

Original Research Article

<https://doi.org/10.20546/ijcmas.2020.902.083>

Study of Trend in Area, Production and Productivity of Cotton Crop in Selected Districts of Karnataka

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A B S T R A C T

Cotton is an important principal commercial fibre crop. It is also known as ‘White gold’ or the “King of Fibres” due to its importance in agricultural as well as industrial economy throughout the world. Cotton is one of the most leading and important cash crops in Indian economy. In the present study an attempt was made using secondary data for forty six years (from 1970 to 2016) to understand the trends in area, production and productivity of cotton crop in selected districts of Karnataka viz., Dharwad, Ballari and Raichur. It was observed that among different polynomial models fitted for area, production and productivity of cotton crop, quadratic model was found to be the best fit for area with an adj R² and RMSE values of 0.780, and 36.354 respectively. For production, cubic model was found to be the best with adj R² and RMSE of 0.685 and 29.909 respectively. Similarly, for productivity, linear model was best fitted with an adj R² of 0.714 and an RMSE of 39.243. For Ballari district, we observe that quartic model was found to be the best fit for area under cotton with an adjR² value of 0.813 and RMSE of 12.848. On the other hand, for production quartic model was the best fit with an adjR² value of 0.869 and RMSE of 18.653. While for productivity, cubic model was the best fit with an RMSE of 50.548 and adj R² value of 0.781. It was observed that quadratic model with negative trend was found to be the best fit for area under cotton with an adjR² value of 0.856 and RMSE of 36.686. However, for production, quadratic model with an increasing trend was the best fit with an adjR² value of 0.801 and RMSE of 28.628. While, for productivity, cubic model with an increasing trend was the best fit with an adj R² value of 0.742 and RMSE of 60.037.

Keywords

Cotton, Area, Production, Productivity, Polynomial models

Article Info

Accepted:

08 January 2020

Available Online:

10 February 2020

Introduction

India is primarily an agriculture based country and its economy largely depends on agriculture. Agricultural growth is necessary

not only for attaining high overall growth but also for accelerating the poverty reduction in a developing country like India (Pavitra, *et al.*, 2018). India cultivates the highest acreage under cotton in the world. It provides the

basic raw material (cotton fiber) to the cotton textile industry (Rajan and Palanivel, 2018). It is the leading textile fiber in the world accounting for 35 per cent of the world fiber use. Cotton was first cultivated about 7,000 years ago, by the inhabitants of the Indus Valley Civilization. This civilization covered a huge swath of the north-western part of the Indian sub-continent, comprising today's parts of eastern Pakistan and north-western India (Mayilsami and Selvaraj, 2016). Cotton has been traditionally known as the backbone of nonfood crops of agricultural economy of India (Sharma, 2015). About 25 per cent of our country's Gross Domestic Product (GDP) comes from agricultural sector. Nearly 75 per cent of the country's population lives in villages and depends on agriculture (Parmar, *et al.*, 2016).

Cotton is an important principal commercial fiber crop. It is also known as 'White gold' or the "King of Fibers" due to its importance in agricultural as well as industrial economy throughout the world. Cotton is one of the leading and important cash crops in Indian economy (Mohammad, *et al.*, 2018). Cotton provides gainful employment to several million people in cultivation, trade, processing, manufacturing and marketing, *etc.* It serves vast handloom sector of the country. Apart from its use in textiles, cotton is also used as surgical lint and for various domestic purposes. Other plant parts of cotton are utilized in the manufacture of industrial products like paper, card board, blotting paper, *etc.* Cotton seeds have recently assumed greater importance as a source of edible oil. Thus, cotton plays a vital role in the Indian economy by contributing to human utilization in a number of ways. Cotton cultivation provides livelihood to millions of farmers. Their economic welfare heavily relies on cotton productivity. Cotton yarn, fabric, garment, *etc.* are dependent on the availability of cotton. Export of raw cotton and cotton

products can earn foreign exchange for India. But India is not able to come up with satisfactory performance in cotton productivity in spite of having varieties of cotton and availability of technology. Its productivity is far below the major cotton producing countries. Demand for cotton textile is rising progressively all over the world. Being the first largest cotton producing area, India has an immense opportunity in the growth of the cotton textile industry and strengthening of Indian economy in the coming years (Mal and Pandey, 2013).

