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*Research Article*

# Forecasting wheat prices in India

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## Abstract

**Wheat is the single most important crop after paddy, which plays vital role in the Indian economy. In this paper, ARIMA model was used to predict the future harvest period prices of wheat before the sowing date to facilitate farmers to make decision on their acreage under wheat. For this, a monthly data of modal prices from January, 2006 to June, 2017 were used for model fitting and forecasting. The best fit ARIMA models were selected based on autocorrelation function and partial auto correlation function at various lags. Forecasting performance of this model was evaluated with 95% confidence interval using criterions like MAE, MAPE and RMSE. Model parameters were estimated by using the Statistical Packages for Social Sciences (SPSS) software. Empirical results showed that ARIMA (0,1,1) (0,1,1) model was found suitable to forecast the future prices of wheat in India during harvesting season with 95% accuracy level. This model can facilitate the farmers and wholesalers in effective decision making. In India, wheat is harvested during the month of February to May. Forecast shows that market prices of wheat, would be ruling in the range of Rs. 1,620 to 2,080 per quintal during harvesting season, 2017-18. The farmers are advised to take sowing and marketing decision accordingly.**

**Keywords :** ACF, ARIMA, Box and Jenkins, Forecasting, PACF, Wheat

## 1. Introduction

Wheat (*Triticum aestivum*) is the most important food grain crop of the world. According to the FAO forecast, the production of wheat in 2017/18 will be 757.4 million tonnes (MT), 0.28 per cent less than the previous year (www.fao.org), while the consumption is set to increase by 0.34 per cent to 736.4 million tonnes. China is the largest producer of wheat with 125 million tonnes followed by India (98.51 million tonnes). India accounts for about 13% of the total wheat production in the world. Wheat crop occupy about 13% of gross cropped area in India.

Wheat is the second most important cultivated food crop in India and feeds hundreds of millions of population on a daily basis. It is an important staple food in the northern and northwestern states of the country. In India, the introduction of the 'Green Revolution' plan led to a massive increase in wheat production, with a doubling of national wheat yields seen within the single decade between 1960 and 1970 (Reddy, 2016a and 2016b). Uttar Pradesh, Punjab, Haryana, Madhya Pradesh and Rajasthan are the leading wheat producing states together contributes to about 82% of the country's wheat production.

*1.1 International wheat markets*

Canada was the leading wheat exporting country in the world followed by US and Russia during 2015-16. Algeria was the largest importing country in the world followed by Italy, Indonesia and Japan in 2015-16. India was net wheat exporter until 2014-15, but since 2016-17 India was net importer (USDA, 2018).

International prices of wheat are highly fluctuating month-on-month, as Indian domestic wheat prices are also influenced by the international prices in the liberalized and open food import and export scenario. Procurement at MSP is limited to less than 20% of wheat production, the reaming sales should be in open market, which were influenced by the international prices, price forecasting provides important information for decision making not only for farmers how much acreage to allocate to wheat, but also gives useful information to traders when to sell etc.

*1.2 Domestic wheat markets and objectives of the study*

Although area, production and productivity increased over the years, price fluctuations are higher in wheat due to market imperfections. Table 2 show that year after year variation in the area, production and productivity of wheat in India is less. Despite the decrease in area during 2016 the production has increased significantly due to higher productivity.

**Table 1.** Global wheat demand and supply

| Item | 2013-14 | 2014-15 | 2015-16 | 2016-17 | 2017-18 |
|---|---|---|---|---|---|
| Production(MT) | 713.1 | 731.8 | 734.2 | 759.6 | 757.4 |
| Supply(MT) | 890.3 | 922.6 | 944.9 | 990.0 | 1009.4 |
| Utilization(MT) | 691.2 | 712.0 | 709.5 | 733.9 | 736.4 |
| Trade(MT) | 159.1 | 156.8 | 166.7 | 176.6 | 173.8 |
| Ending stocks(MT) | 190.8 | 210.8 | 230.4 | 252.0 | 272.0 |
| World stock-to-use ratio (%) | 26.8 | 29.7 | 31.4 | 34.2 | 36.3 |
| Major exporters' stock-to-disappearance ratio (%) | 15.1 | 17.6 | 17.3 | 19.5 | 20.0 |

