Archives of Current Research International

Volume 24, Issue 6, Page 223-229, 2024; Article no.ACRI.120260
ISSN: 2454-7077

Forecasting Maize Production in Telangana State Using Arima Model

M. Maheshnath [a++*], R. Vijaya Kumari [b#], K. Suhasini [c†], D. Srinivasa Reddy [d‡] and A. Meena [e^]

[a] Department of Agricultural Economics, College of Agriculture, Professor Jayashankar Telangana State Agricultural University, Hyderabad, Telangana, India.
[b] Professor Jayashankar Telangana State Agricultural University, Hyderabad, India.
[c] Department of Agricultural Economics, College of Agriculture, Rajendranagar, Hyderabad, India.
[d] Cost of Cultivation Scheme, Professor Jayashankar Telangana State Agricultural University, Hyderabad, Telangana, India.
[e] Department of Statistics and Mathematics, College of Agriculture, Rajendranagar, Hyderabad, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/acri/2024/v24i6780

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/120260

Original Research Article

Received: 15/05/2024
Accepted: 17/07/2024
Published: 20/07/2024

ABSTRACT

The study utilized the Box-Jenkins approach for forecasting maize production in Telangana state. It involved the analysis of 55 years of empirical annual observations of maize production. The autocorrelation (ACF) and partial autocorrelation functions (PACF) were calculated to analyze the

[++] *Ph.D. Research Scholar;*
[#] *Deputy Director of Research;*
[†] *Sr. Professor & Univ. Head;*
[‡] *Field Officer;*
[^] *Assistant Professor;*
**Corresponding author: Email: imaheshnath@gmail.com;*

Cite as: *Maheshnath, M., R. Vijaya Kumari, K. Suhasini, D. Srinivasa Reddy, and A. Meena. 2024. "Forecasting Maize Production in Telangana State Using Arima Model". Archives of Current Research International 24 (6):223-29. https://doi.org/10.9734/acri/2024/v24i6780.*

data. A suitable Box-Jenkins ARIMA model was fitted, and the validity of the model was examined using conventional statistical methods. Lastly, the next three years' worth of maize production was predicted using the autoregressive integrated moving average model's forecasting capability.

Keywords: Maize; forecasting; Autocorrelation Function (ACF); Partial Autocorrelation Function (PACF); Autoregressive Integrated Moving Average (ARIMA); Autoregressive Moving Average (ARMA).

1. INTRODUCTION

“Maize, also known as the "Queen of Cereals," is a vital crop in India, ranking as the third-highest cash crop after wheat and rice. With 16 million Indian farmers engaged in maize cultivation, major maize-producing states like Karnataka, Rajasthan, Madhya Pradesh, and Telangana contribute significantly to the country's overall maize production” [1].

“In Telangana, maize ranks third among all crops, covering an expansive area of 12.74 lakh acres. During the 2022-23 season, maize production in Telangana reached 28.65 lakh tonnes” [2]. “The leading maize-growing districts in the state include Warangal Rural, Khammam, Nirmal, Siddipet, Kamareddy, Mahabubabad, Nizamabad, Warangal Urban, Jagityal, and Karimnagar. Over the past decade, both the cultivated area and production of maize have witnessed significant growth in Telangana” [3].

“To ensure remunerative prices for farmers, India must plan its maize production by enhancing productivity and reorienting the value chain” [4].

2. MATERIALS AND METHODS

2.1 Data Source

Maize production data for Telangana State from 1966-67 to 2021-22, sourced from the Directorate of Economics and Statistics [5], was used to develop a statistical model. The analysis was conducted using the SAS 9.3 software package.

2.2 Stationarity

The noise (or residual) series for an ARMA model must be stationary, meaning the expected values and autocovariance function are independent of time. The standard way to check for non-stationarity is to plot the series and its autocorrelation function. Visually examining the series over time can reveal trends or changing variability. If the series is non-stationary, its autocorrelation function will usually decay slowly. Stationarity tests provide another way to check for stationarity.

