Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2020; 9(1): 1802-1807
Received: 01-11-2019
Accepted: 03-12-2019

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Jute price forecasting in Murshidabad market of west Bengal using ARIMA technique

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Abstract
The present study is an attempt to forecast the prices of jute in the markets of Murshidabad district of West Bengal. The time series data on monthly price of jute required for the study was collected from AGMARKNET website for the period January, 2002 to December, 2019. The seasonal ARIMA model was used for the modelling of price using the Box-Jenkins technique and best model was selected on the basis of lowest RMSE, AIC and MAPE values and the best identified model was ARIMA (1,1,1)(1,0,0)$_{[12]}$. The fitted values for the in-sample period and predicted values for out-sample period were closer to real time price values. The best identified model was used for predicting the future prices of 12 months (January, 2020 to December, 2020). The forecasted price rises from the month of March, 2020 and stabilizes thereafter. The analysis was done in "R" statistical software.

Keywords: ARIMA, AIC, MAPE, forecasting, jute, time series

Introduction
Jute, known as the golden fiber, is an important traditional cash crop in India. In fact, jute is the second most important natural fiber in terms of global consumption after cotton. One of the important characteristics of jute is that it is free from health hazards and environmental pollution. Jute is also versatile, durable, reusable, cheap, and superior to synthetic fibers. Jute is regarded as the best natural substitute for nylon and polypropylene. In agriculture as well as industry, jute directly and indirectly supports employment, commerce and other economic activities. In trade and industry however, in term used as raw jute. Raw jute plays an important role in country's economy, particularly in the eastern and north eastern state. West Bengal is the major jute growing state sharing about three- fourth of the country's production (Mondal *et al*.,2014) [13]. Although jute has been recognized as a solution to produce eco-friendly products for the future, the production of jute and jute products are actually declining globally. This is mainly due to the availability of plastic substitutes, which is likely to continue in the future.
India is the single largest producer of jute goods in the world, contributing about 60% of the global production. The domestic market continues to be the mainstay of industry consuming about 87% of the total production (Kundu D.K.,2016) [12]. In India, Its grown on 0.686 m.ha. area, and production of 9.6 million bales (of 180kgs each). West Bengal is the most leading state of jute production in the country, followed by Bihar and Assam. In West Bengal, it is grown on 0.515 m.ha. area, and production of 7.511 million bales (of 180kgs each), (Indiastat, 2018-19). About 90% of the jute farmers in India belong to the marginal and small categories of which almost 65% are with 1 hectare and below and 25% with 2 ha and below land holdings (Kundu D.K.,2016) [12].
The present study is aimed to forecast the wholesale prices of jute for the markets of Murshidabad district of West Bengal. As the price of jute keep changing from time to time, it creates risks to producers, traders and consumers involved in production, marketing and consumption of jute. Thus, it is important to forecast the jute prices. Price forecasts are critical to market participants who make production and marketing decisions, and to policy makers who administer commodity programs and asses the market impacts of domestic or international events (Sharma, 2015) [15].

Literature Review
Gupta *et al* (2019) [9] studied on price behaviour of pigeon pea in Kawardha market by using of ARIMA model. Dhakre and Bhattacharya (2014) [8] worked on price behaviour of potato and their forecasting in Agra market using the ARIMA models. Gupta *et al* (2018) [10] forecasting of arrivals and prices of major pulse in Chhattisgarh. Darekar *et al*. (2016) [4, 5] validated that ARIMA model forecasted onion prices in Kolhapur and Yeola markets respectively.

Khin *et al*. (2008) [11] forecasted natural rubber price in world market. Burark and Sharma (2012) [3] confirmed the suitability of ARIMA models in agricultural price forecasting. Ozer and Ilkdogan (2013) [14] examined cotton prices in the world by ARIMA model, by using 102 per month which covered the period January 2004 and June 2012 of the world price of cotton. Shukla and Jharkharia (2011) [16] forecasted wholesale vegetable market in Ahmedabad.
Keeping this mind, the present study has been attempted to forecast the monthly average prices of jute during harvesting season by using Autoregressive Integrated Moving Average (ARIMA) model.

Materials and Methods

Data Collection

The time series data on monthly average price of jute in the markets of Murshidabad district of West Bengal for the period of 18 years from January, 2002 to December, 2019 were collected from AGMARKNET website for present study. Murshidabad district includes 5 markets viz., Beldanga, Jangipur, Jiaganj, Kasimbazar, Lalbagh. Monthly prices of these markets were averaged to use as monthly price for overall Murshidabad District and the same was for modelling and forecasting.