Source: FAO(2018)

Note: Production data refer to the calendar year of the first year shown. Supply= Production plus opening stocks. Trade data refer to exports based on a July/June marketing season for wheat. Stocks may not equal the difference between supply and utilization due to differences in individual country marketing years. Major wheat exporters are Argentina, Australia, Canada, the EU, Kazakhstan, Russian Federation, Ukraine and the United States. Disappearance is defined as domestic utilization plus exports for any given season

**Table 2.** Area, production and yield of wheat in India (2007 to 2016)

| Year | Area (lakh ha) | % Change in area | Production (lakh tonnes) | % Change in Production | Yield (kg/ha) | % Change in Yield |
|---|---|---|---|---|---|---|
| 2007 | 280 | | 758 | | 2708 | |
| 2008 | 280 | 0 | 786 | 4 | 2802 | 3 |
| 2009 | 278 | -1 | 807 | 3 | 2907 | 4 |
| 2010 | 285 | 3 | 808 | 0 | 2839 | -2 |
| 2011 | 291 | 2 | 869 | 8 | 2989 | 5 |
| 2012 | 299 | 3 | 949 | 9 | 3178 | 6 |
| 2013 | 297 | -1 | 935 | -1 | 3154 | -1 |
| 2014 | 305 | 3 | 959 | 3 | 3146 | 0 |
| 2015 | 315 | 3 | 865 | -10 | 2750 | -13 |
| 2016 | 302 | -4 | 935 | 8 | 3093 | 12 |

Source: FAO(2018)

Since 2016-17 wheat consumption is stagnant between 97 to 98 million tonnes (USDA, 2018). Domestic prices have been higher than that of International prices since April, 2015 onwards. This is due to a secular increase of Minimum Support Price (MSP) for wheat in comparison to other crops (http://agricoop.nic.in). Given that the wheat is a major rabi crop occupying about 50% of rabi cropped area, enhancing price information to farmers is important. Farmers are unable to make decisions about the acreage allocation to wheat and other competing crops like chickpeas, mustard etc, due to lack of expected price information during the harvest period. Hence there was a need for building a price forecasting model to guide farmer. The paper examined the different price forecasting tools and selected ARMA model to forecast harvest period prices of wheat by using monthly price data for major wheat producing states

## 2. Materials and methods

For the purpose of forecasting of prices of wheat, the study has used the long range of monthly time series data. The data set covers monthly modal prices of wheat i.e. from January, 2006 to June, 2017 for major producing states viz; Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan and at national level. The last few months are skipped due to unavailability of reliable statistic at the time of data analysis. The data has been collected from AGMARKNET website (www.agmarknet.gov.in). For Seasonal analysis moving average method is used which is the most widely used method of measuring seasonal variations.

Keeping in view the aims of the study and nature of statistical information, the ARIMA methodology developed by Box and Jenkins (1976) has chosen for analysis due to its suitability to our dataset and non-stationary nature of time series to be forecasted. ARIMA is univariate model which has several advantages over its multivariate alternates. In general, an ARIMA model is characterized by the notation ARIMA (p, d, q) where, p, d and q denote orders of auto-regression, integration (differentiation) and moving average, respectively. ARIMA model comprises of linear time series function of past actual values and random shocks.

ARIMA model offers a good technique for predicting the future values or events of any variable. This method is suitable for any time series with any pattern of change. It requires a long time series data for analysis (Biswas *et al*., 2014; Darekar and Reddy, 2017 ). ARIMA models were carried out to explain the fluctuations in production and productivity for wheat crop in Ahmedabad (Singh *et al*., 2015).

## 3. Result and discussion

The seasonal price indices were lowest during April and May(about 95%) as most of the market arrivals comes during these months (Table 3). The price index fluctuated in the range of 95.15 to 109.02 per cent throughout the year. Table 4 shows the price index for before start of the market arrivals (Jan-Feb) was 100 per cent, while during the peak-harvest period was 95.6% and prices index increased to 106% five months after the peak harvest. This indicates, gross returns to storage was about 6% in five months, which is not remunerative to store by the farmers. The data of major wheat producing states *viz;* Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan and country as a whole was collected for wheat price forecasting during harvesting season by using ARIMA model (Table 5). Price indices of wheat was found to be highest during off eason and lowest during harvest season. Since wheat is a rabi crop, the higher seasonal indices of prices were observed during October to February during which the arrivals were found to be low.

