AN ANALYSIS OF GROWTH TRENDS IN COTTON PRODUCTIVITY FOR RAJKOT DISTRICT OF GUJARAT

N. J. Rankja[1], B.N. Kalsariya[2] and A.M. Butani[3]

1 Assistant Professor, Department of Agril. Statistics, College of Agriculture, JAU, Junagadh - 362001
2 Assistant Professor, Department of Agril. Extension, College of Agriculture, JAU, Junagadh - 362001
3 Assistant Professor, Department of Horticulture, College of Agriculture, JAU, Junagadh - 362001
Email : njrankja@jau.in, bnkalsariya@jau.in

ABSTRACT

Cotton is one of the oldest and the most important commercial crop of the world and forms the most important fibre crop. The research was carried out on the polynomial (linear, quadratic and cubic) models were fitted on original data as well as three, four and five year moving averages data. The Autoregressive Integrated Moving Average (ARIMA) models were fitted to original time series data after checking the stationary condition, to arrive at a methodology that can precisely explain the fluctuation in productivity for cotton crop in Rajkotd district of Gujarat to compare different models for the period 1960-61 to 2014-15 (55 years). The data from year 1960-61 to 2006-07 were used for model fitting and remaining year for testing the forecast. In polynomial models, the most suitable model was selected on the basis of adjusted R^2, significant regression coefficient, root mean square error, mean absolute error, normality and randomness of residual's (Run test) distribution. The different ARIMA models (p, d, q) were judged on the basis of autocorrelation function (ACF) and partial autocorrelation function (PACF) at various lags. The cubic model on original data approach was selected on the basis of all the criteria with R^2 value 60.00%. Due to moving averages R^2 value were improved to tune of 22.30 per cent over original data.

Keywords: *shapiro and wilk test, run test, polynomial model, ARIMA, autocorrelation function.*

INTRODUCTION

Cotton is mainly a rainfed crop in Gujarat (Neware et al., 2015). About 54 per cent of the state's production comes from Surendranagar, Rajkot, Vadodara, Ahmadabad and Sabarkantha districts. Other important producers include Mehsana, Bhavnagar, Bharuch, Kheda, Surat, Amreli and Panchmahals districts. About 74 per cent of the total area and production of cotton in the country are contributed by four states of Gujarat, Andhra Pradesh, Maharashtra and Punjab. Gujarat state accounts 17.10 lakh hectare area in 1960 and increases up to 30.6 lakh hectare area during year 2014-2015. Production of cotton crop increases 36.78 lakh bales to 125 lakh bale from year 1960 to 2014-2015. Productivity of cotton crop increases from 86 kg/hectare to 707 kg/hectare from year 1960 to 2014 -2015. (Anon., 2015 b). The model developed by Box and Jenkins during the seventies, popularly known as Autoregressive Integrated Moving Average (ARIMA) model, is often found to be superior among all above mentioned models in case of the univariate time series variables which are found correlated with their lag variables.

The advantage of ARIMA modelling over the other univariate time series model is that besides displaying the intrinsic behaviour (generating process) in the time series variables itself, it produces the smallest mean squared forecast error variances. But as a mark of caution, it is noted that ARIMA models are useful only for forecasting the near future values destined to appear, usually, within the five years beyond the last datum observed on the time scale. It is robust to handle any data pattern. As one would expect this is quite a difficult model to develop and apply as it involves transformation of the variable, identification of the model, estimation through nonlinear method, verification of the model and derivation of the forecasts (Gupta, 1993). The strength of ARIMA models lies in their ability to reveal complex structures of temporal interdependence in time series. It has also been shown that ARIMA models are highly efficient in short term forecasting (Fatimah and Gaffar, 1986).

OBJECTIVES

To know the growth trends in cotton productivity for rajkot district of gujarat

METHODOLOGY

The time series data of productivity of cotton crop for Rajkot district for the period 1960-61 to 2014-15 were collected from Directorate of Agriculture, Gujarat state, Gandhinagar and WHO Cell, Department of Agricultural Economics, College of Agriculture, J.A.U (Anonymous, 2015.a). The data from 1960-61 to 2006-07 were used for model fitting. Data from 2007-2008 to 2014-15 were used for testing of forecast.

Fitting of Polynomial models:

(1) Linear Regression Approach (Rangaswamy, 2006)

(2) Quadratic Regression Approach (Montgomery *et al.*, 2003)

(3) Goodness of fit of the models (Montgomery *et al.*, 2003 and Vinaya *et al.*, 2015)

(4) Test for the randomness of the residuals: (Sidney and Castellan, 1988)

(6) Test for normality of the residual :(Shapiro – Wilk, 1965 and Vinaya *et al.*, 2017)

The values of coefficients "a(k)" for different values of n and k are given (Shapiro - Wilk, 1965). When the calculated value of W is non-significant *i.e.* very close to unity, the null hypothesis regarding normality of residual was accepted.

