Forecasting Model of Cotton Production in Andhra Pradesh Using Auto Regressive Integrated Moving Average (ARIMA)

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ABSTRACT

Cotton is a soft, fluffy staple fiber that grows in a boll in Andhra Pradesh occupying 4.176 M ha area out of which Rabi Cotton occupied maximum area of 3.112 M ha during the year 2009-10. The gradual growth in use of technology in agriculture has resulted in increased crop productivity. The actual yields obtained are considerably lower than those recorded in the demonstration plots and research stations/farms. Therefore, there is a need to know the different yield gaps between the farmers' fields and the demonstration plots. The study has suggested that to bridge this gap the use of recommended levels of input is most essential. The farmers should be motivated through visits to progressive farmers and organizations of field demonstrations, seminars and other communication means to use the recommended levels of inputs and improved variety of seeds to enhance the productivity of Cotton in the state.

Key Words: ARIMA, Cotton Production, Prediction model and Andhra Pradesh

INTRODUCTION

Cotton is one of the highly cultivated Indian crops next to wheat in India. Regurl soil and alluvium soil are favourable for the cultivation of this crop. Cotton popularly known as Cotton is the most important food and fodder crop of dry land agriculture. The cereal crop is perennial in nature and possessing corn like leaves and bearing the grain in a compact cluster. Cotton is the

fifth most important cereal crop in the world after wheat, rice, maize and barley. It is found in the arid and semi arid parts of the world, due to its feature of being extremely drought tolerant. The nutritional value of Cotton is same as of that of corn and that is why it is gaining importance as livestock feed. Cotton is also used for ethanol production, producing grain alcohol, starch production, production of adhesives and paper other than being used as food and feed.

Cotton is one of the major staple food grain crops in India.

Out of the total area under Cotton cultivation in India, 50% is cultivated in Maharashtra. Whereas out of the total production of Cotton in the nation, 52% is from Maharashtra. Karnataka, **A**ndhra Pradesh, Tamil Nadu.

One more advantage of this crop is that it can be grown in both Rabi and Rabi season. Also, it can handle and grow on a wide range of soil types starting from fertile to less nutrient soils but an effective output largely depends on soil moisture, resistance and porosity.

Production and Distribution:

Cotton has suffered severely at the hands of other favoured crops. The area under Cotton increased slightly from 155.71 lakh hectare in 1950-51 to 184.12 lakh hectare in 1960-61. Thereafter, it has been fluctuating but the general trend has been towards its reduction.

Trends of production area and yields of Cotton from 1960-61 to 2003-04 are shown in Table 3. India produced 7.3 million tonnes of Cotton from 9.5 million hectares of land with an average yield of 772 kg/hectare in 2003-04. Table 2. Shows the distribution of Cotton in India. It is clear from Table 3. That Andhra Pradesh far excels all other states and produces more than 54 per cent of the total Cotton production of India. As many as 22 districts of Maharashtra produce Cotton but Osmanabad, Nanded, Yavatmal, Buldhana, Parbhani, Kolhapur, Amravati, and Ahmednagar are important producing districts.

In the Andhra Pradesh region, Cotton is the staple food of the people and two crops in a year are raised here. First is sown just before the onset of the monsoon and the second is sown after the retreat of the monsoon. In some districts to the south of Pune, as much as 80 per cent of the cultivated area is devoted to Cotton.

The state suffers from low yield of only 7.4 quintals/hectare against the national average of 7.7 quintals/hectare. Production can be increased by increasing the yields. Madhya Pradesh is the third largest producer but lags far behind Maharashtra in production contributing only 7.87 per cent of the total production of India. **Here Cotton is the second most important food crop after rice**.

METERIALS AND METHODS

Definition: Stationary: A stochastic process is said to be stationary if its mean and variance are constant over time and the value of the covariance between the two time periods depends only on the disturbance or lag between the two time periods and not on the actual time at which the covariance is computed (Damodar, 1995).