Monthly modal prices of wheat was used to fit an ARIMA model as outlined in the methodology. Price series clearly exhibited non-stationary and there was slight seasonality in data. An examination of the ACF and PACF revealed that there was seasonality, but not highly significant. Therefore to make price series stationary, the first difference of price series was done. The computed values of Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) of differenced price series of wheat are shown in Figure 1 with lags up to 24. After the first difference, it was found to be stationary, since, the coefficients dropped to zero after the second lag. Each individual coefficient of ACF and PACF were tested for their statistical significance using t-test. The ARIMA (0,1,0)(0,1,0) model was found to be a good fit for monthly price series. The parameters estimated through an iterative process

**Table 3.** Monthly seasonal price indices of wheat (2006 to 2016)

| Month | Uttar Pradesh | Punjab | Haryana | Madhya Pradesh | Rajasthan | India |
|---|---|---|---|---|---|---|
| Jan | 101.03 | 100.88 | 106.49 | 100.19 | 101.12 | 99.58 |
| Feb | 102.52 | 100.90 | 99.25 | 99.67 | 100.64 | 100.22 |
| Mar | 101.91 | 98.75 | 99.53 | 98.24 | 96.30 | 97.27 |
| Apr | 94.37 | 96.27 | 96.86 | 97.97 | 94.58 | 95.15 |
| May | 96.38 | 96.48 | 95.90 | 99.35 | 95.72 | 95.59 |
| Jun | 96.29 | 96.91 | 95.15 | 97.26 | 96.93 | 96.13 |
| Jul | 96.87 | 101.80 | 94.74 | 97.83 | 98.99 | 98.03 |
| Aug | 98.26 | 101.17 | 96.39 | 98.71 | 99.75 | 99.89 |
| Sep | 99.95 | 98.84 | 100.76 | 99.18 | 100.02 | 99.99 |
| Oct | 101.57 | 99.39 | 102.81 | 100.43 | 101.40 | 102.41 |
| Nov | 104.34 | 102.99 | 105.76 | 105.13 | 106.83 | 106.45 |
| Dec | 106.35 | 105.61 | 106.68 | 105.75 | 107.27 | 109.02 |

Source: AGMARKNET

**Table 4.** Seasonal price indices of wheat (2006 to 2016)

| Period | Uttar Pradesh | Punjab | Haryana | Madhya Pradesh | Rajasthan | India |
|---|---|---|---|---|---|---|
| Before start of market arrivals (Jan-Feb) | 101.8 | 100.9 | 102.9 | 99.9 | 100.9 | 100.0 |
| Peak harvest season (April and May) | 95.4 | 96.4 | 96.4 | 98.7 | 95.2 | 95.4 |
| Five months after peak harvest (Oct-Dec) | 104.1 | 102.7 | 105.1 | 103.8 | 105.2 | 106.0 |

**Table 5.** Model fit statistics of the fitted ARIMA model of monthly prices of wheat

| State | ARIMA Model | MAE | MAPE | RMSE |
|---|---|---|---|---|
| Uttar Pradesh | (0,1,0)(0,1,1) | 36.82 | 3.12 | 53.30 |
| Punjab | (0,1,0)(1,0,1) | 45.84 | 3.89 | 65.12 |
| Haryana | (0,1,1)(1,0,1) | 68.77 | 5.81 | 96.14 |
| Madhya Pradesh | (0,1,0)(0,0,0) | 36.72 | 2.79 | 50.49 |
| Rajasthan | (0,1,0)(0,1,0) | 52.70 | 3.90 | 69.18 |
| India | (0,1,1)(0,1,1) | 43.45 | 3.02 | 55.53 |

by the least square technique which gave the best model are presented in Table 6. The ACF and PACF of the residual indicated the 'good fit' of the model. (Figure 2). The coefficients were statistically significant; hence selected models were deemed as the best fit and used for forecasting. Residuals were obtained by back forecasting to carry out the model adequacy check for the best selected model. The ARIMA (0,1,0)(0,1,1), (0,1,0)(1,0,1), (0,1,1)(1,0,1), (0,1,0)(0,0,0) and (0,1,0)(0,1,0) model were found to be a good fit for forecasting the prices of wheat in Uttar Pradesh, Punjab, Haryana, Madhya Pradesh and Rajasthan respectively.

