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Research Article

TIME SERIES ANALYSIS OF ONION PRODUCTION IN BANGLADESH

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ABSTRACT

Objectives: The main purpose of this paper is to identify the auto-regressive integrated moving average (ARIMA)model that could be used to forecast the production of onion in Bangladesh.

Methods: This paper considers a secondary data set of yearly onion production in Bangladesh over the period 1971-2013. The Box-Jenkins ARIMA model is employed to forecast the Onion productions in Bangladesh.

Results: The most suitable Box-Jenkins ARIMA model for forecasting the onion productions in Bangladesh is ARIMA (0, 2, 1). From the comparison between the original series and forecasted series, it is concluded that the selected models forecast well during and beyond the estimation period to a satisfactory level.

Conclusion: This paper suggests the time series model to forecast the onion production in Bangladesh which will be used for policy purposes as far as forecasts the onion production in Bangladesh.

Keywords: Onion, Modeling, Forecasting, Bangladesh.

INTRODUCTION

Onion (*Allium cepa* L.) belongs to the family Alliaceae and it is one of the most important spices in Bangladesh [1]. Onion has rank top in respect of production and second in terms of cultivated area among the spices crops grown in Bangladesh [2]. Cultivated onions are supposed to have originated from wild relatives that grow in the mountainous region of central Asia [3]. In Bangladesh, it is cultivated all over the country but extensively cultivated in the Faridpur, Dhaka, Rajshahi, Comilla, Jessore, Dinajpur, Mymensingh, Rangpur, and Pabna. In Bangladesh, onion has been an integral part of the people's daily diet and its use is very common in almost all food preparations [4]. Onion is mainly used as spices in Bangladesh. The main edible portion of onion is the bulb which is constituted by the fleshy sheath and stem plate. Onion bulb is rich with phosphorus, calcium, carbohydrates, etc. It also contains protein and vitamin C. The most important character of onion is its flavor which increases the taste of food. Onion is widely used to increase taste of different type of food and varies such as gravies, soups, stew stuffing, fried fish, and meat [1]. The green leaves and lowering stalks are also edible. It is an indispensable part of the Bangladeshi diet and is commonly used both by rich and poor, but domestic production does not achieve even 15% of the annual requirement [4].

In Bangladesh, the yield of onion seed varies from 370 to 500 kg/ha which is very low as compared to the yield of 1,000-1,200 kg/ha in other countries of the world [3]. Low productivity of onion in Bangladesh could be attributed to limited availability of quality seed and lack of appropriate hybrids [1,5]. The yield of onion seed was reasonably affected by the irrigation regimes. Three irrigations each at vegetative, flowering, and seed formation stage may be the optimum and feasible irrigation scheduling for onion seed production under irrigation water shortage situation [6]. There is an acute shortage of onion in relation to its requirement. This necessitates an improvement of per hectare yield, which is possible through adoption of high yielding varieties and judicious application of fertilizer. Concerning fertilizer application, nitrogen and sulfur are important since these two elements are highly deficient in this country's soils. Onion responded to N and S positively in terms of yield and quality of bulbs [7,8]. Several works have been done on the different issues relating to onion in Bangladesh [9-20].

Although production of onion is increasing day by day, but in a land hungry country like Bangladesh, it may not be possible to meet the domestic demand due to increase in population. There is an acute shortage of onion in relation to its requirement. Every year, Bangladesh has to import a big amount of onion from neighboring and other countries to meet up its demand. One of the main aims of the millennium development goals of Bangladesh by the year 2015 is to eradicate hunger, chronic food insecurity, and extreme destitution. To meet the demand of domestic consumption of onion, it is too much essential to estimate the production of onion in Bangladesh which leads us to do this research. The main purpose of this research is to identify the autoregressive integrated moving average (ARIMA) model that could be used to forecast the production of onion in Bangladesh.

METHODS

Data source

This study considered the published secondary data of yearly onion production in Bangladesh which was collected over the period 1971-2013 from website of the Food and Agricultural Organization.