Analytical Method

Box-Jenkins (ARIMA) Model: The Box-Jenkins models (1976), are especially suited to short term forecasting because most ARIMA models place greater emphasis on the recent past rather than the distant past. The ARIMA model analyses and forecasts equally spaced univariate time series data. In this study, the analysis performed by ARIMA is divided into four stages viz., identification, estimation, diagnostics and forecasting. R programming software was used for time series analysis and developing ARIMA models and forecasting jute prices.
The ARIMA(p,d,q) model can be represented by the following general forecasting equation:

$$Y_t = \mu + \sum_{i=1}^{p} \Phi_i Y_{t-i} + \sum_{j=1}^{q} \theta_j \varepsilon_{t-j} + \varepsilon_t$$

where, Y_t is soybean prices, μ is the mean of series, the $\Phi_1, \ldots \Phi_p$ are the parameters of the AR model, the $\theta_1 \ldots \theta_q$ are the parameters of the MA model and the $\varepsilon_t, \varepsilon_{t-1}, \ldots, \varepsilon_{t-q}$ are the noise error terms. The value of p is called the order of AR model while the value of q is called the order of the MA model (Gupta et. al., 2018) [10].
Since seasonal time series data is taken for this study, ARIMA model can be extended easily to handle seasonal aspects denoted as ARIMA(p,d,q) (P,D,Q), where the small letter parentheses part (p,d,q) indicates the non-seasonal part of model while the capital letter part (P,D,Q) indicates the seasonal part of models being the number of periods per season (Barathi 2011) [1]. The general seasonal autoregressive integrated moving average (SARIMA) model written as follows:

$$\Phi_P(B^s)\phi_p(B)\, \nabla_s^D \nabla^d\, Y_t = \theta_q(B)\Theta_Q(B^s)\varepsilon_t$$

where,

- $\Phi_P(B^s) = (1 - \Phi_1 B^s - \ldots - \Phi_P B^{sP})$ is the seasonal AR operator of order P ;
- $\phi_p(B) = (1 - \phi_1 B - \ldots - \phi_p B^p)$ is the regular AR operator of order p;
- $\nabla_s^D = (1 - B^s)^D$ represents the seasonal differences and $\nabla_s^D = (1 - B)^d$ the regular differences;
- $\Theta_Q(B^s) = (1 - \Theta_1 B^s - \ldots - \Theta_Q B^{sQ})$ is the seasonal moving average operator of order Q;
- $\theta_q(B) = (1 - \theta_1 B - \ldots - \theta_q B^q)$ is the regular moving average operator of order q;
- ε_t is a white noise process;

Identification Stage

Model identification involves defining the orders (p, d, and q) of the AR and MA components of the time series model. The first stage of ARIMA modelling is to identify that the variable, which is about to be forecasted, is a stationary time series or not. Stationary means the values of variable over time fluctuates around a constant mean and variance. The ARIMA model cannot be made until we make the series stationary. First, we have to take the difference of the time series 'd' times to obtain a stationary series to obtain an ARIMA (p, d, q) model, where 'd' is the order of differencing.
There should a Caution is to be taken in differencing the time series as over differencing will lead to increase the standard deviation, rather than the reduction. The best idea is to start the differencing with the lowest order (first order, d = 1) and then test the unit root problems for the data.
Before moving further, we will have to test the differenced time series for stationarity (unit root problem) by Augmented Dickey-Fuller test (ADF). After that, best fit ARIMA models were developed using the data from January 2002 to December 2019 and used to forecast the prices during harvesting season.

Criterion of Model Selection: The best model was selected based on the following criterions.

I) **Low Akaike Information Criteria (AIC):** AIC is estimated by

$$AIC = -2\ln(L) + 2K$$

Where, *K*= Number of Parameters and *L*= Maximized log likelihood

II) **Mean Absolute Percent Error (MAPE)**: It is a measure of percentage error for the model and it can be easily to understood for model accuracy.

$$MAPE = \frac{1}{n}\sum_{i=1}^{n} \frac{|(y_i - \hat{y}_i)|}{\hat{y}_i} \times 100$$

Where, y_i = i^{th} actual value and $\hat{y}_i$ = i^{th} predicated value

III) **R.M.S.E (Root Mean Square Error):** Root Mean Square Error is defined as the differences between the value of population and sample predicted by a model and actually observed values.

$$RMSE = \sqrt{\frac{R_{res}SS}{n-p}}$$

Results and Discussion

Model identification

The first step in developing a ARIMA model is to determine if the monthly jute price series are stationary. For this, we used the Augmented Dickey-Fuller test (ADF), which was performed to determine if the series is stationary or not. The test confirmed that the data was nonstationary for without difference. In this case differencing of lag 1 gave significant result, so with differencing of lag 1(d =1) is stationary in respect to mean and variance. Thus, there is no need of further differencing the time series and then the adopted difference order is d = 1 for the ARIMA (p, d, q) model. The test statistic and its p-value is presented in Table 1.