Due to their non-stationarity, most time series need to be transformed before being modeled using ARIMA. The standard procedure is to take the difference between one period and the next and examine the differenced series if the series exhibits a trend, seasonality, or other non-stationary patterns. At times, it becomes necessary to differentiate the series multiple times or at intervals longer than one. A suitable substitute for differencing may be to provide explanatory variables if the trend or seasonal impacts are highly regular.

2.3 Differencing

A deterministic seasonal pattern will make the series non-stationary, as the expected value varies across time periods depending on the season. When the series exhibits seasonality, you can difference it at a lag equal to the seasonal cycle length. To take a second difference, simply add another differencing period. There is no limit to the order of differencing or the degree of lagging for each difference.

2.4 ARIMA Process

The Auto Regressive Integrated Moving Average (ARIMA) model is a process that combines the ARMA (Auto Regressive Moving Average) model with differencing to handle non-stationary time series data. When the time series {Yt} is non-stationary, the ARIMA model is used instead of the ARMA model.

The key steps in the ARIMA modeling process are:

1. Identify the model parameters (p, d, q) - where p and q refer to the number of autoregressive and moving average terms, and d refers to the order of differencing required to make the series stationary.
2. Estimate the model by transforming the non-stationary series through differencing,

then fitting the appropriate ARIMA (p, d, q) model. Parameter selection is based on the autocorrelation (ACF) and partial autocorrelation (PACF) functions.

3. Perform diagnostic checks on the model, analyzing the residuals to ensure the model adequacy. This includes evaluating the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) to select the best-fitting parsimonious model.
4. Use the validated model for forecasting the time series.

This structured Box-Jenkins methodology provides a comprehensive approach to modeling and forecasting non-stationary time series data using the ARIMA framework.

3. RESULTS AND DISCUSSION

Box Jenkins models were preferred for forecasting maize production in Telangana state over multiplicative time series models. The results are presented below.

To select an appropriate autoregressive integrated moving average (ARIMA) model for forecasting maize production, the first step was to apply the Augmented Dickey Fuller (ADF) unit root test. This test checked whether the data was stationary or non-stationary, which is a key requirement for ARIMA modeling. This test helped to choose between auto regressive moving average (ARMA) and ARIMA models for further processing and forecasting. The analysis and forecasting were based on 55 years (1966-67 to 2021-22) of empirical annual observations of maize production.

The original observed data on maize production was non-stationary, but it became stationary after the first difference was applied. This was evident from the graphical analysis presented in Figs. 1 and 2, and was further confirmed by the Augmented Dickey-Fuller (ADF) test at a 0.05 level of significance [6].

The model selection process was based on the lowest Akaike Information Criterion (AIC) value. For the maize production data, the ARIMA (0,1,1) model had the lowest AIC value of 291.20 and a Bayesian Information Criterion (BIC) value of 295.35, as shown in Table 1 [7].