India is the only country in the world growing all the four cultivated species of cotton, *viz.*, *G.hirustum*, *G.arboretum*, *G.herbaceaumand* *G. barbadense*. The maximum area has been covered by the hybrids (Samuel *et al.*, 2013). Major Cotton producing countries are India, China, USA, Pakistan, Brazil, Australia, Uzbekistan, Turkey, Turkmenistan and Burkina (Rajan and Palanivel, 2017). In the recent period, cotton is gaining momentum in non-traditional areas such as Odisha, West Bengal and Tripura. India accounts for approximately 25 per cent of world's total cotton area and 18 per cent of global cotton production (Kulkarni *et al.*, 2017). India ranks first with respect to area and production and eighth rank with respect to productivity of cotton. Cotton in India occupies an area of 118.81 lakh hectares with a production of 345.82 lakh bales and productivity of 495 Kg/ha. Cotton is cultivated in a majority of the states in the country. The ten major cotton producing states of India are Gujarat, Maharashtra, Telangana, Karnataka, Andhra Pradesh, Haryana, Madhya Pradesh, Rajasthan, Punjab and Tamil Nadu and accounts for more than 95 per cent of the area under cotton. In Karnataka area under cotton is around 7.5 lakh hectares which is 7 per cent of country's area. The production of the crop is 28 lakh bales (around 4 per cent of country's production) while the productivity

is 653 kg/ha. The main cotton growing districts in Karnataka are Dharwad, Ballari and Raichur. India is unique among the major cotton growing countries because of the broad range of agro-climatic and soil conditions which permit cultivation of all varieties and staple lengths of cotton.

Materials and Methods

In the present study, major cotton growing districts of Karnataka namely, Dharwad, Ballari and Raichur were selected. In order to study the trend of cotton in selected districts of Karnataka, secondary data pertaining to the area, production and productivity of cotton crop for the period of 46 years (from 1970-71 to 2015-16) was obtained from the Directorate of Economics and Statistics, Bengaluru.

Statistical tools and models employed

The obtained data was compiled and analyzed for area, production and productivity of cotton in selected districts of Karnataka. To understand the trend in area, production and productivity of cotton, an appropriate polynomial models were fitted by using the method of ordinary least squares. Linear, Quadratic, Cubic and Quartic models have been used in the present study (Singh and Supriya, 2017).

Linear function

The linear equation is given by,

$$Y_t = a + bt + e_t$$

Where, Y_t is the dependent variable i.e., area, production and productivity, t is the independent variable, time in years, e_t is error term and a and b are the constants.

Quadratic function

The quadratic equation is given by,

$$Y_t = a + bt + ct^2 + e_t$$

Where, Y_t is the dependent variable i.e., area, production and productivity, t is the independent variable, time in years, e_t is error term and a, b and c are constants.

Cubic function

The cubic model is given by the equation,

$$Y_t = a + bt + ct^2 + dt^3 + e_t$$

Where, Y_t is the dependent variable i.e., area, production and productivity, t is the independent variable, time in years, e_t is error term a, b, c and d are parameters.

Quartic function

The quartic model is given by the equation,

$$Y_t = a + bt + ct^2 + dt^3 + et^4 + e_t$$

Where, Y_t is the dependent variable i.e., area, production and productivity, t is the independent variable, time in years, e_t is error term and a, b, c, d and e are parameters.