Table 1: Augmented Dickey-Fuller test

Without difference	Dickey-Fuller statistic = -3.3176	p-value =0.0697
With difference	Dickey-Fuller statistic = -5.2579	p-value =0.01

This test allows to go further in the steps for ARIMA model development which are to find out the appropriate values of (p,d,q) (P,D,Q). It was done by observing Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) values. The Auto Correlation Function helps in choosing the appropriate values for ordering of moving average terms (MA) and Partial Auto-Correlation Function for those autoregressive terms (AR). The ACF graph showing significant spike at lag 1 but there is no significant spikes at seasonal lags (lag 12, 24) which gives us the non-seasonal and seasonal MA orders i.e. q=1 and Q=0. Similarly, PACF graph showing significant spike at lag 1 but no significant spikes at seasonal lags (lag 12, 24) which gives us the non-seasonal and seasonal AR orders i.e. p=1 and P=1. These are tentative orders and we tried some other models similar to these models.

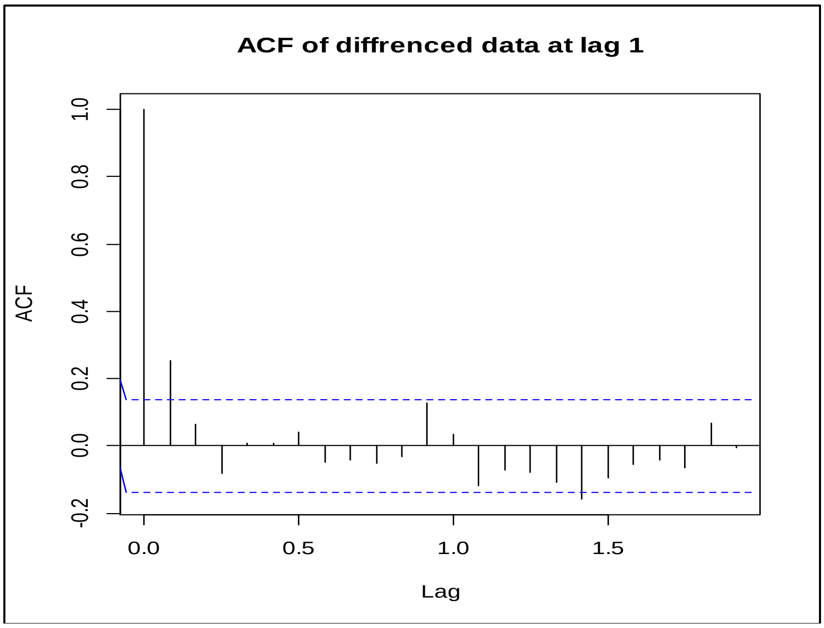

Fig 2: Autocorrelation Function (ACF) of first differenced series by lag

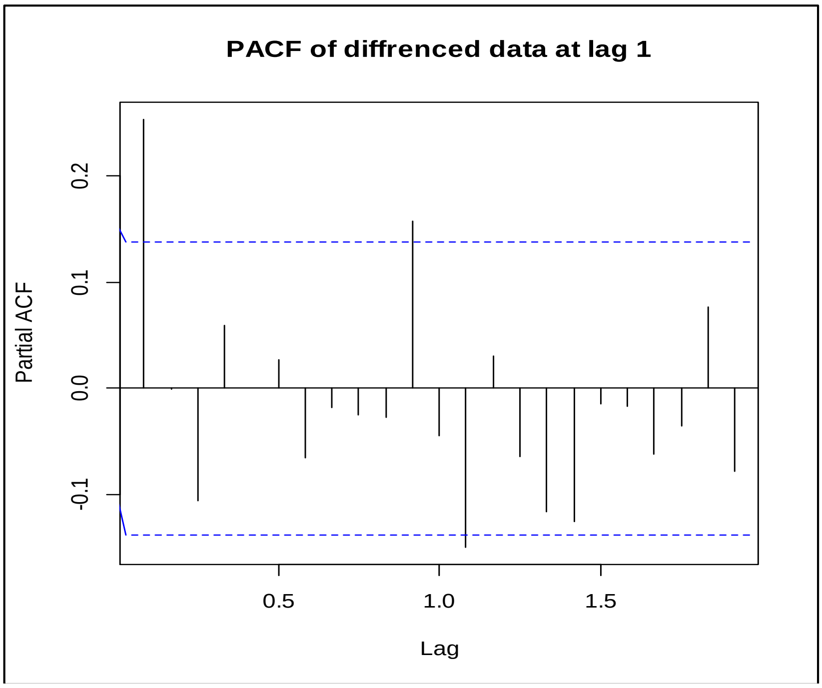

Fig 3: Partial Autocorrelations Function of first differenced time series by lag

The lowest values of RMSE, MAPE, and AIC, the model ARIMA (1,1,1) and ARIMA $(1,1,1)(1,0,0)_{[12]}$ were best fitted model for Murshidabad district. The results of these coefficients are given in Table 2. ARIMA model was estimated after transforming the variables under study into stationary series through computation of either seasonal or non-seasonal or both, order of differencing. A careful examination of ACF and PACF up to 24 lags revealed the presence of seasonality in the data.

Table 2: Residual analysis of monthly prices of jute in Murshidabad district

In Sample					Out Sample
S.N	**MODELS**	**RMSE**	**MAPE**	**AIC**	**MAPE**
1.	ARIMA (1,1,1)	10.45032	0.346278	2664.61	6.34127
2.	ARIMA $(1,1,1)(1,0,0)_{[12]}$	10.12219	0.341314	2666.27	5.827544

The model verification is concerned with checking the residuals of the model to see if they contained any systematic pattern which still could be removed to improve the chosen ARIMA (Darekar and Reddy, 2017) [7]. After model validation, MAPE value found to be 6.34127 and 5.827544 for ARIMA (1,1,1) and ARIMA $(1,1,1)(1,0,0)_{[12]}$ respectively. The model ARIMA $(1,1,1)(1,0,0)_{[12]}$ have lowest MAPE over ARIMA (1,1,1). Hence we conclude that model ARIMA $(1,1,1)(1,0,0)_{[12]}$ was best fitted for forecasting jute price in market of Murshidabad district of west Bengal. The results show that autocorrelations of residuals were not significantly different from zero at any reasonable level. This proved that the selected ARIMA model was an appropriate model for forecasting soybean price in market of Murshidabad district. The result of Box Ljung Q statistics also confirms the same. The results of diagnostics a represented in fig.3 and fig.4.