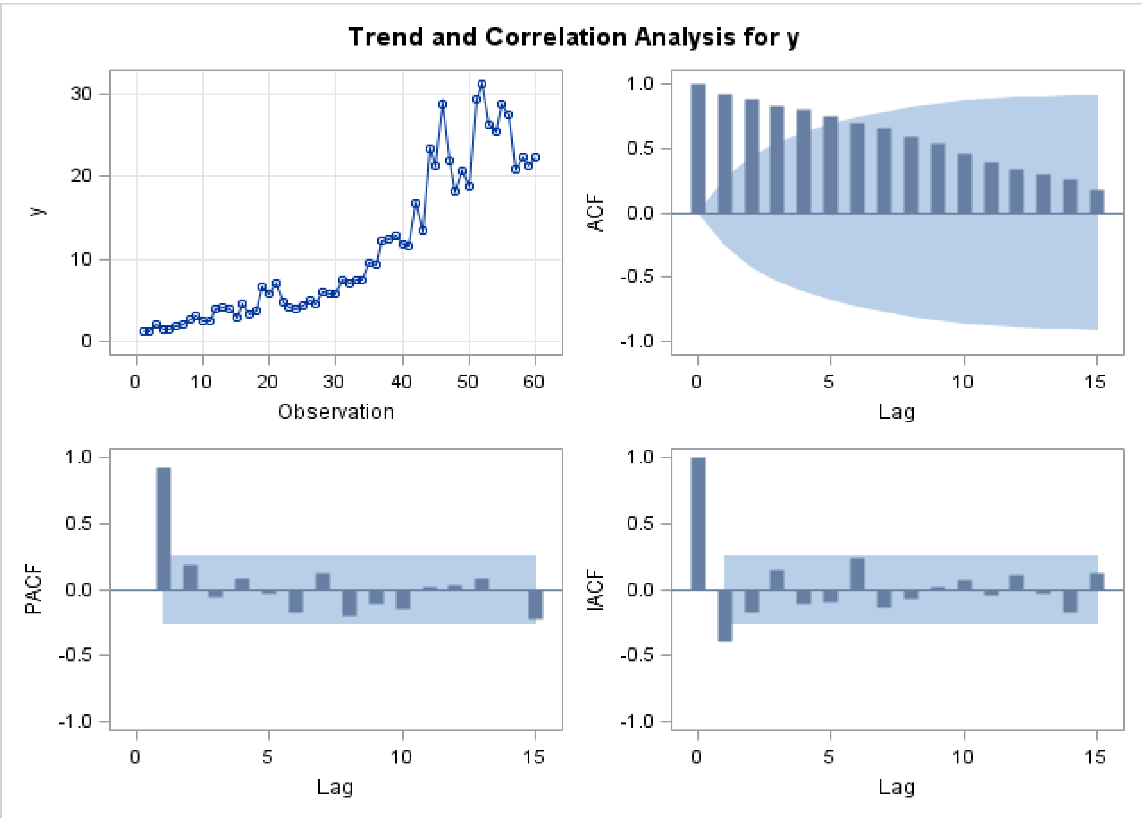

Fig. 1. The line plot depicts the original series in maize production

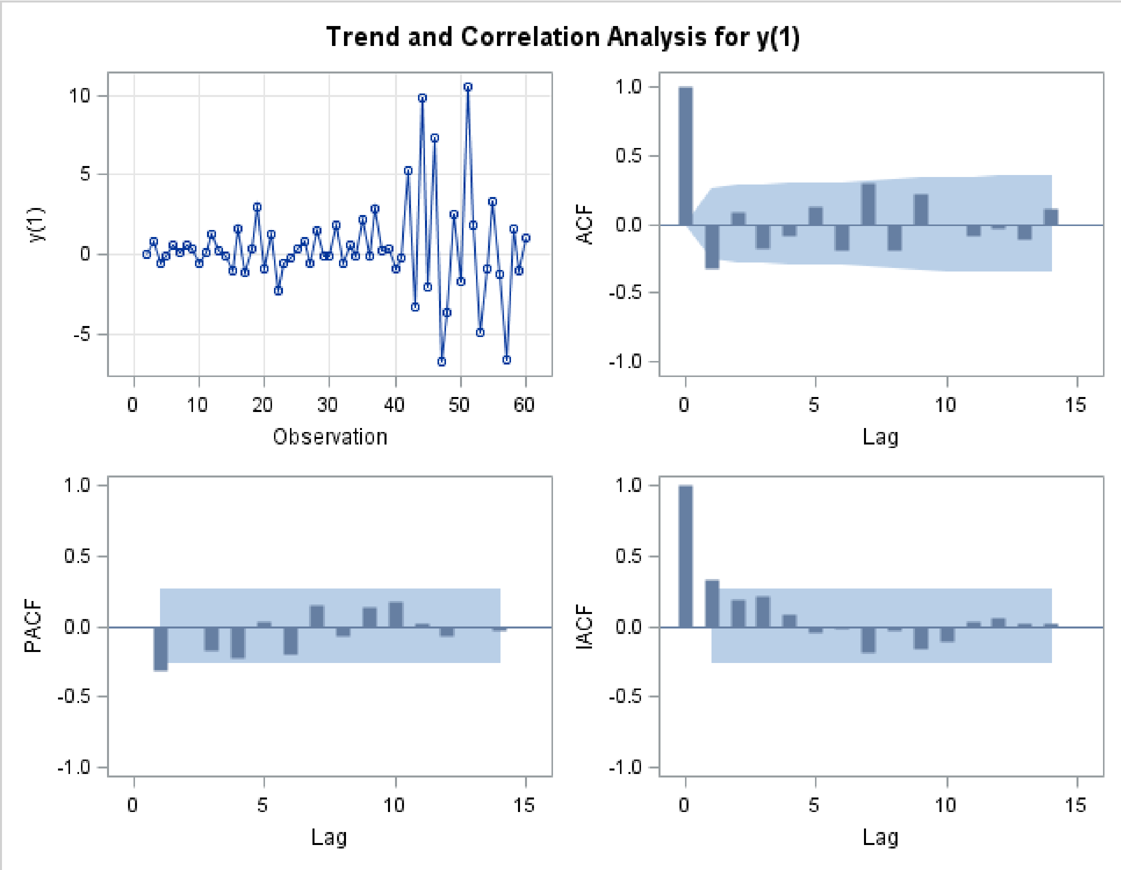

Fig. 2. The first order differenced maize production data is best represented by a line plot

Table 1. The AIC (Akaike Information Criterion) and BIC (Bayesian Information Criterion) values for various ARIMA (Autoregressive Integrated Moving Average) models were analyzed to determine the optimal model for predicting maize production in Telangana State

Model	AIC	BIC
ARIMA (000)	436.41	438.50
ARIMA (111)	292.29	298.52
ARIMA (011)	291.20	295.35
ARIMA (110)	291.65	295.81
ARIMA (210)	293.65	299.88
ARIMA (012)	292.90	299.13
ARIMA (211)	295.63	303.94
ARIMA (112)	295.17	303.48
ARIMA (212)	296.48	306.87

The Box-Jenkins approach was used to perform diagnostic checks on the fitted model. Specifically, the residuals of the estimated model were examined to test the randomness of the series and determine the adequacy of the model. The autocorrelation and partial autocorrelation plots of the residuals (Fig. 3) showed that they were random, as none of the coefficients were significantly different from zero. This was further supported by the significant Augmented Dickey-Fuller (ADF) test of the residuals at the 0.05 level of significance. These diagnostic tests confirmed that the tentatively identified and estimated models were appropriate for predicting maize production in Telangana [8].

The Box-Jenkins method was then used to obtain ex-post values for maize production, as shown in Fig. 4. An ARIMA model was fitted using 55 years of data from 1966-67 to 2021-22, and a 3-year forecast was generated from 2022-23 to 2024-25. The results indicate that maize production in Telangana is forecasted to increase from 23.10 lakh tonnes (LT) in 2022-23 to 23.82 LT in 2024-25 [9].

The ARIMA (0,1,1) model was selected based on the lowest Akaike Information Criterion (AIC) value and was found to be appropriate for predicting maize production in Telangana. As with the diagnostic checks, the residuals of the estimated model were random, as confirmed by