Model adequacy checking

Adequacy of a model indicates the suitability of the model to explain the inherent nature of the collected information. The assumptions made in a linear regression model are, linear dependence of "Y" on regressors, independence and identical distribution (normal) of errors with zero mean. Gross violations of the assumptions may yield an unstable model in the sense that a different

sample could lead to a totally different model with opposite conclusion. We cannot detect departures from the underlying assumptions by examination of the summary statistics such as “t” or “F” statistics or R^2 . These are “Global” model properties and as such they do not ensure model adequacy. Hence, diagnostic methods, primarily based on study of the model residuals. The diagnostics checks of randomness and normality of residuals ascertains the independence and distribution assumption of data.

The coefficient of determination (R^2) is a test statistic that will give information about the appropriateness of a model. R^2 value is the proportion of variability in a data set that is accounted for by the statistical model. It provides a measure of how well the assumed model explains the variability in dependent variable.

$$R^2 = \frac{RSS}{TSS} = 1 - \frac{ESS}{TSS}$$

Where, ESS is error sum of squares, RSS is regression sum of squares, TSS is total sum of squares. Computed R^2 value lies between zero and one. If R^2 value is closer to 1 indicates that the model fits the data. Adjusted R^2 and Root Mean Square Error (RMSE) are also used for the checking of the fit of model.

Adjusted R^2

The adjusted R-squared is a modified version of R-squared that has been adjusted for the number of predictors in the model. The adjusted R-squared increases only if the new term improves the model more than would be expected by chance. It decreases when a predictor improves the model by less than expected by chance. The adjusted R-squared can be negative, but it's usually not. It is always lower than the R-squared.

$$Adjusted R^2 = \frac{RSS/df}{TSS/df}$$

Where, RSS is regression sum of squares, TSS is total sum of squares and df is the respective degrees of freedom.

Testing for significance of regression coefficient

Significance of regression coefficient is tested using F-test statistic.

Root Mean Square Error (RMSE)

The Root Mean Square Error (RMSE) (also called the root mean square deviation, RMSD) is used to assess the amount of variation that the model is unable to capture in the data. The RMSE is obtained as the square root of the mean squared error hence considered as the model prediction capability and is obtained as,

$$RMSE = \sqrt{\frac{\sum_{i=1}^n (Y_t - \hat{Y}_t)^2}{n}}$$

Where, Y_t = observed value, \hat{Y}_t = predicted value and n= number of observation.

Results and Discussion

Different polynomial models were fitted for the time series data on area, production and productivity of cotton crop in selected districts of Karnataka.

A model was selected as a best fit for the data when the coefficient of the higher order polynomial was non-significant. In the present study, four growth models *viz.*, linear, quadratic, cubic and quartic have been fitted to the time series data on area, production and productivity of the cotton crop in selected districts of Karnataka.

Table.1 Parameter estimates of fitted models for Area, Production and Productivity of Cotton in Dharwad, Ballari and Raichur districts

Districts		Model	Parameter estimates					R ²	Adj R ²	RMSE	P Values
			a	B	c	d	e				
Dharwad	Area	Quadratic	267.485**	-3.853**	-0.031*			0.790	0.780	36.354	<0.001
	Production	Cubic	-18.312**	15.716**	-0.707**	0.010**		0.706	0.685	29.909	<0.001
	Productivity	Linear	57.833**	4.745**				0.720	0.714	39.243	<0.001
Ballari	Area	Quartic	151.996**	-16.969**	1.517**	-0.054**	0.000**	0.830	0.813	12.848	<0.001
	Production	Quartic	51.664**	-9.455**	1.039**	-0.036**	0.000**	0.881	0.869	18.653	<0.001
	Productivity	Cubic	51.503**	19.257**	-0.908**	0.015**		0.795	0.781	50.548	<0.001
Raichur	Area	Quadratic	354.672**	-17.453**	0.236**			0.863	0.856	36.686	<0.001
	Production	Quadratic	63.145**	-1.933*	0.129**			0.809	0.801	28.628	<0.001
	Productivity	Cubic	136.615**	-2.829**	0.284*	-0.001**		0.759	0.742	60.037	<0.001