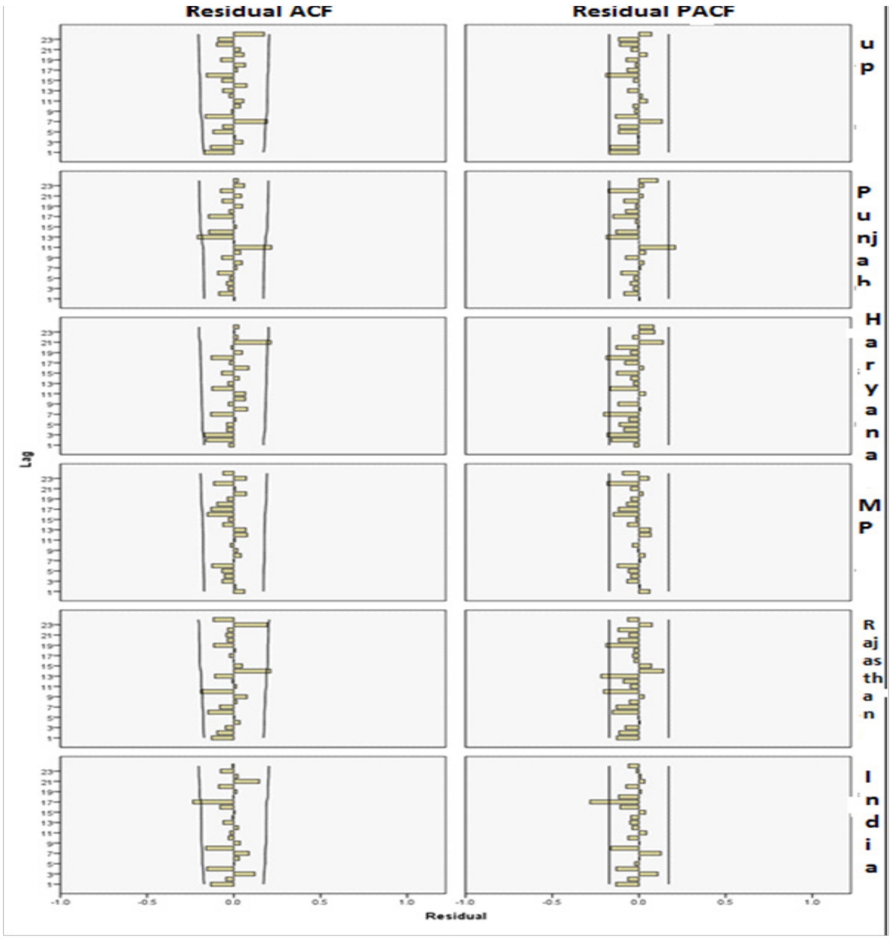


**Fig. 1** ACF and PACF of residuals of ARIMA (0,1,1)(0,1,1) model for wheat prices

The values of MSE, MAPE and RMSE were significant, indicating the accuracy of the forecasts. At country level, ARIMA (0,1,1) (0,1,1) model for wheat were found to be the most appropriate model with 43.45, 3.02 and 55.53 of MAE, MAPE and RMSE respectively. Figure 3 shows observed and forecasted prices of wheat in selected states and India. The figure indicates that the forecasted prices predicts prices with 95% confidence interval. Using the identified models, prices of wheat were forecasted for the harvesting period. As results revealed, the forecasted prices of wheat would be lowest in Rajasthan (Rs. 1,490/q). In case of Haryana, Punjab, Madhya Pradesh and Uttar Pradesh the prices would be Rs. 1,630, 1,660, 1,670 and 1,690 quintal respectively (Table 6). This information on price forecasting could be useful to farmers to make their marketing decisions. Figure 2 Shows the forecasted prices for wheat in selected states during harvesting season 2017-18 (Rs. /q). The comparison of all the ARIMA models was carried out in the process based on the MSE, MAPE and RMSE values which were considered to be least. ARIMA (0,1,1) (0,1,1) model for wheat were found to be the most appropriate model with 43.45, 3.02 and 55.53 of MAE, MAPE and RMSE respectively. The forecasted prices of wheat were almost similar to actual prices with a good validation. Forecast shows that market prices of wheat, would be ruling in the range of Rs. 1,620 to 2,080 per quintal during harvesting season, 2017-18 (Figure 2).

