a + bt$
2. Logarithmic function $Y_t = a + b \ln(t)$
3. Inverse function $Y_t = a + b/t$
4. Quadratic function $Y_t = a + bt + ct^2$
5. Cubic function $Y_t = a + bt + ct^2 + dt^3$
6. Compound function $Y_t = ab^t$
7. S-curve function $Y_t = \text{Exp}(a + b/t)$ (or) $\ln Y_t = a + b/t$
8. Growth function $Y_t = \text{Exp}(a + bt)$ (or) $\ln Y_t = a + bt$
9. Power function $Y_t = at^b$
10. Exponential function $Y_t = a \text{ Exp}(bt)$

In all the above functions,

'Y_t' is the dependent variable i.e., area or production or productivity

't' is the independent variable, time in years

'a' is the intercept

'b' , 'c' and 'd' are the regression coefficients

B) GROWTH RATES:

1. Linear Growth Rate

The linear growth rate is calculated by the formula:

$$\text{Linear growth rate (LGR \%)} = \frac{b}{\bar{y}} X\ 100$$

Where,

b is the regression coefficient of linear function

$\bar{y}$ is the average of observed area or observed production or observed productivity

2. Compound Growth Rate

The compound growth rate (CGR %) is calculated by using the formula

CGR (%) = (b-1) x 100

Where,

b is the regression coefficient of compound fuonction

The significance of the growth rates can be tested by applying student's 't' test i.e.,

t = r/SE (r) with (N-2) degrees of freedom

Where,

'r' is the growth rate

'N' is the total number of years considered under study

'SE(r)' is the standard error of growth rate

C) VARIABILITY OF AREA, PRODUCTION AND PRODUCTIVITY OF SELECTED CROPS:

The statistical tool which is used to measure the variability of area, production and productivity of selected crops of Guntur district is Coefficient of Variation (CV %).

The Coefficient of Variation (CV%) is calculated by using the formula as follows

$$\text{CV\%} = \frac{Standard\ deviation}{Mean} \quad X\ 100$$

D) MODEL SELECTION:

The choice of the trend equation amongst the available alternatives is very crucial. Many researchers uses coefficient of multiple determination (R^2) or adjusted R^2 as the criterion of model selection.

$$R^2 = \frac{\text{Regression sum of squares}}{\text{Total sum of squares}}$$

$$= \frac{\sum_{i=1}^{n}(\hat{y}_i - \bar{y})^2}{\sum_{i=1}^{n}(y_i - \bar{y})^2}$$

$$\text{Adj } R^2 (\bar{R}^2) = 1 - \left[\frac{n-p}{n-p-1}\right](1 - R^2)$$

Where,

p is the number of parameters in the equation

n is the total number of observations

RESULTS AND DISCUSSION

To understand the growth performance of paddy area, production and productivty in Guntur district during the period 1970 to 2011, time series data was analyzed by using growth models. The linear, logarithmic, inverse, quadratic, cubic, compound, power, exponential models were fitted and the parametric values are presented in Table 1.

1 Paddy area:

In Guntur district of Andhra Pradesh, the average area under paddy during the study period

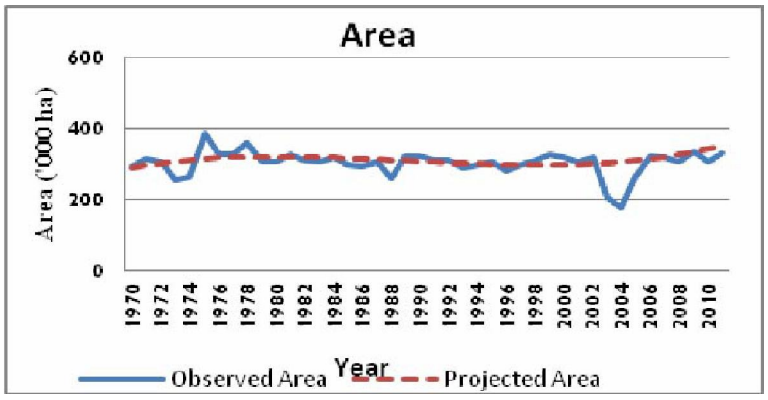
Table 1. Growth models of paddy area, poduction and productivity in Guntur district of Andhra Pradesh