** Significant at 1% level, * Significant at 5% level, NS-Non-significant

Fig.1a Best fitted Quadratic model for Area under Cotton in Dharwad district

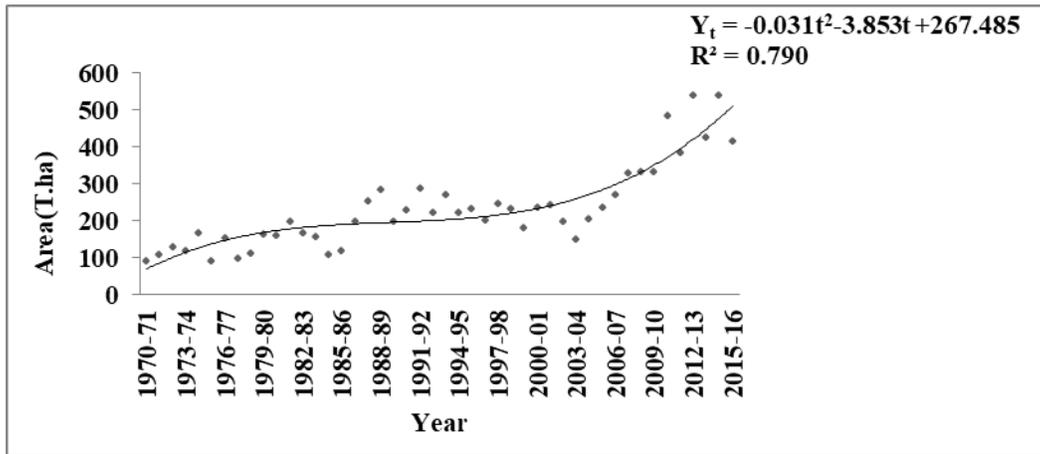


Fig.1b Best fitted Cubic model for Production of Cotton in Dharwad district

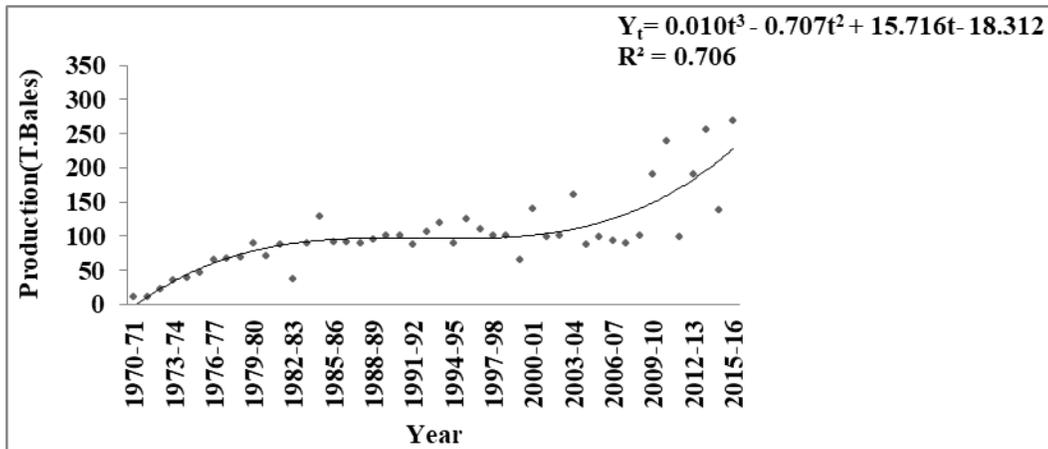