Market information, especially price information is very limited among farmers. Farmers has to get know predicted harvest period prices of different crops before sowing, so that they can take informed decisions keeping the resources and expected prices of different crops. Thus, in present paper a price forecasting model has been built and tested for forecasting wheat harvest period prices for rabi 2017-18 harvest season.

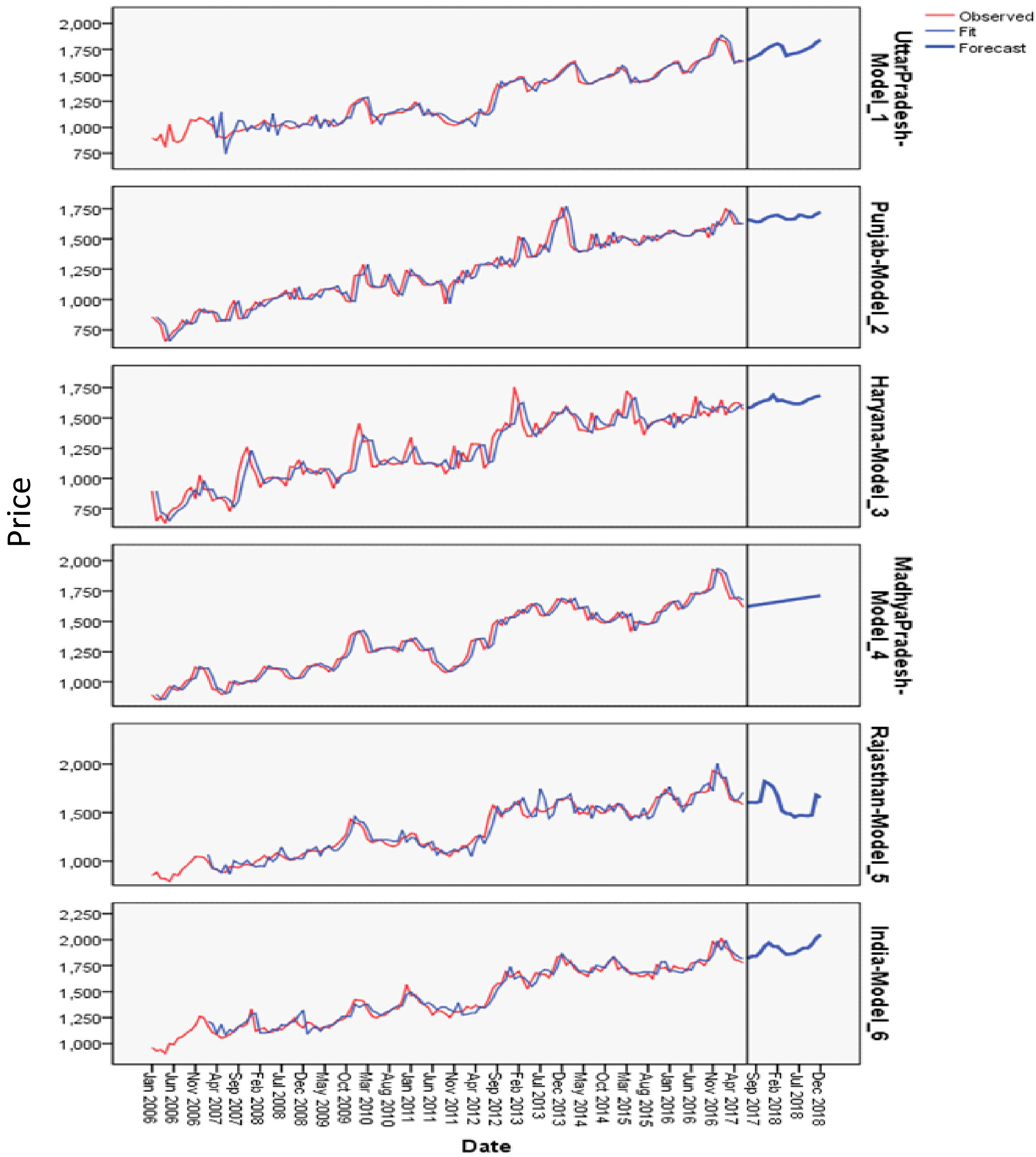


**Fig. 2** Observed and forecasted prices of wheat in selected states and India

**Table 6.** Forecasted prices for wheat in selected states during harvesting season 2017-18 (Rs. /q)

| State | Lower Limit | Forecasting | Upper Limit |
|---|---|---|---|
| Uttar Pradesh | 1,390 | 1,690 | 1,990 |
| Punjab | 1,260 | 1,660 | 2,060 |
| Haryana | 1,210 | 1,630 | 2,030 |
| Madhya Pradesh | 1,350 | 1,670 | 1,990 |
| Rajasthan | 1,060 | 1,490 | 1,920 |
| India | 1,620 | 1,860 | 2,080 |

The paper considered many available price forecasting models and chosen the best fit ARIMA model for price forecasting. The comparison of all the ARIMA models was carried out in the process based on the MSE, MAPE and RMSE values which were considered to be least. ARIMA (0,1,1) (0,1,1) model for wheat were found to be the most appropriate model with 43.45, 3.02 and 55.53 of MAE, MAPE and RMSE respectively. The forecasted prices of wheat were almost similar to actual prices with a good validation. Forecast shows that market prices of wheat, would be ruling in the range of Rs. 1,620 to 2,080 per quintal during harvesting season, 2017-18. The farmers are advised to take sowing and marketing decision accordingly. So that, the ARIMA model stands as a good technique for forecasting the magnitude of any variable. ARIMA is suitable for any time series with any pattern of change and it does not require the forecaster to choose a-priori values of any parameter. It requires long time series (large sample size) for analysis. Similar model was used by Sharma (2015) and Darekar *et al.* (2015) (2016) to forecast the prices of agricultural commodities and drawn conclusions. This forecast is based on past data and ARIMA model and that the forecasted prices predict prices with 95% confidence interval.