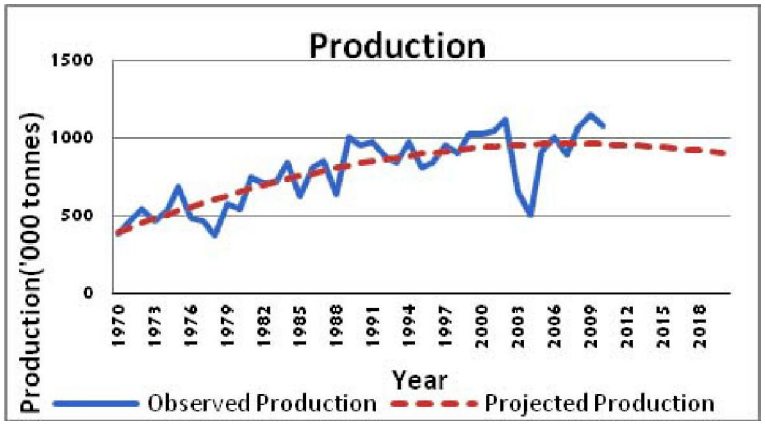
Parameters	Linear	Logarithmic	Inverse	Quadratic	Cubic	Compound	Power	S-curve	Growth	Exponential
					Area					
a	311.90**	314.04**	302.14**	315.02**	282.68**	311.50**	314.31**	5.70**	5.74**	311.50**
b	-0.453	-4.239	0.073	-0.879	7.649	0.998**	-0.017	0.01	-0.002	-0.002
c				-0.01	-0.48					
d					0.008					
R^2	0.026	0.011	0	0.027	0.122	0.028	0.013	0	0.028	0.028
adj R^2	0.001	-0.013	-0.025	-0.023	0.052	0.004	-0.012	-0.025	0.004	0.004
RMSS	1211.37	1228.908	1243.07	1240.61	1149.186	1217.246	1235.29	1248.76	1217.25	1217.246
					Production					
a	484.95**	236.81**	855.71**	358.06**	367.48**	494.06**	339.16**	6.73**	6.20**	494.06**
b	13.75**	193.91**	-729.39	31.054**	28.56	1.019**	0.281**	-1.121**	0.019**	0.981**
c				-0.402*	-0.26					
d					-0.002					
R^2	0.586**	0.596**	0.314**	0.645**	0.645**	0.568**	0.623**	0.369**	0.568**	0.568**
adj R^2	0.576**	0.586**	0.297**	0.627**	0.617**	0.557**	0.614**	0.353**	0.557**	0.557**
RMSS	20596.3	20115.33	34123.2	18118.2	18384.45	23279.75	19071.24	31989.9	23279.8	23279.75
					Productivity					
a	1552.50**	709.55**	2850.68**	1103.75**	1390.25**	1585.98**	1078.87**	7.937**	7.369**	1585.98**
b	48.645**	673.59**	-2449.31	109.83**	34.29	1.021**	0.298**	-1.132	0.021**	0.021**
c				-1.423**	2.918					
d					-0.067					
R^2	0.732**	0.717**	0.353**	0.805**	0.824**	0.681**	0.704**	0.378**	0.681**	0.681**
adj R^2	0.725**	0.71**	0.337**	0.795**	0.81**	0.673**	0.696**	0.362**	0.673**	0.673**
RMSS	133833	141176.5	322537	99669.1	92555.63	173134.2	122008.8	294749	173134	173134.2

** Significant at 1% level

* Significant at 5% level

Projections of paddy area, production and productivity in guntur district of Andhra Pradesh during 1970 to 2012





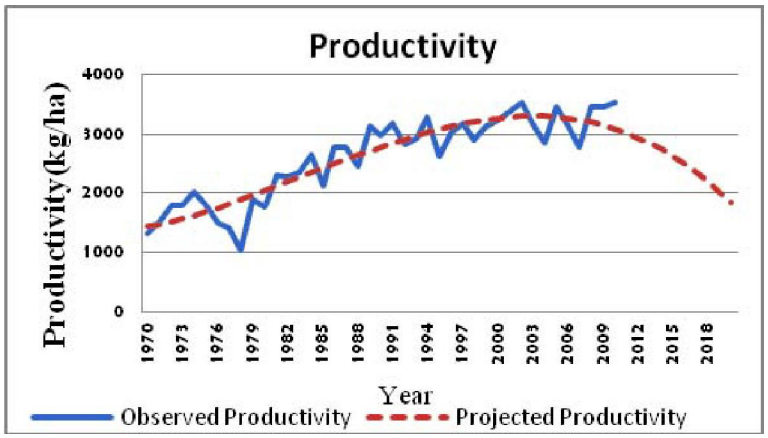


Table 2. Projections of area, production and productivity of paddy in Guntur district of Andhra Pradesh

Year	Area ('000 Ha)	Production ('000 Tonnes)	Productivity (Kg ha^{-1})
2012	-	950.088	2933.185
2013	-	946.168	2840.983
2014	-	941.444	2736.929
2015	-	935.916	2620.621
2016	-	929.584	2491.657
2017	-	922.448	2349.635
2018	-	914.508	2194.153
2019	-	905.764	2024.809
2020	-	896.216	1841.201

Note: Projection of paddy area was impossible due to non-significant adjusted R^2 values for all growth models

(1970-2011) was 302.153 thousand hectares. Area of paddy in Guntur district of Andhra Pradesh state showed a systematic growth pattern during the study period of 1970 to 2011. The results obtained by fitting all the ten growth models were presented in Table (1). The linear and compound growth rates recorded during the study period were of the order -0.15 and -0.17 per cent per annum respectively. The Coefficient of variation of paddy area was 11.52%. Adjusted R^2 values for all the models were non-significant. The area of paddy was non-significant during the study period for Guntur district of Andhra Pradesh. No model was found to be well fitted for area under paddy because of non-significant adjusted R^2 values. The area of paddy in the district was almost stationary around the 42 years average of 302 thousand hectares with less variations. Hence it was unrealistic to use any model for future projections.