Fig.1c Best fitted Linear model for Productivity of Cotton in Dharwad district

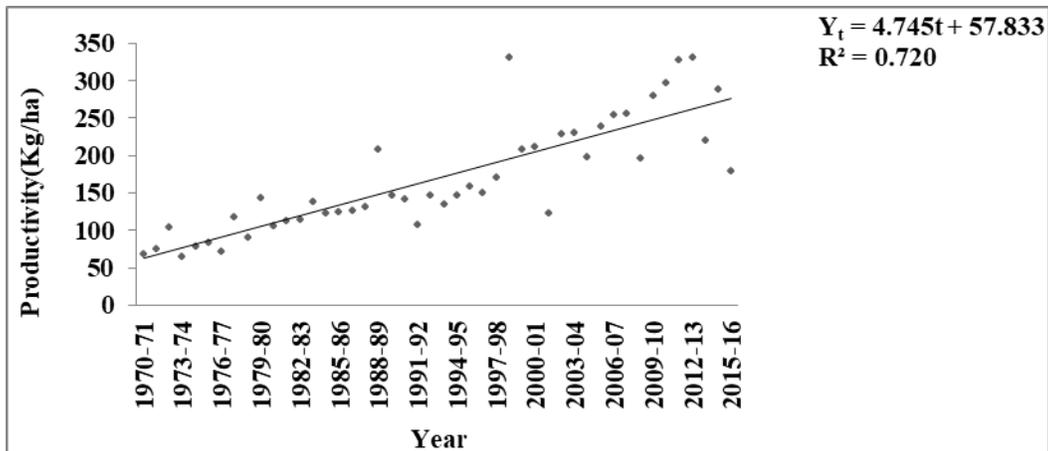


Fig.2a Best fitted Quartic model for Area under Cotton in Ballari district

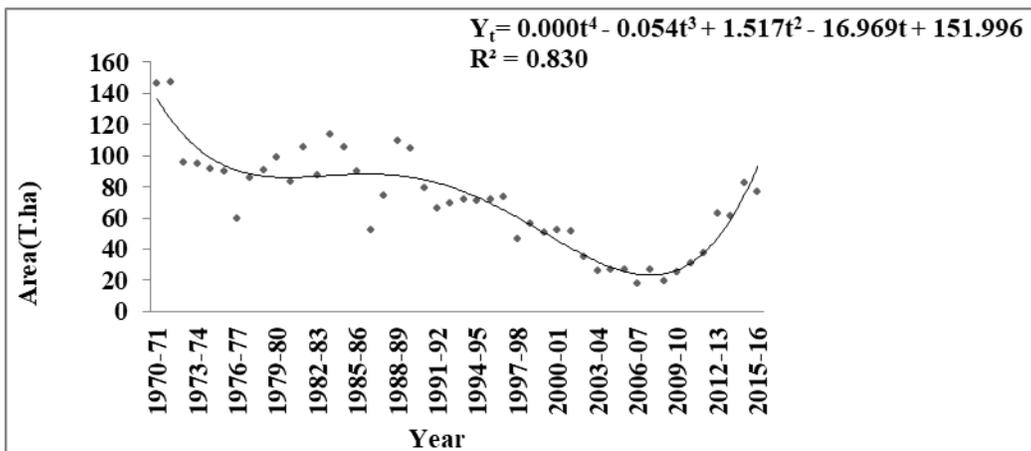


Fig.2b Best fitted Quartic model for Production of Cotton in Ballari district