## References


1. AGMARKNET(2018) http://agmarknet.gov.in/ website accessed on 1st March 2018.
2. Biswas B, Dhaliwal LK, Singh SP and Sandhu SK. 2014. Forecasting wheat production using ARIMA model in Punjab. *International Journal of Agricultural Sciences* **10**(1): 158-161.
3. Box GEP and Jenkins GM. 1976. Time series analysis: Forecasting and control, Holden-Day, San Francisco. 575.
4. Darekar AS, Pokharkar VG and Datarkar SB. 2016. Onion Price Forecasting in Kolhapur Market of Western Maharashtra Using ARIMA Technique. I*nternational Journal of Information Research and Review* **03**(12): 3364-3368.
5. Darekar AS, Pokharkar VG, Gavali AV and Yadav DB. 2015. Forecasting the prices of onion in Lasalgaon and Pimpalgaon market of Western Maharashtra. *International Journal of Tropical Agriculture* **33**(4:IV): 3563-3568.
6. Darekar A and A Amarender Reddy (2017). Forecasting of Common Paddy Prices in India, *Journal of Rice Research* **10** (1):71-75.
7. FAO(2018) http://www.fao.org/faostat/ website accessed on 1st January 2018
8. USDA (2018) India Grain and Feed Annual, GAIN report 8027. Website accessed on 22nd April 2018 https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Grain%20and%20Feed%20Annual_New%20Delhi_India_3-16-2018.pdf
9. Reddy AA. (2016a). Impact of E-markets in Karnataka, India. *Indian Journal of Agricultural Marketing* **30**(2):31-44.
10. Reddy AA. (2016b). Status of Market Reforms. *Indian Farming* **66**(8):33-37.
11. Sharma H. 2015. Applicability of ARIMA Models in Wholesale Wheat Market of Rajasthan: An Investigation. *Economic Affairs* **60**(4): 687-691.
12. Singh LN, Darji VB and Parmar DJ. 2015. Forecasting of wheat production and productivity of Ahmedabad region of Gujarat state by using ARIMA models. *Indian Journal of Economics and Development* **3**(6): 1-7.