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Forecasting and Growth Model of Cotton in Tamil Nadu State

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Computing the growth of any entity over a time period is important for understanding the past behaviour and for future planning. 'Compound growth rate' is one of the frequently used methods for calculating the growth rate models. Among the statistical study was carried out on different growth models *viz.,* Linear, Quadratic, Cubic, Exponential, Compound, Logarithmic, Inverse, Power, Growth and S-Curve models to project the area, production and productivity cotton crop in Tamil Nadu for 1970-71 to 2012-13. The study revealed that through all models exhibited significant; the cubic model is the best fitted, for its highest adjusted R^2 and exhibited decreasing future projection trends with respect to area and production of cotton. Although the productivity showed slightly increasing trends during the past and future.

Keywords: Growth models; adjusted R^2; area; production; productivity; cotton.

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1. INTRODUCTION

Cotton is an important cash crop and India cultivates the highest acreage in the world. It provides the basic raw material (cotton fibre) to the cotton textile industry. Cotton also known as 'White Gold' dominates India's cash crops, and makes up 65 per cent of the raw material requirements of the Indian textile. Cotton play a vital role in economy in many cotton producing nations. India is the major cotton producing nation with 27 million bales production which is approximately account for 24% of global cotton production (2014). India has tripled cotton production form 13 million bales to 40 million bales and has doubled its market share of global cotton production form 12% in 2002 to 25% in 2014, representing a quarter of total global cotton production. The major cotton growing states in India are Punjab, Haryana, Rajasthan, Madhya Pradesh, Gujarat, Maharashtra, Andhra Pradesh, Tamil Nadu and Karnataka.

The main objective of this study was to focus on past and future trends of cotton area production and productivity in Tamil Nadu in India by using appropriate forecasting and trend analysis model. The selecting Growth models can provide a fitting data summary can be useful for predicting future trends. Rimi et al [1], Finger,[2], Hussaini [3], Chengappa,[4] etc., used various growth models in different crops. Singh et al.[5] employed statistical growth analysis in paddy crop by various growth models. Martin and Yeh [6] and Ahuja [7] calculated the future projections for the production of various crops. Dhakre and Amod Sharma [8] had undertaken the study to compute the growth rates of area, production and yield of Ginger in north-eastern region. Aparna et al [9] analysed the trend in growth rates of major vegetables in Visakhapatnam district with the help of compound growth by using exponential function. Srinivasulu and Srinivasa Rao [10] examined growth rates of turmeric and estimated the future projections by using different regression models. Borthakur and Bhattacharya [11] studied on trend of area, production and yield of potato crop in Assam. Rajarathinam [12] study trend and growth of tobacco in Anand region Gujarat. The Growth model approach is simple to understand and apply for projection of future trends, and is competent of curve fitting a whole range of different models. It also has the advantage that several models, for a given data series, can be simply investigated by highest R^2 and adjusted R^2 values thus easing the model selection. In this trend investigation studies on cotton will provide insight to policy makers, stake holders and researchers in policy making strategies on sustainable cotton production in the future.

2. MATERIALS AND METHODS

The present study has been conducted on area, production and productivity of cotton crop in Tamil Nadu during the period 1970-71 to 2012-13. The cotton crop secondary data were collected from Cotton Corporation of India (CCI). In his study we have compared different models *viz*., linear, quadratic, cubic, exponential, compound, logarithmic, inverse, power, S-curve, and growth model for estimating the growth of cotton on area, production, and productivity to find the best fit using the statistical methods such as highest R^2 and adjusted $R^2 = \overline{R}^2$. Subsequently forecasted the cotton growth using the same statistical methods. The goodness of fit is examined by using the co-efficient of determination (R^2). According to Kvalseth [13] the different models and their (R^2) value are used in model selection as in equation (1). This is most appropriate for nonlinear statistical model.

$$R^2 = 1 - \sum (y_i - \hat{y}_i)^2 \ \sum (y_i - \bar{y})^2 \quad (1)$$

It would be used as the coefficient of determination for goodness of fit. The potential range of values of this R^2 is well defined with end points corresponding to perfect fit and complete lack of fit, such as $0 < R^2 < 1$, where $R^2 = 1$ corresponds to perfect fit and $R^2 \geq 0$ for any reasonable model specification. Growth models are that which describe the behaviour of a variable overtime.

