Research Article

Forecasting of maize production in Telangana

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Abstract This paper presents the forecasts of maize production in Telangana state using Box-Jenkins methodology. The forecasts of maize can be used in planning of agriculture and poultry sector in the newly formed Telangana state. The forecasts suggest that, the maize production in the state would meet 3.74 million tonnes by the year 2020-21. If present situation continues, Karimnagar and Nizamabad districts would form a maize belt in the state.
Keywords: Maize, Box-Jenkins Methodology, MAPE and Index of agreement.

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INTRODUCTION

Maize is the most important cereal and it is mainly used as grain, feed, fodder, starch and industrial products. Demand for maize is increasing due to its versatile uses in different sectors like poultry, feed and fodder, industrial uses and also exports to South-East Asian countries. Telangana is one of the large maize producing states in India. In Telangana, maize is cultivated in all the districts (except Hyderabad) in both the Kharif and Rabi seasons. The total maize production doubled in the state within the past ten years (DES, 2014). The maize production in the state has been largely influenced by increasing demand from the feed industries and various industrial uses (Ranjit Kumar *et al.* 2014). Major maize growing districts in Telangana are Karimnagar, Warangal, Nizamabad, Mahaboobnagar, Khammam and Medak. Area and production of maize have increased manifolds in the state during the previous decade. In most of the maize growing districts in Telangana, maize is occupying the area of some of other crops like Jowar, Millets, Cotton and low value crops due to attractive markets and remunerative prices, in addition to the fewer requirements of irrigation practices as compared with the high value crops. Poor and unprecedented rainfall, improper power supply and availability of high yielding hybrids in the state are key reasons for the increase in maize area and production in the state. Recently, Mahaboobnagar have shown a significant increase in the maize area and which is mainly due to replacement of other crops such as Jowar and small millets during the past decade. There was a significant change in the area and yield of maize observed in Khammam, Warangal, Nizamabad and Mahaboobnagar (Kumar *et al.* 2013). Maize grain yield is more than 4 tonnes per hectare is noticed only in Khammam district, whereas, Karimnagar, Nizamabad and Adilabad districts accounted for 2-4 tonnes per hectare. Maize grain yield is below 2 tonnes per hectare observed for Mahaboobnagar, Medak and Ranga Reddy districts during the past five years. In Medak district, the maize yield has declined over the years with very high instability (Kumar *et al.*, 2013). Since maize demand is increasing consistently, it has become important to understand the existing maize situation in the newly formed Telangana state and plan the future of maize in the state based on the past and present situation. An attempt is made in this paper, to forecast the yearly maize production in Telangana based on the historical data. One of the most widely used time series forecasting methods in practice includes the Box-Jenkins methodology. An ARIMA model is developed and used for forecasting maize production in Telangana State.

METHODOLOGY

Box and Jenkins (1970) developed a coherent, versatile four stage iterative cycle for time series identification,

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estimation, checking and forecasting, rightly known as the Box-Jenkins methodology (De Gooijer and Hyndman, 2006). The Box-Jenkins methodology deals with the non-stationary models such as autoregressive integrated moving average (ARIMA) models. In an ARIMA model, the future value of a variable is assumed to be a linear function of past observations and random errors. ARIMA models are, in theory, the most general class of models for forecasting a time series which can be stationarized by transformations such as differencing. Let $\{Z_t\}$ be a non-stationary time series with stabilized variance. Let $\tilde{W}_t = \nabla^d \tilde{Z}_t$ where ∇=1-B, choose *d* such that the mean of W_t is stabilized, then $\{W_t\}$ will be a stationary time series. In practice, the differencing operator *d* is usually 0, 1 or at most 2. The ARMA model for stationary series $\{W_t\}$ is given by $\phi(B)\tilde{W}_t = \theta(B)a_t$ or this can be written as $g(B)\tilde{Z}_t = \theta(B)$ where g(B) = $\phi(B)\nabla^d$. Since $\nabla^d \tilde{Z}_t = \nabla^d Z_t$, this model can be written as