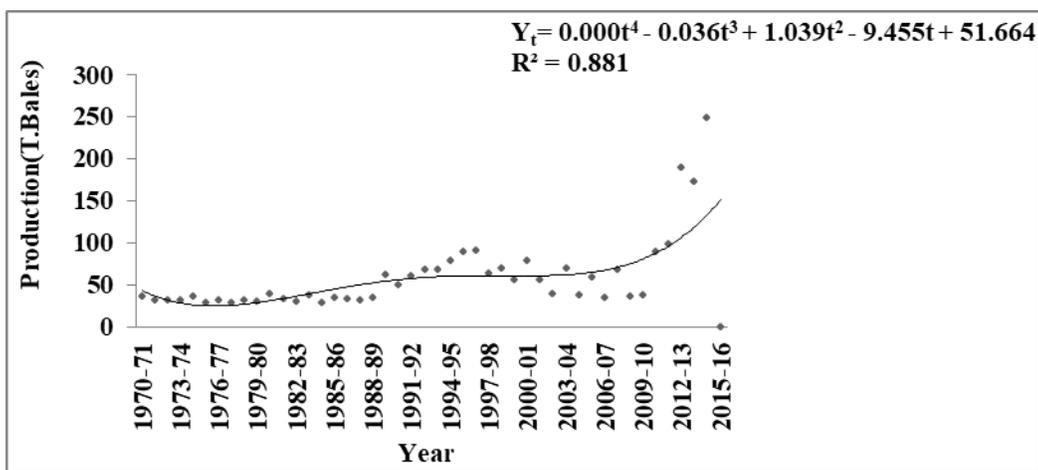


Fig.2c Best fitted Cubic model for Productivity of Cotton in Ballari district

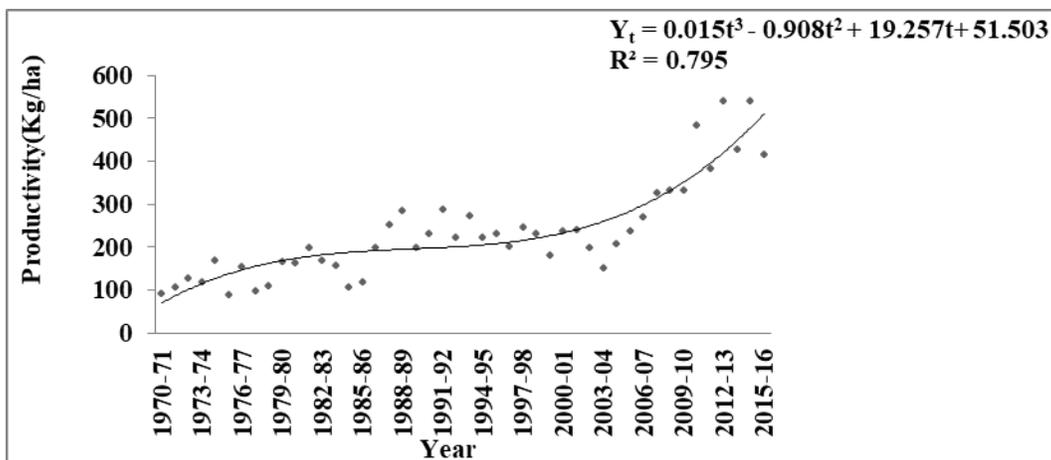


Fig.3a Best fitted Quadratic model for Area under Cotton in Raichur district

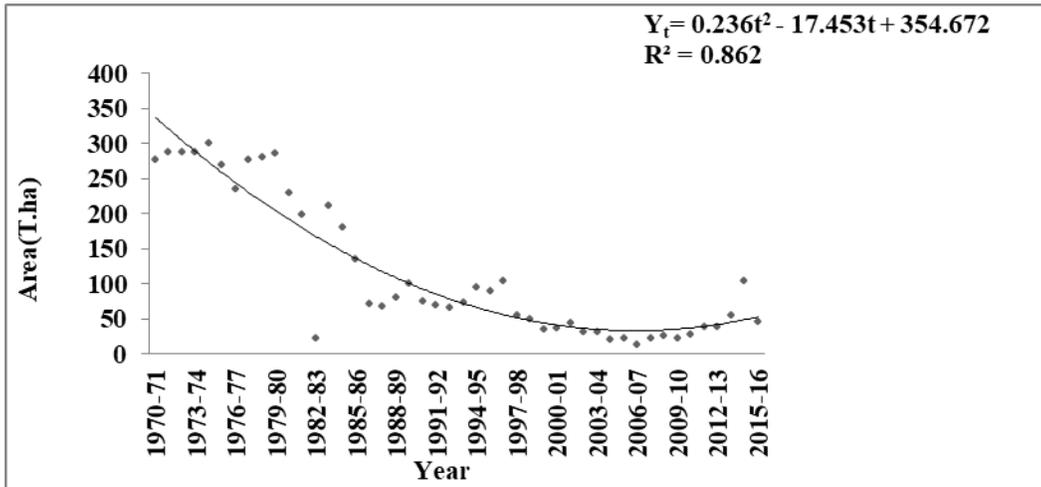