2.1 Forecast through Regression Models

Since the variables involved are time and output all possible types of models are used. They models taken under consideration are as follows:

Models	Equations of the models
Linear	$Y_t = b_0 + b_1 t$
Quadratic	$Y_t = b_0 + b_1 t + b_2 t^2$
Cubic	$Y_t = b_0 + b_1 t + b_2 t + b_3 t^3$
Exponential	$Y_t = ae^{bt}$
Compound	$Y_t = ab^t$
Logarithmic	$Y_t = a + b\,In(t)$
Inverse	$Y_t = a + \frac{b}{t}$
Power	$Y_t = at^b$
S-Curve	$Y_t = e^{\left(a + \frac{b}{t}\right)}$
Growth	$Y_t = e^{a + (b * t)}$

The choice of the model amongst the available alternatives is judged on adjusted $R^2 = \overline{R}^2$ as the criterion of model selection.

$$Adjusted\, R^2 = \overline{R}^2 = 1 - \left[(1 - R^2) \frac{n-1}{n-p-1} \right] \quad (2)$$

Where, p is the number of parameter in the equation and n is the number of observations.

3. RESULTS AND DISCUSSION

In the above Table 1 shows that descriptive statistics of Cotton crop in Tamil Nadu. During the area under the cotton crop minimum is 0.85 (Lakh/Hec) and maximum is 3.47(Lakh/Hec), with the mean of area 2.21(Lakh/Hec) in Tamil Nadu. The production of Cotton is minimum 2.48(Lakh bales) and maximum 6.00 (Lakh bales), with mean of production 4.42(Lakh bales) in Tamil Nadu. The productivity (Yield) of Cotton is minimum 160(Kg/Hec) and maximum 1003(Kg/Hec),with the mean of 404(Kg/Hec) in Tamil Nadu.

The results from Table (2),(3) and (4) revealed that all the values of exactitude measures are highest R^2 and adjusted R^2 . Based on the analysis, it was found that all the functions were initiate significant. However, the cubic model was selected best fit because of its highest adjusted R^2 for cotton area (0.67), production (0.35) and productivity (0.92). In case of area, the parametric values are 2.99(a), -0.05(b), 0.002(c) and -0.001(d) although in case of production are 3.38(a), -0.02(b), 0.007(c) and 0.001(d). In case of productivity, the parametric values are 192.01(a), 5.37(b), -0.18(c) and 0.01(d).

Table 1. Descriptive statistics of cotton cultivated crop in Tamil Nadu (1970-71 to 2012-13)

Cotton crop	Minimum value	Maximum value	Mean
Area	0.85	3.47	2.21
Production	2.48	6.00	4.42
Productivity	160	1003	404

The best selected goodness of fit statistics reveals that there was marginally difference among the models as far as adjusted R^2 are concerned.The Cubic Function was observed to be the selected best fit for its highest adjusted R^2 with developed to area, production and productivity (Table 2, 3 and 4). Hence, the future projections of area, production and productivity of cotton crop in Tamil Nadu were calculated based on the cubic model and are presented in Table 5.

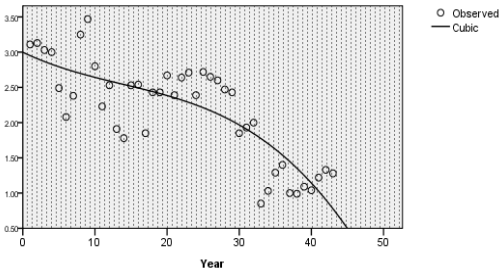

Fig. 1. Area of cotton in Tamil Nadu

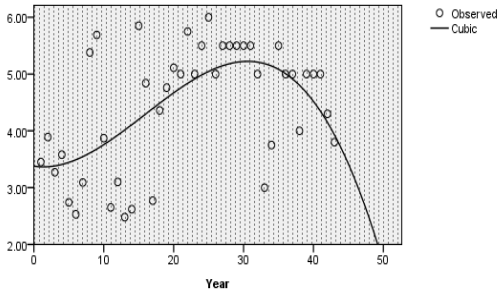

Fig. 2. Production of cotton in Tamil Nadu

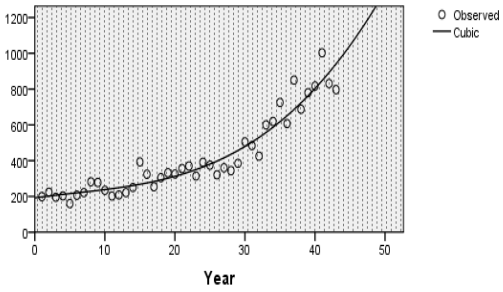

Fig. 3. Productivity of cotton in Tamil Nadu

Obviously, accurate growth models should be computed by identifying the model which describes agreeably the path followed by response variable over time. Time series growth modelling can be applied to forecast the future cotton crop area, production and productivity, as there is limited studies in cotton projection. Statistical modelling will be of immense help in formulating suitable strategies and planning for law makers in future cotton crop development.