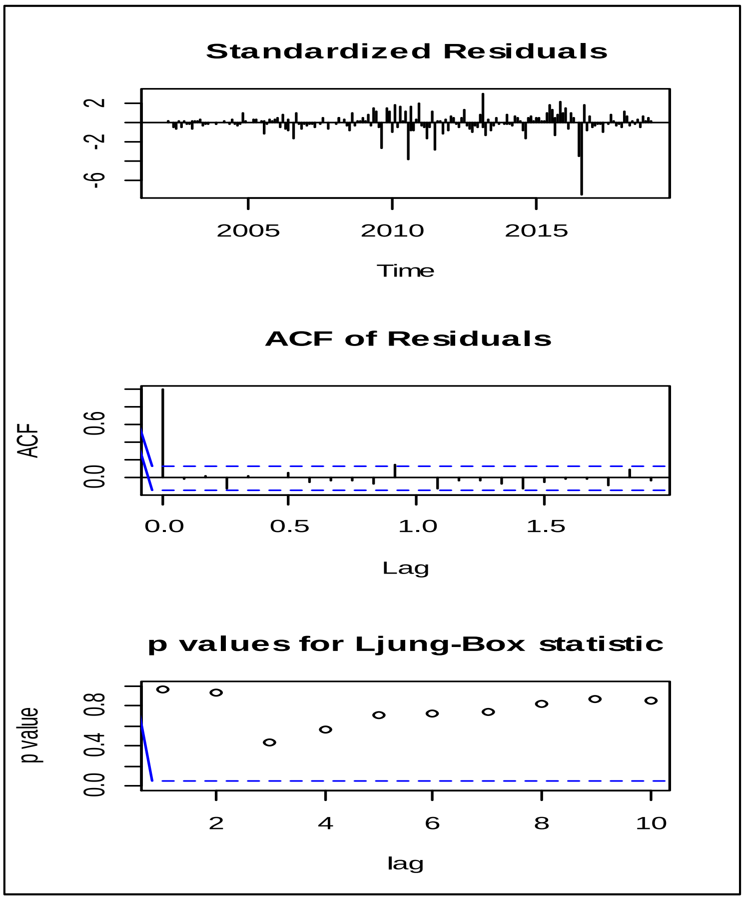

Fig 3: Residuals analysis of model ARIMA $(1,1,1)(1,0,0)_{[12]}$.,

Forecasting using selected model ARIMA $(1,1,1)(1,0,0)_{[12]}$:
The above selected model ARIMA $(1,1,1)(1,0,0)_{[12]}$, which we are fitting to our time series data. The results of forecast of prices of jute are shown in the Table 3. The forecasts indicate that there are narrow variations in between the actual and forecasted values of prices of jute in the selected state and the forecasted values of prices showed an increasing trend in the future months. The result suggests that the price of jute will range from 3788.46 to 3789.67 from January, 2020 to December, 2020. The result shows the price increases from the month of March, 2020 and stabilizes thereafter. The graphical representation of sample period forecasts and post sample period forecasts are presented in which shows that actual values of prices and fitted values from selected model were closer.

Table 3: Forecasts of jute prices in Murshidabad district

Month	Year	Forecasted prices	Low 80%	High 80%	Low95%	High 95%
Jan	2020	3788.468	2759.562	4817.375	2214.892	5362.045
Feb	2020	3788.948	2716.377	4861.519	2148.593	5429.304
Mar	2020	3789.105	2674.414	4903.796	2084.332	5493.877
Apr	2020	3789.055	2633.736	4944.374	2022.147	5555.964