ARIMA model is a combination of AR and MA models with suitable order of differencing. Hence before describing ARIMA model, it is essential to know AR and MA models.

Auto Regressive (AR) Model

$$Z_t = Ø_1 Z_{t-1} + U_t \quad \dots (1)$$

Where, Z_t = the value of variable for forecasting at time't'

$Ø_1$ = Regression coefficient

U_t = Random error

This model is known as AR (1) model. The above model can be extended to any number of lags, as follows:

$$Z_t = Ø_1 Z_{t-1} + \ldots + Ø_p Z_{t-p} + U_t \quad (2)$$

The above model is then AR (P) model or AR (P) process.

Moving Average (MA) Model

Sometimes residuals with different lags may exhibit relationships with the dependent variable as follows:

$$Z_t = c + a_t - Ø_1 a_{t-1} + \ldots + Ø_q a_{t-q}$$

Where

Z_t = The value of the variable for forecasting at time t (Rainfall, in the present case)

c = Constant

a_t = Error term

$Ø_t$ $Ø$ = Partial regression coefficients

This model is known as MA (q) model.

Auto Regressive Moving Average (ARMA) Model

In the model Y_t depends on AR as well as MA variables and can be specified as

$$Z_t - Ø_1 Z_{t-1} - \ldots - Ø_p Z_{t-p} = c + a_t - Ø_1 a_{t-1} + \ldots + Ø_q a_{t-q}$$

Where,

$Z_t = Y_t – Y$ (deviation of Y_t from the mean of Y).

The above model is ARIMA (p, q) model.

In the light of the above models let us consider the ARIMA model:

Auto Regressive Integrated Moving Average (ARIMA) Model

In the above models it was assumed that the error U_t is random error (white noise) i.e., the data is stationary. However, in general, the data is not stationary. For example, the data on economic variables such as area, production, productivity often exhibit trend. Similarly, the rainfall data frequently exhibits seasonal and cyclic fluctuations. In the presence of these components the time series models described above cannot be applied. These components can be eliminated. For instance, if the data exhibits trend, it can be estimated by fitting a suitable trend equation and finally it can be eliminated from the data. Similarly, when seasonality is present, it can be removed by successive differencing. These two situations are respectively referred as trend stationary and difference stationary models.

The difference stationary models lead to ARIMA model. Here, the non-stationary time series is reduced to stationary by selecting suitable order of differencing. An ARIMA model is therefore a ARIMA model with suitable differencing (d) that reduces the data to stationary. It is referred as ARIMA (p, d, q) model. The concept of ARIMA model was developed by Box and Jenkins. ARIMA model essentially require identification of three constants p, d, q i.e. the order of AR terms (p), order of differencing (d) and the order of MA terms (q).

Fitting of ARIMA model : It is a four step procedure.

Step 1: Identification

This involves identification of stationary, order of differencing and the order for AR and MA models. These can be obtained through ACF and PACF graphs referred respectively as correlograms and partial correlograms[1*] using the criteria as described earlier.

Step 2: Estimation

The parameters of ARIMA model (later identifying p, d, and q) can be estimated by applying the Grid-Search procedure as advocated by Box and Jenkins (1978). This procedure, which is iterative, help in estimating the MA coefficients in addition to the AR coefficients (which is not possible with the least squares method). The procedure can be illustrated in the context of ARIMA (2,2)[2*] .The ARMA(2,2) can be specified as :

$$Z_t - b_1 Z_{t-1} - b_1 Z_{t-1} = U_t - Ø_1 U_t - Ø_2 U_t \quad \ldots(1)$$

Defining the backward shift operator B as

And rearranging (1), have

$(1 - b_1 B - b_2 B^2) Z_t = U_t - Ø_1 U_{t-1} - Ø_2 U_{t-2}$…(2)

