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Forecasting Groundnut Area, Production and Productivity in Rajasthan, India using ARIMA Model

S. B. Bhusanar [a#*] and Satyveer Singh Meena [b#]

[a] *School of Agri-Business Management, D. Y. Patil Agriculture and Technical University, Talsande Kolhapur, India.*
[b] *Institute of Agri- Business Management, Swami Keshwanand Rajasthan Agricultural University, Bikaner, India.*

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

This paper presents an analysis of the area, production and productivity of groundnut in Rajasthan over the last thirty years and a forecast of these variables using the auto regressing integrated moving average (ARIMA) model. Descriptive statistics show that there was a large fluctuation in the lowest and maximum values of area, production, and productivity of groundnut in Rajasthan over the period of last thirty years. The ARIMA model was used to forecast the area, production, and productivity of groundnut in Rajasthan. The parameter estimates of the ARIMA model were used to determine the model fit statistics, including the R-squared value, which indicates how well the model fits the data. The Ljung-Box Q Statistics and the corresponding Sig. indicate that there is no significant autocorrelation in the residuals of the model. Finally, forecasts for 2021, 2022, 2023, 2024, and 2025 are presented, along with their corresponding upper and lower confidence limits.

[#] *Assistant Professor;*
**Corresponding author: E-mail: sbb.iabm@gmail.com;*

The results indicate that there is a considerable upward trend in area, production, and productivity of groundnut in Rajasthan over the last thirty years. The ARIMA model was found to be successful in forecasting the area, production, and productivity of ground. The findings of this paper can help in the formulation of better policies for groundnut production in Rajasthan.

Keywords: Forecasting; ARIMA; SPSS; groundnut; area; production; productivity.

ABBREVIATIONS

ARIMA : Auto Regressive Integrated Moving Average Model
SPSS : Statistical Package for the Social Sciences
CAGR : Compound Annual Growth Rate
SD : Standard Deviation
CV : Coefficient of Variation
HYV : High Yielding Varieties

1. INTRODUCTION

Groundnut is a major oilseed crop around the world. It is also known as the 'King' of oilseeds and is known as peanut or monkey nut over the world. This plant originated in Brazil and is now farmed throughout the world's tropical, subtropical, and warm temperate zones. Groundnut's botanical name, *Arachis hypogaea* L., is derived from two Greek words: Arachis, which means legume, and hypogaea, which means below ground. Groundnut is an important crop in Rajasthan, and it is the state's second largest producer after Gujarat, accounting for 20% of total production in 2018-2019 (FAO, 2020). Bikaner and Jodhpur are the most productive groundnut producing districts in Rajasthan, accounting for 30% and 15% of total production, respectively [1]. Since the previous decade, there has been a significant surge in demand for groundnut and confectionary-based groundnut goods all over the world. Rajasthan state ranks second in terms of production, but seventh in terms of processing and export when compared to other Indian states (APEDA, 2020).In an uncertain sector like agriculture, accurate and timely estimates provide valuable and practical recommendations for successful, foresighted, and attentive planning.

The objectives of this paper is to understand the change in groundnut area, production, and productivity in Rajasthan, as well as to forecast crop area, production, and productivity. This approach enables improved policy decisions in terms of food nutrition security and land use allocation. Among other things, our approach for generating a support policy choice, optimal land use allocation, and environmental concerns. The ARIMA model is most commonly used it for forecasting time series that are based on the publications. A univariate time series model is forecasted using the auto regressing integrated moving average (ARIMA) model. It would help to emphasize the need for collaboration and communication between stakeholders in order to ensure that accurate and timely information is available to all parties in Rajasthan

2. LITERATURE REVIEW

Chaudhari & Tingre [2] discussed the use of ARIMA models to forecast the Green gram prices for Maharashtra. The study used time series data of monthly average prices for the period from January 2001 to September 2012 of Akola market. To test the reliability of the model, R2, Mean Absolute Percentage Error (MAPE), and Bayesian Information Criterion (BIC) were used. The results of the study showed that the ARIMA (0,1,0) model was the best fitted model with the lowest BIC value. Based on the model results, the estimated Green gram prices for Maharashtra were projected to increase.

Celik et al. [3] presented a detailed analysis of the time series modelling of annual groundnut production amounts from the period of 1950-2015. The authors conducted a process of non-stationarity transformation to make the data suitable for forecasting, and then applied several candidate ARIMA models to the data. After testing and assessing the different models, the authors found that the ARIMA (0,1,1) model was the best fit for the data, and used it to forecast groundnut production amounts up to the year 2030.

Darekar & Reddy [4] examines the use of the ARIMA model to forecast the price of groundnut in the major producing states in India during the kharif harvesting season of 2017-18. The authors use the time series data of monthly average prices for the period of 11 years (January 2006 to December 2016) to develop the ARIMA model. The authors use various parameters such as R2, RMSE, MAPE, MAE and normalized BIC to test the reliability of the model. The authors conclude that the model is reliable and can be used to help farmers make better marketing decisions.