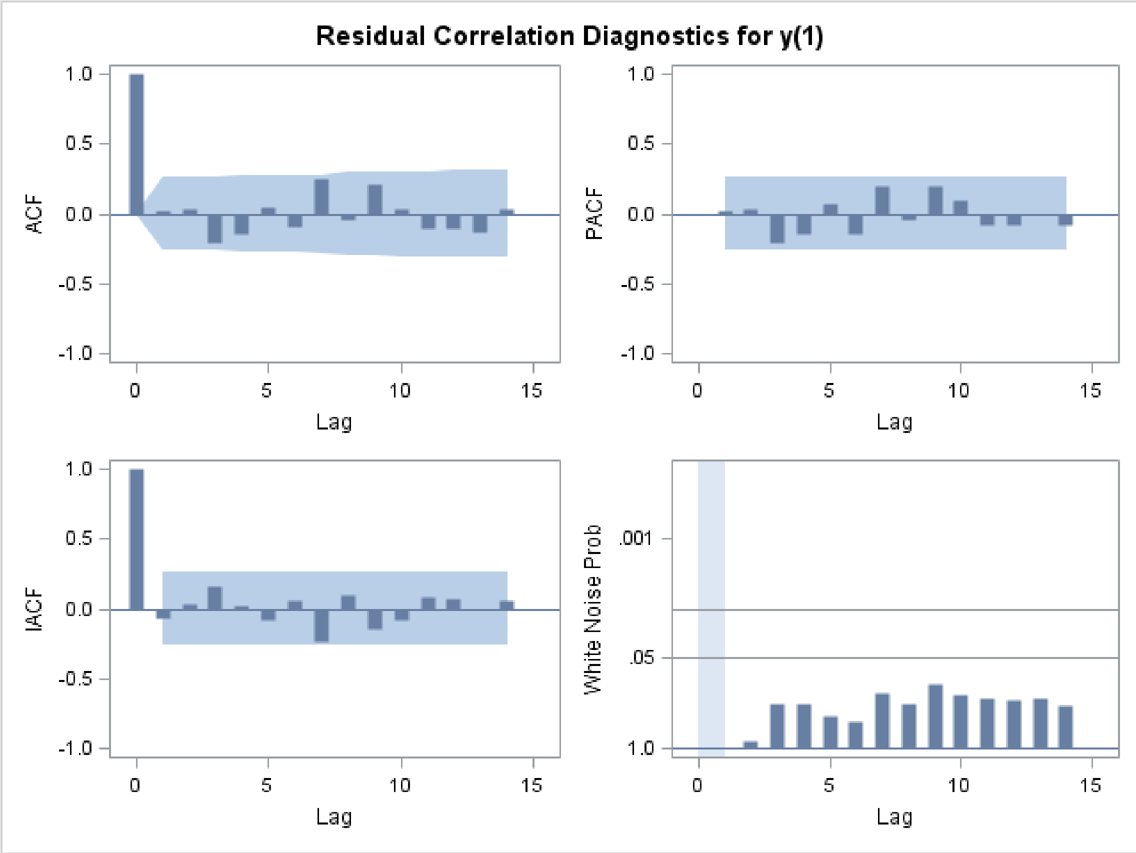

Fig. 3. The autocorrelation function (ACF) and partial autocorrelation function (PACF) of the residuals from the fitted ARIMA model provide important diagnostic information about the model's adequacy