Or $Z_t = \frac{1}{(1-b_1 B-b_2 B^2)}(Ut - Ø1Ut - 1 - Ø2\ Ut - 2) \ldots .(3)$

Let $V_t = = \frac{U_t}{(1-b_1 B-b_2 B^2)} - - - - \rightarrow 4$

$\Rightarrow U_t = V_t (1 - b_1 B - b_2 B^2)$….(5)

And also

$V_t = b_1 V_{t-1} + b_2 V_{t-2} + U_t$ …..(6)

Substituting U_t from equation (5) for different t's i.e., t, t-1 and t-2 in equation (3) ,we get

$V_t = Z_t + Ø_1 V_{t-1} + Ø_2 V_{t-2}$ …(7)

The 'search' for MA coefficients ($Ø_1$, $Ø_2$) can be carried out (iteratively) as follows: Within the stability region for ($Ø_1$,$Ø_2$) select the plausible value($(\widehat{Ø_1}, \widehat{Ø_2})$
Stating with $\hat{V}$=0 and V_1 =0, generate the successive estimated values of by (7).

$V_2 = Z_2$ (t =2)
$V_3 = Z_3 + Ø_1 V_2$ (t=3)
$V_4 = Z_4 + Ø_1 Z_3 + Ø_1 V_2$ (t=4) etc……

Then, using the Vt, estimate b_1 and b_2 by using ordinary least squares, Through the equation (6) by regressing V_t onV_{t-1} and V_{t-2} .Then compute the residual sum of squares:

$$\sum {e_t}^2 = \sum\left(\widehat{V_t} - b_1 V_{t-1} - b_1 V_{t-2}\right)^2$$

Since the approach is minimizing the residual sum of squares, the values Of $Ø_1$, and$Ø_2$ can be selected such that the residual sum of squares becomes minimum. If the number of parameters in the moving average part of the ARIMA model is high, this procedure is not very efficient . In practice, however, one does not require a large number of MA coefficients, so that the procedure can be effectively applied.

RESULTS AND DISCUSSION

The findings of the study show that while food use of Cotton has declined sharply at the all-India level, its use as food is still important in major producing states after rice and wheat although at levels 50% below that in 1972–73. The decline in per capita food consumption of Cotton , however seems to be plateauing at this lower level as indicated by data between 1999 and 2005. At the same time, the use of Cotton in alternative uses has increased from about 5% since 1993–94 to 30% or more between 1999 and 2005. Our estimates further indicate that of the total food use of Cotton , 50% is accounted for Rabi Cotton while the rest is from Cotton (Rabi) . Thus close to 50% of Rabi Cotton goes for alternative uses. These include demand from animal feed industry mainly poultry and to some extent dairy, alcohol industry, starch industry, food processing and export demand. With dairy sector for milk and poultry sector for meat growing at 5% and 12% per annum respectively the demand for feed from these sectors is expected to increase and that would include Cotton besides other grains. Industrial demand for grain-based alcohol is also expected to post a double digit growth rate.

The recent policy of Government of India issuing 23 new licenses for distilleries producing grain-based alcohol and Maharashtra State policy of offering subsidy of `10 for every litres of alcohol produced from grain will lead to large-scale diversion of Cotton (Rabi) for this sector and hence utilization of Cotton for alternative uses is anticipated to increase. Although the potential demand for food processing is still on a small scale, the prospects are encouraging for value addition. Here Cotton grown in rabi season would be preferred due to its superior grain quality. Researchers, policy makers and stakeholders should thus adopt a different strategy for Rabi and Rabi Cotton. Looking at the trends of Rabi Cotton production available for alternative uses and declining area under Rabi Cotton, serious efforts should be made to address the problem of stagnation in area under Rabi Cotton