Autoregressive (AR) and Moving Average (MA) models : (Pankratz, 1983)

(1) Autoregressive (AR) process :

$$Z_t = C + \varphi_1 Y_{t-1} + a_t \qquad \text{……...………..(12)}$$

Where Z_t= time sequenced random variable

C = constant term related to mean (μ) such that C = μ(1-φ_1)

Φ_1 = relationship of Y_t with Y_{t-1}

a_t = a random shock element at time t

(2) Moving average (MA) process :

$$Z_t = c - è_1 a_{t-1} + a_t \qquad \text{………...………… (13)}$$

Where C = constant term related to mean μ and

θ = relation of a_t with $a_{t-1,}$ $_{than}$ fitted the Box-Jenkins ARIMA

RESULTS AND DISCUSSION

Fitting of trend on cotton productivity in Rajkot district:

(1) Fitting of polynomial models:

The results of fitting polynomial models are presented in Table.1.

Table 1 : Fitted polynomial models for cotton productivity in Rajkot district

Sr. No.	Moving Average	Regression constant	Regression coefficients			Adj. R^2	RMSE	MAE	S-W Test	Run test (|Z|)
		a	b	c	d					
Linear	Original	119.516**	10.767**	-	-	44.7**	158.439	111.912	0.932**	0.882
	3 year	144.547**	9,813**	-	-	52.5**	118.584	76.926	0.845**	3.618**
	4 year	159.679**	9.140**	-	-	58.6**	95.625	61.201	0.823**	4.119**
	5 year	174.227**	8.471*	-	-	68.4**	70..149	48.323	0.821**	4.012**
Quadratic	Original	236.668**	-3.578	0.299*	-	48.9**	150.623	111.638	0.967	1.117
	3 year	233.182**	-.502	0.246*	-	56.1**	112.637	78.408	0.909**	3.919**
	4 year	225.241**	0.588	0.190*	-	61.1**	91.619	62.926	0.895**	3.203**
	5 year	215.441**	2.976	0.125	-	69.6**	68.011	49.662	0.893**	3.783**
Cubic	Original	17.315	48.537**	-2.387**	0.037**	60.0**	131.772	101.075	0.964	1.767
	3 year	32.337	46.946**	-2.358**	0.038**	69.9**	92.149	65.351	0.912**	3.014**
	4 year	57.915	42.915**	-2.135**	0.34**	74.6**	73.081	51.703	0.924**	3,508**
	5 year	79.528	38.043**	-1.845**	0.030**	82.3**	51.282	38.345	0.955	3.394**

* Significant at 5% level, ** Significant at 1% level

Table 2 : fitted ARIMA model for cotton productivity in Rajkot district

ARIMA	AIC	SBC	AR(ϕ)	MA(θ)	CONS	RMSE	SW-TEST	BLQ- TEST
(0,1,1)	292.264	201.926	-	0.255	16.551	151.935	0.951	19.919
(1,1,1)	293.060	204.386	-0.692	-0.511	16.130	153.263	0.948*	18.328
(1,1,0)	293.271	202.933	-0.207	-	16.291	152.3131	0.948*	19.634

* Significant at 5% level, ** Significant at 1% level

Table 3 : Testing of forecast values for remaining eight years by using selected models *i.e.* cubic model in original data approach of cotton productivity in Rajkot district

Years	Observed Values	Cubic	
		Predicted values	Error Per cent
2007-08	695	694.296	0.101
2008-09	772	720.577	6.661
2009-10	870	748.185	14.001
2010-11	640	777.163	-21.340
2011-12	716	807.556	-12.798
2012-13	749	839.406	-11.980
2013-14	786	872.757	-11.038
2014-15	834	907.652	-8.831

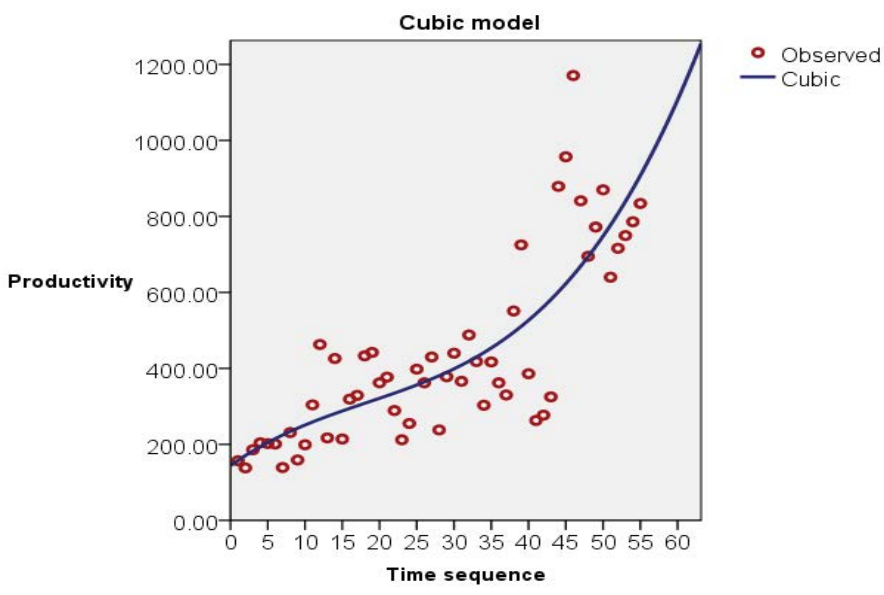

Figure 1 : Trend in cotton productivity based on cubic model in original data approach in Rajkot district