Fig.3b Best fitted Quadratic model for Production of Cotton in Raichur district

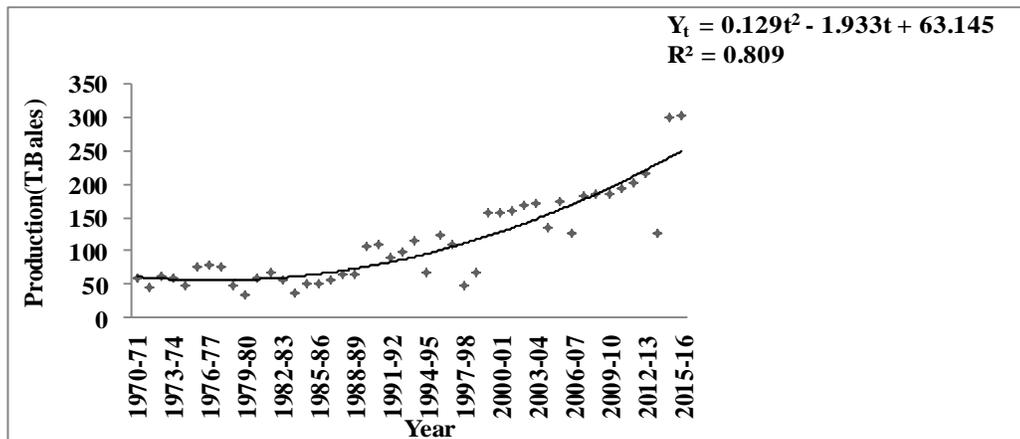
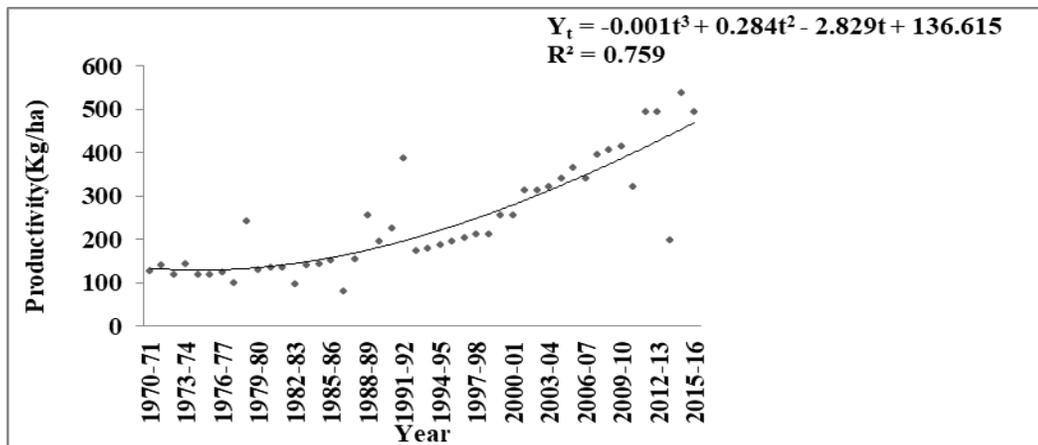


Fig.3c Best fitted Cubic model for Productivity of Cotton in Raichur district



Polynomial models for area, production and productivity of cotton crop in Dharwad district