$$g(B)Z_t = \theta(B)a_t \quad (2.\ 1)$$

The model in equation (2. 1) is a non stationary model in Z_t and is known as autoregressive integrated moving average model of order (p,d,q) i.e. ARIMA(p,d,q). The general ARIMA process may be generated by summing or "integrating" the stationary ARMA process W_t, *d* times. In this model $\phi(B) = 1 - \phi_1 B - \phi_2 B^2 - .... - \phi_P B^P$ is a polynomial in B of order p and is known as AR operator. $\theta(B) = 1 - \theta_1 B - \theta_2 B^2 - ......\theta_q B^q$ is a polynomial in B of order q and is known as MA operator. g (B) = $\phi(B)\nabla^d$ is a polynomial in B of order in (p+d) and is known as non-stationary operator (Chatfield, 1991). Model parameters are identified based on the autocorrelation and partial autocorrelation function. Once a tentative model is specified, the parameters are estimated using nonlinear optimization procedures. Diagnostic checking of model accuracy is basically to check if the model assumptions about the errors are satisfied. If the model is not adequate, the above three steps are repeated until an adequate model is obtained. Diagnostic information helps in suggesting alternative models. The selection of the model is based on the principle of parsimony. The final selected model can be used for forecasting purposes. The model performance measured using different error measures such as mean absolute percentage error (MAPE) and Index of agreement (Willmott, 1981; Raghavender, 2010; Boiroju, 2012). In this paper, ARIMA modeling is implemented via SPSS and MS Excel is used for computations and charts.

RESULTS AND DISCUSSION

The yearly maize production data is compiled and collected from Directorate of Economics and Statistics, Hyderabad, Telangana State. The data comprises the yearly maize production in tonnes in the state from the year 1974-75 to 2013-14, but District-wise maize area and production data are available up to 2012-13 (DES, 2014). The district-wise area and production at triennium ending 2012-13 is depicted in the following figure.

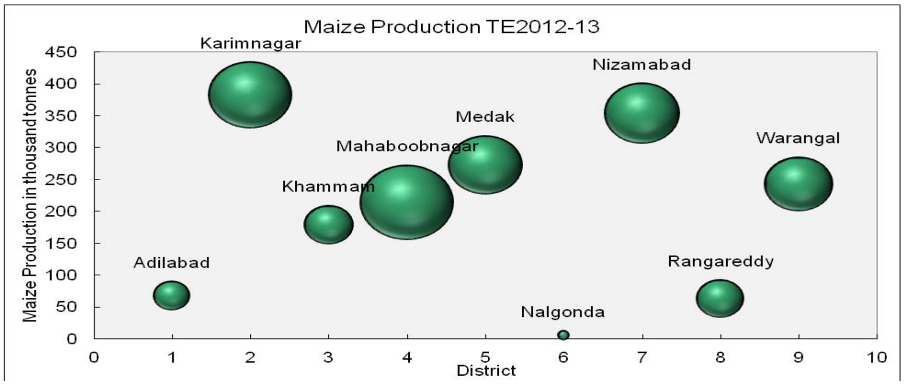

Figure 1: District-wise maize area and production at triennium ending 2012-13

In Figure 1, the size of the bubble shows the maize area and its location in the chart shows the maize production of nine districts in the state during triennium ending 2012-13. Maximum maize area is in the Mahaboobnagar district and lowest maize area is observed in Nalgonda district. On production side, Karimnagar and Nizamabad are major contributors, whereas low maize producing districts include Nalgonda, Adilabad and Rangareddy districts. The following graph shows the trend in the maize production in Telangana.

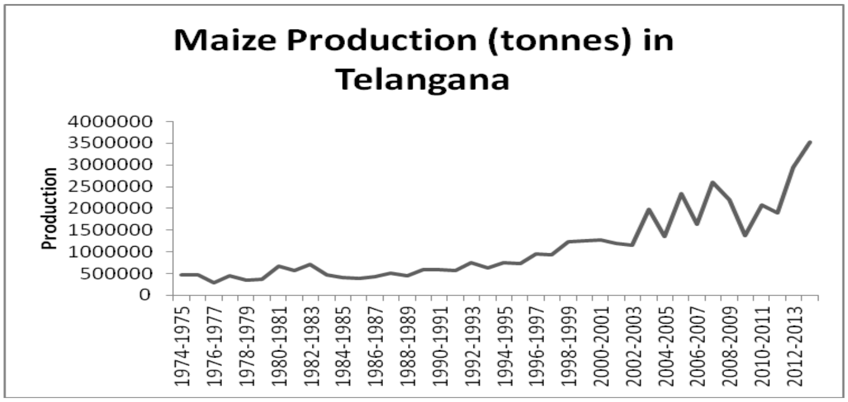

Figure 2: Maize production trend in the Telangana

The maize production in 1974-75 is 0.46 million tonnes, which is escalated to 1.25 million tonnes in 1999-2000 and the same, is raised to 3.52 million tonnes during 2013-14. During the past decade, there is much variation observed in the maize production in the Telangana state due to improper weather conditions and other socio-economic reasons. Yearly maize production data converted in to a stationary series by natural logarithm transformation and successive differencing of order one (d=1). The Box-Jenkins methodology applied and identified an ARIMA (1, 1, 0) model with the following parameters.