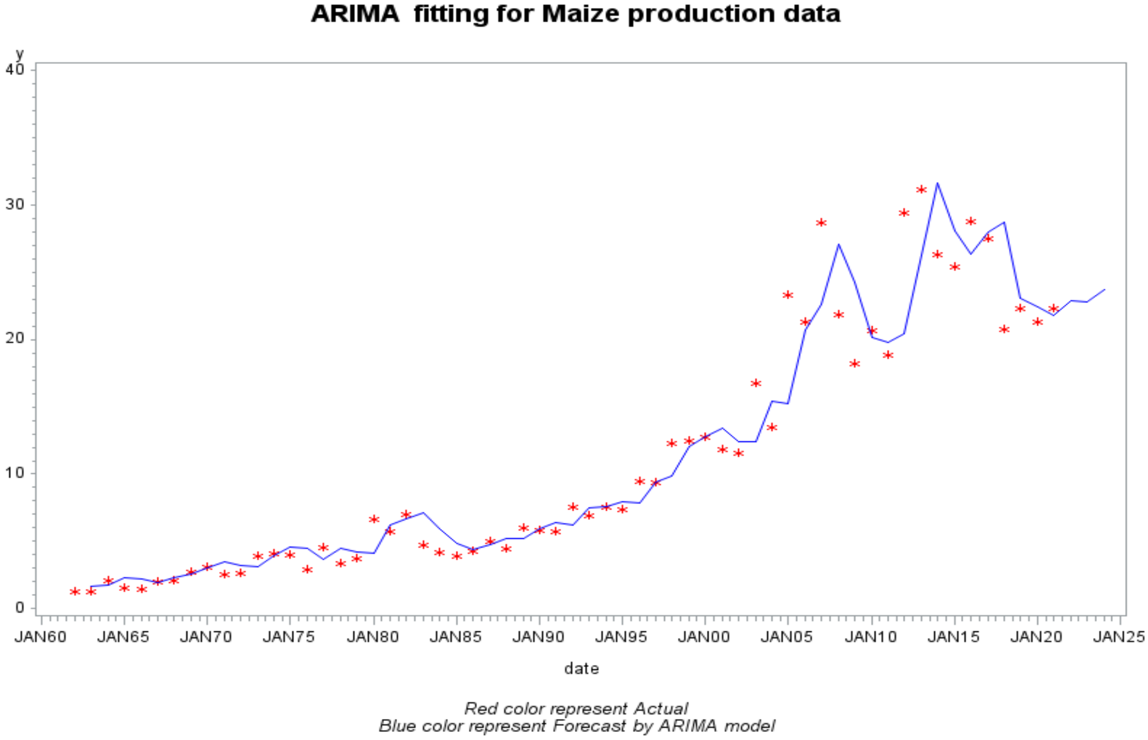

Fig. 4. This report presents the actual and forecasted maize production data for the state of Telangana from 1960 to 2024

Table 2. Forecasts of Maize production in Telangana up to 2025

Forecasts for maize production				
Observations	**Forecast**	**Std Error**	**95% Confidence Limits**	
2022-23	23.1097	3.3140	16.6144	29.6051
2023-24	23.4689	3.7529	16.1134	30.8244
2024-25	23.8281	4.1456	15.7029	31.9533

the significant ADF test at the 0.05 level. These findings suggest that the Box-Jenkins approach and ARIMA models can be useful in forecasting agricultural production in similar contexts, consistent with the results obtained by Mandal (2005) for sugarcane production in India [10].

4. SUMMARY AND CONCLUSIONS

The study employed the Box-Jenkins approach to forecast maize production in Telangana state. It analyzed 55 years of empirical annual maize production data. Initially, the maize production data was non-stationary, but it was transformed to stationary after taking the first difference, as confirmed by the Augmented Dickey Fuller (ADF) test.

Based on the lowest Akaike Information Criterion (AIC) value, the ARIMA (0,1,1) model was selected as the most suitable for forecasting maize production in Telangana. Diagnostic checks were performed on the fitted model, including examining the residuals to test for randomness. The autocorrelation and partial autocorrelation plots of residuals showed randomness, and the ADF test of residuals supported the adequacy of the model.

Using the ARIMA (0,1,1) model, maize production in Telangana is forecasted to be 23.10 lakh tonnes in 2022-23, 23.46 lakh tonnes in 2023-24, and 23.82 lakh tonnes in 2024-25. These forecasts will provide valuable insights for policymakers and stakeholders in the agricultural sector.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models

(ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFFERNCES

1. IIMR. Indian Institute of Maize Research. Government of India; 2023-24.
2. DES. Directorate of Economics and Statistics. Government of Telangana; 2022-23.
3. TS Agriculture, www.tsagriculture.com 2022-23.
4. IIMR. Indian Institute of Maize Research. Government of India; 2023-24.
5. DES. Directorate of Economics and Statistics. Government of Telangana; 2021-22.
6. Badmus MA, Ariyo OS. Forecasting cultivated areas and production of Maize in Nigeria using ARIMA Model. Asian Journal of Agricultural Sciences. 2011;3(3):171-176.
7. Kumari RV, Ramakrishna G, Panasa V, Sreenivas A. Price movements of redgram major markets in India by using cointegration analysis. International Research Journal of Agricultural Economics and Statistics. 2019;2(10):234-239.
8. Bourdon MH. Agricultural commodity price volatility: An overview. OECD Food, Agriculture and Fisheries Papers. OECD Publishing; 2011.
9. Box GEP, Jenkins G. Time series analysis, forecasting and control. Holden-Day. San Francisco. CA; 1976.
10. Mandal. Forecasting Sugarcane production in India with ARIMA model. A Journal of Theoretical and Applied Statistics. 2005; 8(2):142-145.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/120260