Table 1 depicts the estimates of regression coefficients, adj R^2 values, RMSE and p-value of the model for area, production and productivity of cotton crop in Dharwad district. It was observed that among different polynomial models fitted for area, production and productivity of cotton crop, quadratic model was found to be the best fit for area (Fig.1a) with an adj R^2 and RMSE values of 0.780, and 36.354 respectively. For production (Fig.1b), cubic model was found to be the best with adj R^2 and RMSE of 0.685 and 29.909 respectively. Similarly, for productivity, linear model (Fig.1c) was best fitted with an adj R^2 of 0.714 and an RMSE of 39.243. Thus, for the overall study period from 1970-71 to 2015-16, it was observed that quadratic regression model with an increasing trend was identified as the best model for area. While for production and productivity, cubic and linear models were found to be the best fitted models respectively for Dharwad district. Further, area, production and productivity showed increasing trends.

Polynomial models for area, production and productivity of cotton crop in Ballari district

Based on the results of p-value, adj R^2 value and RMSE value presented in the Table 1, best polynomial model was selected. For Ballari district, we observe that quartic model was found to be the best fit for area (Fig.2a), under cotton with an RMSE of 12.848 and adj R^2 value of 0.813. On the other hand, for production (Fig.2b), quartic model was the best fit with an RMSE of 18.653 and adj R^2 value of 0.869 while for productivity (Fig.2c), cubic model was the best fit with an RMSE of 50.548 and adj R^2 value of 0.781. Thus, for the overall study period from 1970-71 to 2015-16, for Ballari district it was

observed that quartic regression model was the best fit with an increasing trend for area and production of cotton. While, for productivity of cotton, cubic model was found to be the best fitted model for Ballari district. Further, area, production and productivity showed increasing trends.

Polynomial models for area, production and productivity of cotton crop in Raichur district

Based on the results of p-value, adj R^2 value and RMSE value presented in the Table 4.8 best polynomial model was selected. It was observed that quadratic model with negative trend was found to be the best fit for area (Fig.3a), under cotton with an RMSE of 36.686 and adj R^2 value of 0.856. However, for production (Fig.3b), quadratic model with an increasing trend was the best fit with an RMSE of 28.628 and adj R^2 value of 0.801. While, for productivity (Fig.3c), cubic model with an increasing trend was the best fit with an RMSE of 60.037 and adj R^2 value of 0.742. Hence, the analysis for the overall study period from 1970-71 to 2015-16, for Raichur district, it was observed that quadratic regression model was the best fit for area with a decreasing trend and production with an increasing trend. Whereas, for productivity of cotton, cubic model with an increasing trend was found to be the best fitted model for Raichur district.

In conclusion, a prudent attempt has been made in the present study to understand the trend in area, production and productivity of cotton crop in selected districts of Karnataka, viz., Dharwad, Ballari and Raichur. The data was obtained from Directorate of Economics and Statistics, Karnataka for the period from 1970-71 to 2015-16. The trend equations were fitted to the area, production and productivity of cotton crop and best fitted model was chosen for the purpose of future prediction. It is clear from the analysis that there is an

increasing trend in area, production and productivity of cotton crop for Dharwad, Ballari and Raichur districts over the years except for Raichur district area under cotton decreasing from 1970 to 2016. Based on $\text{adj}R^2$ and RMSE values it is evident that the linear model was sought to be best fit for area under cotton for productivity, quadratic model is found to be the best fit while for production, cubic model is said to be the best fit for Dharwad district. For Ballari district, area and production was best fitted with quartic model, while for productivity, cubic model was seemed to be the best fit. In case of Raichur district, for area and production, quadratic model was the best fit, while for productivity cubic model was observed to be best fit.

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How to cite this article:

Ramesh, K. N. Krishamurthy, Maruthi, G. S. Naveenkumar and Avinash, G. 2020. Study of Trend in Area, Production and Productivity of Cotton Crop in Selected Districts of Karnataka. *Int.J.Curr.Microbiol.App.Sci.* 9(02): 679-688. doi: <https://doi.org/10.20546/ijcmas.2020.902.083>