The results indicated that, all of the coefficients of determination (Adj. R^2) were significant in all the models. The regression constants were significant in all the models in all approaches (except in different cubic models). The linear regression coefficients were significant in linear and third degree polynomial models for all data approaches. All the linear regression coefficients of different quadratic model were non-significant with negative value. All of quadratic and cubic regression coefficients were significant in second and third degree polynomial model respectively (except quadratic coefficient in second degree polynomial model on five data approaches) and had negative value of quadratic coefficients in cubic model. In original data approach the value of Adj.R^2 was increased by 4.20 per cent in quadratic regression as compared to linear regression while in case of cubic regression, it was increased by 20.70 per cent over the quadratic model. By taking five years moving averages, R^2 were increased by 23.7, 12.20 and 22.30 per cent in case of first, second and third degree polynomial models ,respectively over original data. Thus, lots of improvement in coefficient of determination was observed due to moving average approach. The third degree polynomial model on original data approach had comparatively lower value of RMSE and MAE with all significant coefficients, whereas coefficient of determination value was 60.00 percent. Normality of residual satisfied only by original data approach in second and third degree polynomial model.

CONCLUSION

The cubic model on original data approach was selected on the basis of all the criteria with R^2 value 60.00%. Due to moving averages R^2 value were improved to tune of 22.30 per cent over original data. The selected cubic model on original data had significant all regression coefficients with positive linear and cubic trends and negative quadratic trends, also satisfied assumption of residuals. For predicting the trend of cotton productivity in Rajkot district, none of ARIMA model was satisfied all statistical requirements. The lowest prediction error observed through cubic model was 0.101% and highest was -21.340% during year 2007-08 and 2010-11 respectively.

The fitted model of Rajkot district for cotton productivity is

$$\hat{Y}_t = 17.315^{**} + 48.537^{**}t - 2.387^{**} t^2 + 0.037^{**}t^3$$

(Adj. R^2 =60.00%)

REFERENCES

Anonymous, 2015.a The Pocket book on Agricultural Statistics 2015, Directorate of Economics and Statistics, New Delhi.

Anonymous, 2015.b Current Cotton Scenario - The Cotton Corporation of India, Ltd. *http://cotcorp.gov.in/current-cotton*. assessed on 17 November ,2014.

Box, G.E.P. and Jenkins, G.M., 1976. *Time Series Analysis: Forecasting and Control*, Second Edition, Holden Day

Fatimah, M. H. and Ghaffar, R. A. 1986. Univariate approach towards Cocoa price forecasting. *The Malaysian Journal of Agricultural Economics, 3:1-11*

Gupta, G.S. 1993. ARIMA model for forecasting on tea production in India. *Indian Economic Journal of*, 41(2):88-110

Hasija, R. C., Kausik, L. S., Suhag, K. S. and Aneja D. R. 2004. Growth and trend in area, production and productivity of wheat in Hariyana. *Agriculture Science Digest*, 24(2):91-94

Montgomery, D. C.; Peck, E. A. and Vining, G. G. 2003. In: Introduction to Linear Regression Analysis. John Wiley & sons, Inc.:221-258

Neware, S. S., Sonawane, H.P. and Shirke, V. S. (2015). Economic Evaluation of IPM Technology for Cotton in Yavatmal District of Maharashtra. Guj. J. Ext. Edu., 26(1): 21-26

Pankratz, A. 1983. Forecasting with univariate Box-Jenkins Models - Concepts and Cases. *John Wiley & Sons*, New York

Rangaswamy, R. 2006. In: A text book of agricultural Statisticsistics. *New Age International (P) Limited Publishers :* 158-210

Shapiro, S. S. and Wilk, M.B. 1965. An analysis of variance test for normality (complete samples). *Biometrika*, 52:591-611

Sidney, S. and Castellan, Jr. N. J. (1988). An analysis of variances test for normality (complete samples). *Biometrica*, 52: 591-611

Vinaya Kumar, H. M., Shivamurthy, M., and Lunagaria, M. M. (2017). Impact of rainfall variability and trend on rice yield in Coastal Karnataka. Journal of Agrometeorology. 19 (3): 286-287

Received : August 2017 : Accepted : November 2017