Mohapatra et al. [5] conducted study about "Price Forecasting of Groundnut in Odisha" provides a valuable insight into the current market situation and future trends in the groundnut price of Jajpur market. The researcher has used Seasonal ARIMA model to build an appropriate forecasting model for the price of groundnut. The results of the study have revealed that the forecasted groundnut price of Jajpur market has increased gradually from January 2018. The findings of the study are useful for farmers to take decision on time of marketing and to reap maximum benefit.

Kumar et al. [6] discussed the use of ARIMA models for forecasting groundnut production in the New Andhra Pradesh state of India. It is noted that the agricultural sector of the region accounts for a large share of the state's GDP and employs a significant portion of the labour force. The analysis is based on time series data covering the 2003-2018 period, with the aim of determining the best ARIMA model for fitting and forecasting of groundnut area, yield and production.

3. MATERIALS AND METHODS

Rajasthan is India's second greatest producer of groundnuts. According to the availability of time series data connected to groundnut prices from secondary sources, 30 years (from June 1991 to June 2021) have been collected. Forecasting the area, production, and productivity of groundnut in Rajasthan using statistics.

A. Objectives of the study

1. Forecasting of Area, Production and Productivity of groundnut in Rajasthan

B. Statistical analysis

The data was assessed with the help of statistical software SPSS for SD, level of significance, compound growth rate, ARIMA model etc. are given below

1. Coefficient of Variation

$$\text{C. V. (\%)} = \frac{\text{Standard deviation}}{\text{Mean}} \times 100$$

2. ARIMA

Time series data is analysed and forecasted using the ARIMA model. A value in a response time series is predicted by an ARIMA model as a linear mixture of its own prior values. Box and Jenkins (1976) pioneered the ARIMA technique, and ARIMA models are frequently referred to as Box-Jenkins models [4]. The model diagnostics were checked using the minimum of root mean squared error (RMSE), Akaike Information Criteria (AIC), and Schwarz Bayesian Information Criteria (SBIC). The ARIMA analysis work is in four stages:-

1. Identification Stage.

2. Estimation Stage,3. Diagnostic Checking, 4. Forecasting Stage.

The general functional form of ARIMA (p,d,q) model is:

$$\Phi p(B)\Delta d\ yt = c + \theta q\ (B)at$$

where,

y = Area, Production, Productivty
B = Lag operator
a = Error term (Ŷ-Y, where Ŷ is the estimated value of Y)
t = time subscript
θp (B) = non-seasonal AR i.e. the autoregressive operator,
represented as a polynomial in the back shift operator
∆d = non-seasonal difference
θq(B) = non-seasonal MA i.e. the moving-average operator,
represented as a polynomial in the back shift operator
Φ's and θ's are the parameters to be estimated

4. RESULTS AND DISCUSSION

Descriptive statistics show the mean, maximum (Max.) and minimum (Min.) values in addition to other statistical properties. Table 1. demonstrates that there was a large fluctuation in the lowest and maximum values of area, production, and productivity of groundnut in Rajasthan over the period of last thirty years.

For Groundnut production, the standard deviation value (Stdev.) for each variable is excessively high, creating an erratic pattern. The coefficient of variation (CV), [7] which compares the amount of variation between two data series, is useful even when the means are significantly different. It is calculated using the ratio of standard deviation to mean. A distribution or data collection is considered to be symmetric (Skewness value around zero) if it appears the same to the left and right of the centre point [6,8,9]. Kurtosis is a metric used to determine how heavily or thinly tailed the data are in relation to a normal distribution.

Table 1. Descriptive statistics for groundnut in Rajasthan from 1991-92 to 2019-20

	Mini	Maxi	Mean	Std. Dev.	CV (%)	Skewness	Kurtosis
Area	195	739.02	359.38	140.25	3.12	1.451	1.171
Production	166.1	1619.33	534.31	407.73	6.10	1.326	0.603
Productivity	687	2191	1374.4	455.04	2.64	0.456	-1.154

(Source: Researcher's own computation from Secondary data)

Table 2. Parameter estimates of ARIMA Model

					Estimate	SE	t	Sig.
Area-Model_1	Area	Square Root	**Constant**		.037	.019	1.957	.062
			AR	Lag 1	-.534	.172	-3.097	.005
			Difference		2			
			MA	Lag 1	.996	4.210	.237	.815
Production-Model_2	Production	Square Root	**Constant**		.092	.046	2.011	.055
			AR	Lag 1	-.609	.161	-3.776	.001
			Difference		2			
			MA	Lag 1	.990	2.252	.440	.664
Production-Model_3	Production	Square Root	**Constant**		.026	.065	.400	.692
			AR	Lag 1	-.591	.162	-3.647	.001
			Difference		2			
			MA	Lag 1	.990	2.206	.449	.658