by targeting production to different end users like livestock and poultry feed manufacturers, alcohol sector, etc. In order to compete effectively with other close substitutes (such as maize, pearl millet and finger millet) the per unit cost of production should be brought down through high-yielding improved cultivars. This would also make the grain competitive in the export market where its demand for feed is increasing since large quantities of maize at global level are being diverted to ethanol production. The research efforts of the breeding programs should target towards 100% substitution of Cotton with maize, pearl millet, etc in alternative uses. Studies also have reported that the Cotton grain produced during rainy season is of poor quality because of grain mold and other postharvest handling problems. This needs to be addressed to make the production of Rabi Cotton attractive for alternative uses and for exports. Policy makers should enable forward linkages where farmers enter directly in agreement with industrial users through contract farming, bulk marketing, etc. This will enable an assured price to the growers while the industry can expect bulk supplies of the required quality grain.

Table 1: Comparison of ARIMA models

ARIMA (p d q)	R-square value	MAPE	BIC value
2 1 0	0.835	12.963	10.037
2 1 1	0.837	13.160	10.139
3 1 0	0.836	13.142	10.140
1 1 2	0.834	13.145	10.155
2 1 3	0.859	11.701	10.215
2 1 2	0.837	13.121	10.246
3 1 1	0.836	12.749	10.253
1 1 3	0.832	13.283	10.277
3 1 2	0.849	12.649	10.283
3 1 3	0.836	12.949	10.474

Table 2: Estimation of parameters for ARIMA Model (3 1 2)

Parameter	Estimate	Standard Error
Constant	18.7701	9.3121
AR 1	-1.7283	1.5250
AR 2	-1.3290	1.1988
AR 3	-0.5584	0.8210
MA 1	-1.0004	1.5476
MA 2	-0.0772	0.4376

Table 3: Predicted values of ARIMA Model (3 1 2)

	Cotton -Yield (Kg./Hectare)		95% Confidence Limits	
Year	Actual	Predicted	LCL	UCL
1966	613			
1967	482	631	256	1007
1968	493	572	242	902
1969	496	599	323	875
1970	377	529	253	805
1971	450	500	224	776
1972	432	505	229	781
1973	471	442	167	718
1974	619	496	221	772
1975	426	533	257	808
1976	521	530	255	806

1977	621	599	324	875
1978	605	537	262	812
1979	690	603	328	878
1980	527	687	412	962
1981	602	637	362	913
1982	718	680	405	955
1983	569	631	356	906
1984	653	659	384	934
1985	650	718	443	993
1986	600	646	371	921
1987	662	679	404	954
1988	467	689	414	964
1989	688	613	338	888
1990	715	675	400	950
1991	624	616	341	891
1992	864	720	445	995
1993	829	787	512	1062
1994	680	761	486	1036
1995	731	858	583	1133
1996	735	813	538	1088
1997	653	742	467	1017
1998	695	752	477	1027
1999	727	752	477	1027
2000	914	719	444	994
2001	992	804	529	1079
2002	973	880	605	1155
2003	1145	992	717	1267
2004	1032	1077	802	1352
2005	1324	1063	788	1338
2006	972	1218	943	1493
2007	1420	1116	841	1391
2008	1563	1322	1047	1597
2009	1135	1268	993	1543
2010	1213	1406	1131	1681
2011	1602	1450	1175	1725