2 Paddy production:

The average production of paddy during the study period (1970 to 2011) was 780.57 thousand tonnes. The results obtained for production of paddy during the study period by fitting all the models were presented in Table 1. The linear growth rate and compound growth rate recorded for the study period were of the order 1.76 and 2.11 per cent per annum respectively which were significant at 1% level of significance .The Coefficient of variation of paddy production was 28.22 per cent . Adjusted R^2 values for all the fitted models were significant. But only quadratic function which had the least RMSS with high significant adjusted R^2 (0.627). Hence, quadratic function was chosen for future projections of Paddy production.

3 Paddy productivity:

Regarding the productivity in Guntur district of Andhra Pradesh, the average yield of paddy during the study period (1970 to 2011) was 2598.4 kg ha^{-1}. The results obtained by fitting all the models were presented in Table (1). The data on productivity of paddy in Guntur district of Andhra Pradesh during the study period of 1970 to 2011 showed an increasing trend. The linear and compound growth rates during the study period were of the order 1.87 per cent and 2.11 per cent respectively which were significant at 1% level of significance. The Coefficient of Variation of paddy productivity was 26.85 per cent. Adjusted R^2 values for all the models were significant. In case of productivity, cubic functions had the least residual mean sum of square value with high significant adjusted R^2 (0.810). Hence, cubic function is used for future projections.

Projections:

The future projections of area, production and productivity of paddy by 2020 AD were calculated for Guntur district of Andhra Pradesh state and the results were presented in the Table (2).

The future projections of area of paddy in Guntur district of Andhra Pradesh by 2020 AD were not calculated because no model was found to be fitted well for the projection of area due to non-significant adjusted R^2 values for all the fitted models. So, it was unrealistic to use any model for future projections. Hence, projection would be impossible in this case.

Regarding the production of paddy, quadratic function was found to be the best model for future projections by 2020 AD as it has the least Residual Mean Square and significant adjusted R^2

(0.627). The projected production would be 896.216 thousand tonnes by 2020 AD which was higher than the 42 years average production of 780.57 thousand tonnes.

Productivity of paddy was projected by using cubic function which has less RMSS and significant adjusted R^2 (0.810). The future projection for productivity of paddy would be 1841.201 kg ha^{-1} by 2020 AD showing a diminishing future trend over the 42 years average of 2598 kg ha^{-1}.

From the above results it can be concluded that the average area, production and productivity under Paddy in Guntur district of Andhra Pradesh during the study period were 302.153 thousand hectares, 780.577 thousand tonnes and 2594.359 kg/ha respectively. No model was found to be well fitted because of non-significant adjusted R^2 values incase of paddy area. Among the area, production and productivity, the productivity exhibited higher growth rates with an increasing trend due to increased trend in growth rates of production. The variability was observed higher for paddy productivity when compared to paddy area and production. However, the graph showing a negative trend in area for the study period. The higher variability was recorded incase of paddy production when compared to area and productivity of paddy. Future projection of paddy production by using quadratic model showed a significant decreasing trend in future and incase of productivity, cubic function indicated that there would be significant trend in decreasing future.

LITERATURE CITED

Aparna B, Shareef S M, Raju V T and Srinivasa Rao V 2008 Growth trends of major vegetables in Visakhapatnam, *The Andhra Agricultural Journal*, 55(1): 68-69

Ahuja K N 1987 Indian's food demand in 2000 AD. International Seminar on Agricultural Research Systems and Management in the 21st Century. NAARM, Hyderabad, December 8-10, pp A32-41

Borthakur S and Bhattacharya B K 1998 Trend Analysis of Area, Production and Productivity of Potato in Assam, *Economic Affairs*, 43 (4)

Devraj, Karan Singh, Hemant Kumar and Reddy A A 2007 Growth performance of Chickpea: a zone-wise analysis, *Agricultural Situation in India*, 64: 297-301

Martin and Yeh H 1965 Yield predictions for 1965 wheat, oats and barley in Manitoba, Canadian *Journal of Agricultural Economics*, 13: 306-309

Srinivasa Rao V and Srinivasulu R 2006 Growth comparisons of Turmeric upto 2020 AD, *The Andhra Agricultural Journal*, 53 (1&2): 108-109

(Received on 22.05.2012 and revised on 29.10.2012)