(Source: Researcher's own computation from Secondary data)

The table above presents the parameter estimates of an ARIMA model. The estimates are for the area, production and productivity models. The estimates include the constant, AR Lag 1, Difference, and MA Lag 1. The constant is the intercept of the model and is represented by a number between 0 and 1, indicating the magnitude of the model's intercept. The AR Lag 1 is the autoregressive coefficient, which indicates the magnitude of the effect of the previous observation on the current one. The Difference is the order of the model's differencing, which determines how many times the series must be differenced before it becomes stationary. The MA Lag 1 is the moving average coefficient, which indicates the magnitude of the effect of the moving average error on the current observation. The SE and t values are the standard errors and t-statistics, respectively, which indicate the strength of the parameter estimates. The Sig. value indicates the significance of the parameter estimates, with lower values indicating more significance.

The above table shows that the model fit statistics. The Area-Model_1 has 0 predictors and an R-squared value of 0.905, which suggests that the model is a good fit for the data. The MAPE value of 9.895 indicates that the model is reasonably accurate, with an RMSE value of 116.825 [3]. The Normalized BIC value of 7.987 indicates that the model is parsimonious. The Ljung-Box Q Statistics (15.504) and the corresponding Sig. (.488) indicate that there is no significant autocorrelation in the residuals of the model [4].

The Production-Model_2 also has 0 predictors and an R-squared value of 0.873. The MAPE value of 28.855 suggests that the model is still reasonably accurate, with an RMSE value of 362.824. The Normalized BIC value of 10.435 indicates that the model is parsimonious. The Ljung-Box Q Statistics (19.148) and the corresponding Sig. (.261) indicate that there is no significant autocorrelation in the residuals of the model [10].

Table 3. Diagnostic checking of residuals autocorrelations

Model fit statistics							
Model	**Number of Predictors**	**R-squared**	**MAPE**	**RMSE**	**Normalized BIC**	**Ljung-Box Q Statistics**	**Sig.**
Area	0	.905	9.895	116.825	7.987	15.504	.488
Production	0	.873	28.855	362.824	10.435	19.148	.261
Productivity	0	.496	21.239	658.563	11.964	16.567	.414

(Source: Researcher's own computation from Secondary data)

Finally, the Pr-Model_3 has 0 predictors and an R-squared value of 0.496. The MAPE value of 21.239 suggests that the model is not very accurate, with an RMSE value of 658.563. The Normalized BIC value of 11.964 indicates that the model is not very parsimonious [11,5]. The Ljung-Box Q Statistics (16.567) and the corresponding Sig. (.414) indicate that there is no significant autocorrelation in the residuals of the model [2,12].

Area: The forecast for 2021 predicts an area of 784.04, with an upper confidence limit (UCL) of 928.22 and a lower confidence limit (LCL) of 649.35. This means that the actual area is likely to fall between the two values. The forecasts for 2022, 2023, 2024, and 2025 are 846.27, 905.36, 972.99, and 1043.07 respectively, with corresponding UCL and LCL values. Production: The forecast for 2021 predicts a production of 1762.47, with an upper confidence limit (UCL) of 2354.97 and a lower confidence limit (LCL) of 1238.01. This means that the actual production is likely to fall between the two values. The forecasts for 2022, 2023, 2024, and 2025 are 1992.71, 2197.07, 2450.87, and 2708.08 respectively, with corresponding UCL and LCL values. Pr: The forecast for 2021 predicts a Pr of 2271.27, with an upper confidence limit (UCL) of 3193.84 and a lower confidence limit (LCL) of 1474.15. This means that the actual Pr is likely to fall between the two values. The forecasts for 2022, 2023, 2024, and 2025 are 2389.50, 2491.43, 2610.84, and 2728.00 respectively, with corresponding UCL and LCL values [13,14].

Table 4. Forecast values of area, production, productivity

		Forecast				
Model		**2021**	**2022**	**2023**	**2024**	**2025**
Area	Forecast	784.04	846.27	905.36	972.99	1043.07
	UCL	928.22	1014.06	1119.96	1220.91	1330.93
	LCL	649.35	690.33	708.66	747.18	782.84
Production	Forecast	1762.47	1992.71	2197.07	2450.87	2708.08
	UCL	2354.97	2678.02	3102.45	3499.96	3950.71
	LCL	1238.01	1387.72	1416.39	1551.22	1653.61
Productivity	Forecast	2271.27	2389.50	2491.43	2610.84	2728.00
	UCL	3193.84	3428.63	3826.49	4121.12	4471.31
	LCL	1474.15	1500.45	1387.74	1380.09	1335.93

UCL & LCL - Upper and lower confidence limits (95%) (Source: Researcher's own computation from Secondary data)