All the iterative procedures require starting values of the parameters. The select of good initial values can spell the difference between success and failure in locating the fitted value or between rapid and slow convergence to the solution. It has been observed from Tables 2, 3 and 4 that all the ten models have been fitted well with the dataset. However, when we compared the models based on various Goodness of fit criteria it was found that cubic model performed better than the other models. The cubic model was found to be the best fit for its highest adj R^2 for sugarcane crop in Andhra Pradesh, Mohan Naidu [14].

Hence, the results revealed that the cotton area, production and productivity in Tamil Nadu maybe-0.54(lakh/ha),1.23 (lakh/bales) and 1418(Kg/ha) respectively in 2020.The projections of cotton statistics during the study period 1970-2013, found that the area and production showed an decreasing trend, while productivity shown an increasing trend, which means that area and production of cotton in Tamil Nadu will decline in the future 2014-2020, while productivity will increase in the future when compared with earlier trend (Table 5).

Table 2. The results of estimated coefficient for total area cultivated

Models	Linear	Logarithmic	Inverse	Quadratic	Cubic	Compound	Power	S-Curve	Growth	Exponential
a	3.15	3.72	1.97	2.81	2.99	3.43	4.51	0.62	1.23	3.43
b	-0.05	-0.55	1.91	0.01	-0.05	0.97	-0.28	0.92	-0.03	-0.03
c				-0.001	0.01					
d					-4.22					
R^2	0.622	0.464	0.201	0.663	0.671	0.606	0.414	0.157	0.606	0.606
Adj R^2	0.613	0.451	0.181	0.646	0.646	0.596	0.399	0.136	0.596	0.596

Table 3. The results estimated coefficient for production

Models	Linear	Logarithmic	Inverse	Quadratic	Cubic	Compound	Power	S-Curve	Growth	Exponential
a	3.59	2.77	4.64	2.69	3.38	3.44	2.84	1.51	1.24	3.44
b	0.04	0.58	-2.10	0.16	-0.02	1.01	0.15	-0.49	0.01	0.01
c				-0.01	0.01					
d					0.001					
R^2	0.189	0.221	0.104	0.307	0.350	0.207	0.219	0.091	0.207	0.207
Adj R^2	0.169	0.202	0.082	0.272	0.3	0.188	0.2	0.069	0.188	0.188

Table 4. The results of estimated coefficient or productivity

Models	Linear	Logarithmic	Inverse	Quadratic	Cubic	Compound	Power	S-Curve	Growth	Exponential
a	67.03	-97.31	471.35	240.88	192.01	162.05	101.77	6.05	5.08	162.05
b	15.94	182.23	-529.91	-7.24	5.37	1.04	0.45	-1.42	0.04	0.04
c				0.53	-0.18					
d					0.01					
R^2	0.807	0.516	0.156	0.915	0.920	0.891	0.649	0.229	0.891	0.891
Adj R^2	0.802	0.504	0.139	0.911	0.914	0.889	0.64	0.21	0.889	0.889

Table 5. Projection of cotton from 2013-20

Year	Area (Lakh/ ha)	Production (Lakh/bales)	Productivity (Kg/Hec)
2013	0.64	3.69	991
2014	0.5	3.42	1044
2015	0.34	3.12	1100
2016	0.18	2.8	1158
2017	0.02	2.45	1219
2018	-0.16	2.07	1282
2019	-0.35	1.67	1348
2020	-0.54	1.23	1418

4. CONCLUSION

The present study regression parameter for estimating of cultivated cotton crop area, production and productivity in Tamil Nadu state India. Appropriateness of a model was judged by the magnitude and sign of the parameter estimates and goodness of fit viz., adjusted R^2 for best fit model. The developed regression model for cotton was found to be best fitted in cubic regression model and cotton crop area and production of Tamil Nadu during the study period exhibited decreased trends. The results were predicted for values of cotton productivity and are found to be in slightly increasing trends during 2019 to 2020 (Table 5).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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