May	2020	3789.089	2594.51	4983.667	1962.139	5616.038
Jun	2020	3789.059	2556.469	5021.65	1903.975	5674.144
Jul	2020	3789.179	2519.714	5058.645	1847.699	5730.659
Aug	2020	3789.094	2483.794	5094.393	1792.81	5785.377
Sep	2020	3789.302	2449.127	5129.478	1739.68	5838.924
Oct	2020	3789.401	2415.234	5163.568	1687.794	5891.009
Nov	2020	3789.566	2382.228	5196.904	1637.228	5941.903
Dec	2020	3789.675	2349.93	5229.419	1587.775	5991.574

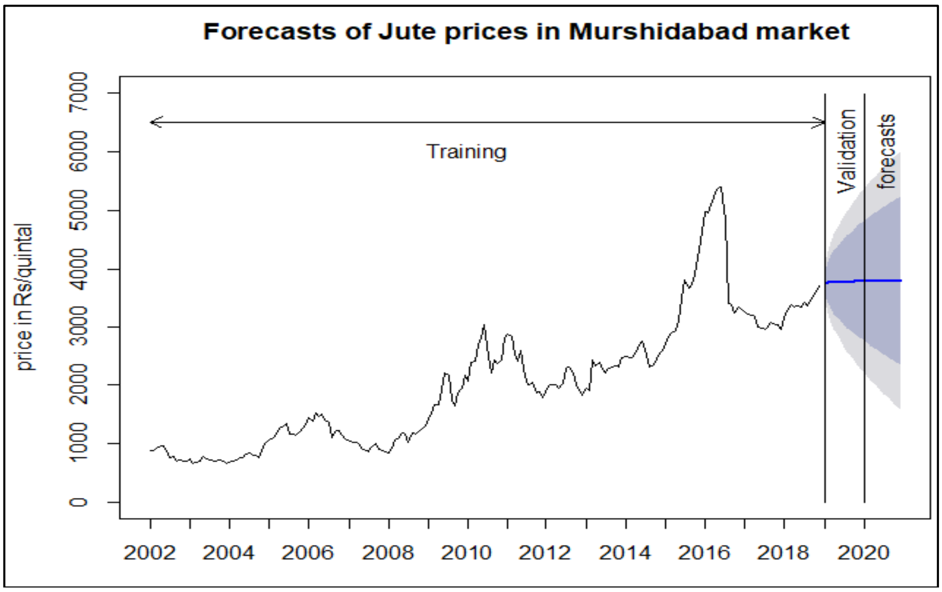

Fig 5: Fitted and forecasted values of jute prices in Murshidabad district.

Conclusion

The paper forecasted jute prices for the year 2020 by using historical monthly prices. The study analysed the time series data of prices of jute through ARIMA modelling and concluded that ARIMA (1,1,1) (1,0,0) [12] is best identified model for forecasting of jute prices in Murshidabad market. The study also concluded that there is rise in prices from the month of January, 2020. The fitted values by selected ARIMA model were closer to the real time price values. The ARIMA model forecasted prices revealed an increase in the prices of jute in the future years and also demand for the crop. Hence, increase in the area of production of jute and their sale in the suitable markets can be planned suitably.

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