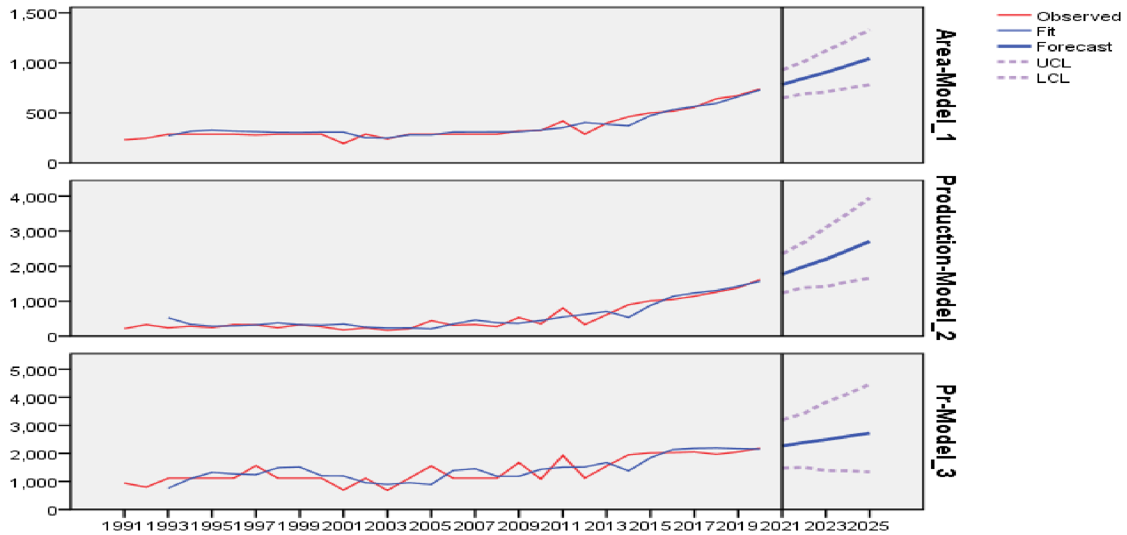

Fig. 1. Forecast values of area, production, productivity

It was determined that the ARIMA model was more effective at predicting the Area [ARIMA (10,1,1,)] of groundnut in Rajasthan. Table 4 displays the measured values of groundnut area, production, and productivity in Rajasthan along with their corresponding relative deviations [15]. Groundnut production, productivity, and area modelling and forecasting in Rajasthan could all be done successfully using the ARIMA model [16,17]. The estimated values of Area, Production, and Productivity Groundnut in Rajasthan as relative departure of the allowed limits are displayed in Table 4. It has been discovered that there is a considerable upward trend in these variables. For calculating Area, Production, and Productivity of Groundnut in Rajasthan [18-20]. The degree of accuracy attained by ARIMA (0,1,1) was found to be sufficient.

5. CONCLUSION

In this study has used descriptive statistics, autocorrelation, and ARIMA models to analyze and forecast the area, production, and productivity of groundnut in Rajasthan. The descriptive statistics show that there was a large fluctuation in the lowest and maximum values of the variables over the last thirty years. Autocorrelation revealed that there was no significant relationship between production in different periods. The ARIMA model was found to be effective in predicting the Area of groundnut in Rajasthan with an R-squared value of 0.905, an MAPE value of 9.895, and an RMSE value of 116.825. The Ljung-Box Q Statistics and the corresponding Sig. values indicated that there was no significant autocorrelation in the residuals of the model. Table 4 presents the forecast values for 2021-2025 for area, production, and productivity of groundnut in Rajasthan, along with their corresponding upper and lower confidence limits. Overall, it can be concluded that ARIMA (0,1,1) was a suitable model for forecasting the area, production, and productivity of groundnut in Rajasthan.

6. SCOPE OF THE STUDY

Analysing the current production and productivity of groundnut in Rajasthan. Estimating the future production and productivity of groundnut in Rajasthan region. Estimating the potential areas where groundnut can be cultivated in Rajasthan. Assessing the impact of climate change on the production and productivity of groundnut in Rajasthan. Identifying the challenges faced by the farmers in cultivating groundnut and suggesting the possible solutions to address them. Creating awareness among the farmers about the importance of groundnut cultivation and its benefit to the state.

7. LIMITATIONS OF STUDY

Lack of accurate data: Accurate data is essential for forecasting, but it can be difficult to obtain in the case of groundnut production in Rajasthan. Data may not be available for the historical period, or it may be unreliable or incomplete. Limited resources: Forecasting requires resources such as time, money and personnel. Rajasthan may not have the necessary resources to properly conduct a forecasting analysis. Lack of expertise: To effectively forecast groundnut production in Rajasthan, expertise in areas such as agriculture, economics, climate science and market analysis is required.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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