Table 1: ARIMA Model parameters

Parameter	Estimate	SE	t-test	P-value
AR1	-0.484	0.142	3.414	0.002

The parameter of the model is significant at 5% level of significance and the resulting model is $(1+0.484B)\nabla^1 Y_t = a_t$ where $Y_t = \ln(Z_t)$. Model adequacy is tested using Ljung-Box test statistic and residual autocorrelations. It is observed that, none of the residual autocorrelations are significant at 5% level and which indicates that the errors are random. Ljung-Box Q statistic (Ljung and Box, 1978) is 17.584 for 17 degrees of freedom having the p-value 0.416. Since P-value is more than 0.05, therefore we accept the null hypothesis of the selected model is an adequate model. The selected model have index of agreement is 81% and MAPE 18.503. With the selected model, minimum mean squared error method is used for forecasting of the future maize production and the results are shown in the following table.

Table 2: Forecasts of maize production (tonnes) in Telangana State

Year	Production (t)	Lower Limit	Upper Limit
2014-2015	3337833	1925296	5420568
2015-2016	3512179	1882240	6033016
2016-2017	3505031	1639597	6648509
2017-2018	3587102	1538209	7228310
2018-2019	3626238	1414833	7783746
2019-2020	3687589	1326363	8341499
2020-2021	3739216	1241877	8889017

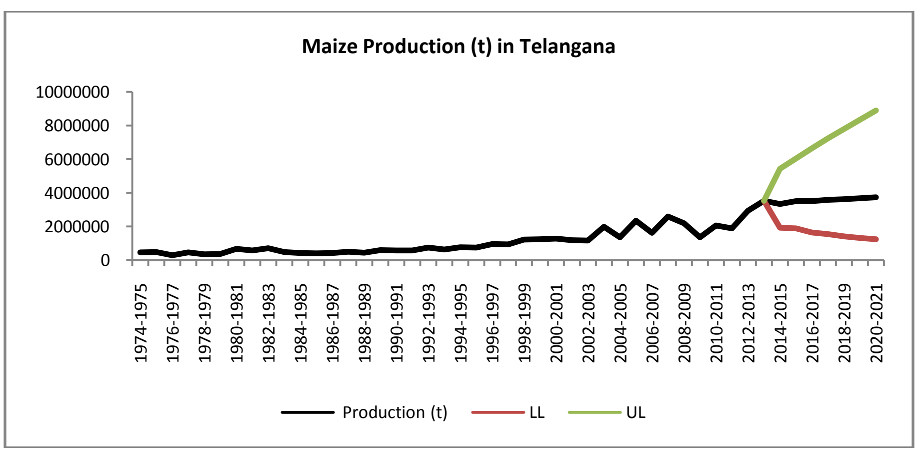

Figure 3: Forecasts of maize production in Telangana State

From the above Table and Figure 3, it is evident that, there is no much growth in the maize production forecasts and we would expect on the average of 3.74 million tonnes of maize production by 2020-21, which shows only 6.1% of the increase in maize production as compared with the 2013-14. The 95% confidence intervals of the maize production promises the production lies in between 1.2 million tonnes and 8.9 million tonnes in the state by the year 2020-21.

CONCLUSION

The significant growth in the production and its spread across the districts proved maize as a golden crop in Telangana. As availability of limited data, the forecasts and their confidence intervals are subject to the statistical errors. However, the forecasts suggest that, the maize production in the state by year 2020-21 is 3.74 million tonnes. Timely, revision of the model provides more accurate forecasts. The major share in the maize production in the state is observed mainly from Karimnagar and Nizamabad districts. Recently, Telangana government introduced "Mission Kakatiya" and other irrigation projects in all the districts. With the implementation of "Mission Kakatiya" and completion of irrigation projects, one can expect a great improvement in the maize production in future from Mahaboobnagar, Adilabad and Nalgonda districts also.

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