Figure 1: ACF and PACF of Cotton production

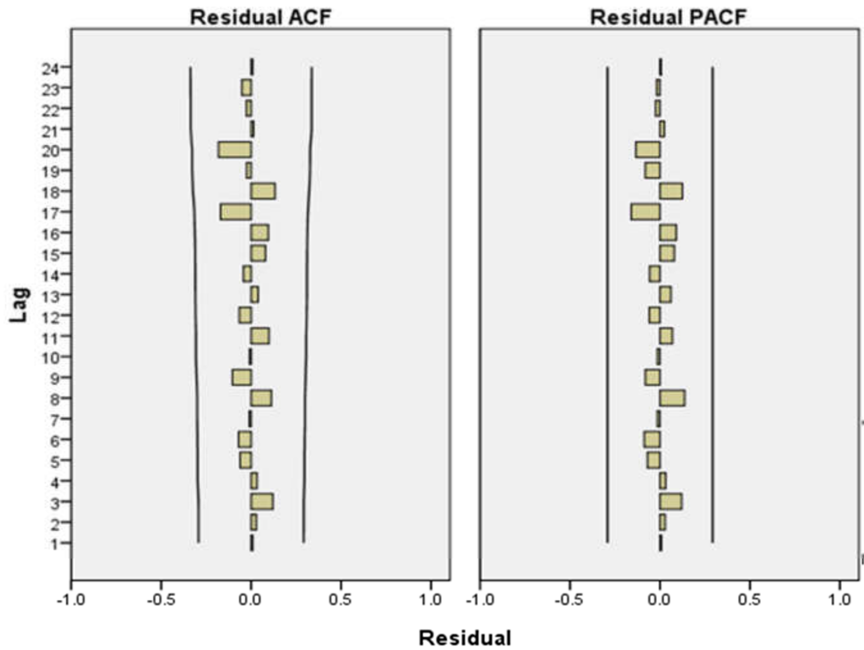
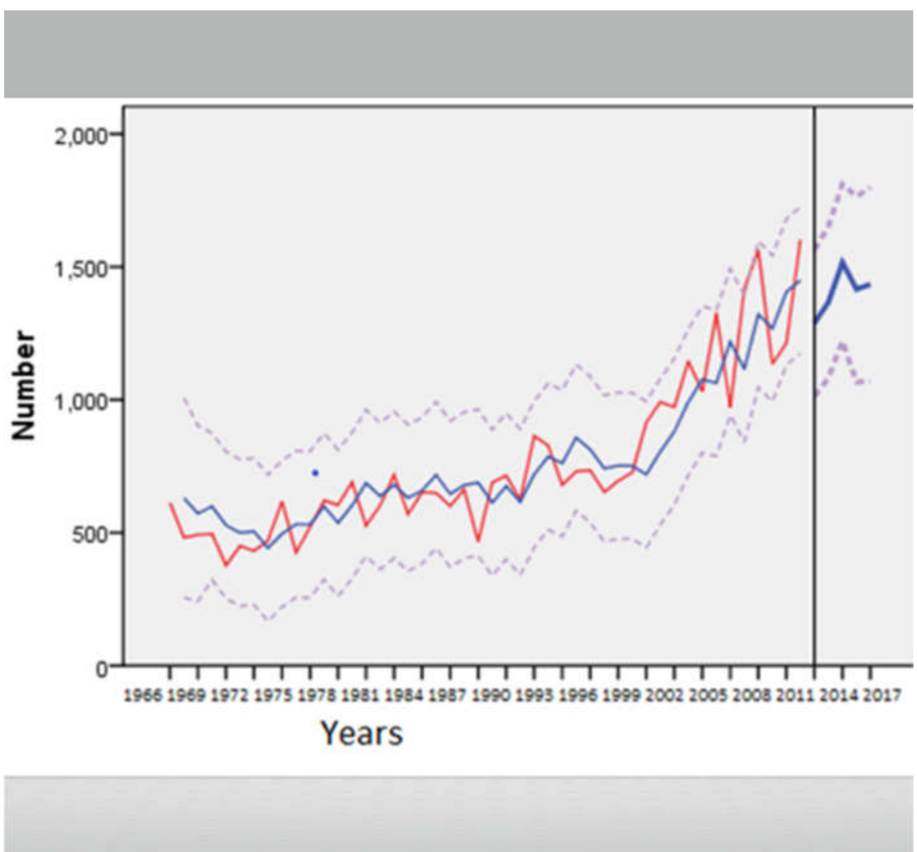


Figure 2: Trend values of Cotton production with UCL and LCL



CONCLUSION

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