ARIMA model

Suppose that $\{\zeta_t\}$ is a white noise with mean zero variance σ^2, then $\{Y_t\}$ is defined by $Y_t=\zeta_t+\beta_1\zeta_{t-1}+\beta_2\zeta_{t-2}+...+\beta_q\zeta_{t-q}$ is called a moving average process of order q and is denoted by $MA(q)$. If the process $\{Y_t\}$ is given by $Y_t=\alpha_1 Y_{t-1}+\alpha_2 Y_{t-2}+ ... +\alpha_p Y_{t-p}+\zeta_t$ then it is said to be an auto-regressive process of order p and is denoted by $AR(p)$. Models that are combination of AR and MA models are known as ARMA models. An ARMA (p, q) model is defined as

$Y_t=\alpha_1 Y_{t-1}+\alpha_2 Y_{t-2}+...+\alpha_p Y_{t-p}+\zeta_t+\beta_1\zeta_{t-1}+\beta_2\zeta_{t-2}+...+\beta_q\zeta_{t-q}$, where, Y_t is the original series, for every t, we assume that ζ_t is independent of Y_{t-1}, Y_{t-2}.,Y_{t-p}... A time series $\{Y_t\}$ is said to follow an ARIMA model if the

d^{th} difference $W_t = \nabla^d Y_t$ is a stationary ARMA process. If $\{W_t\}$ follows an ARMA (p, q) model, we say that $\{Y_t\}$ is an ARIMA (p, d, q) process.

Box-Jenkins method

The influential work of Box-Jenkins [21]shifted professional attention away from the stationary serially correlated deviations from deterministic trend paradigm toward the ARIMA (*p, d, q*) paradigm. It is popular because it can handle any series, stationary or not with or without seasonal elements. The basic steps in the Box-Jenkins methodology are given below.

Preliminary analysis

Create conditions such that the data at hand can be considered as the realization of a stationary stochastic process.

Identification of a tentative model

Specify the orders *p, d, q* of the ARIMA model so that it is clear the number of parameters to estimate. Empirical autocorrelation functions (ACF) play an extremely important role to recognize the model.

Estimation of the model

The next step is the estimation of the tentative ARIMA model identified in Step-2. By maximum likelihood method, we estimate the parameters of the model.

Diagnostic checking

Check if the model is a good one using tests on the parameters and residuals of the model.

Forecasting

If the model passes the diagnostics step, then it can be used to interpret a phenomenon, forecast.

Evaluation of forecast error

There are many summary statistics available in the literature for evaluating the forecast errors of any model, time series, or econometric. Here, an attempt is made to identify the best models for onion production in Bangladesh using the following contemporary model selection criteria, such as root mean square percentage error (RMSPE), mean percent forecast error (MPFE), and theil inequality coefficient (TIC).

RMSPE

RMSPE is defined as,

$$RMSPE = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(\frac{Y_t^f - Y_t^a}{Y_t^a}\right)^2}$$

Where Y_t^f is the forecast value in time *t* and Y_t^a is the actual value in time *t*.

MPFE

MPFE is defined as,

$$MPFE = \frac{1}{T}\sum_{t=1}^{T}\left(\frac{Y_t^a - Y_t^f}{Y_t^a}\right)$$

Where Y_t^f is the forecast value in time *t* and Y_t^a is the actual value in time *t*.

TIC

TIC is defined as [22],

$$TIC = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(Y_t^f - Y_t^a\right)^2}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(Y_t^a\right)^2} + \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(Y_t^f\right)^2}}$$

Where Y_t^f is the forecast value in time *t* and Y_t^a is the actual value in time *t*.

RESULTS AND DISCUSSION

In general, Augmented-Dickey-Fuller (ADF), Phillips-Perron (PP), and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) unit root tests are used to check whether the data series is stationary or not. This paper also considers these tests. After the second differencing, the ADF test with Pr $(|\tau| \geq -7.4804) < 0.01$ and PP test with Pr $(|\tau| \geq -32.8901) < 0.01$ and also the KPSS unit root test with Pr $(|\tau| \geq 0.0274) > 0.1$ at 5% level of significance declared that the onion production data series is stationary and suggest that there is no unit root. The graphical

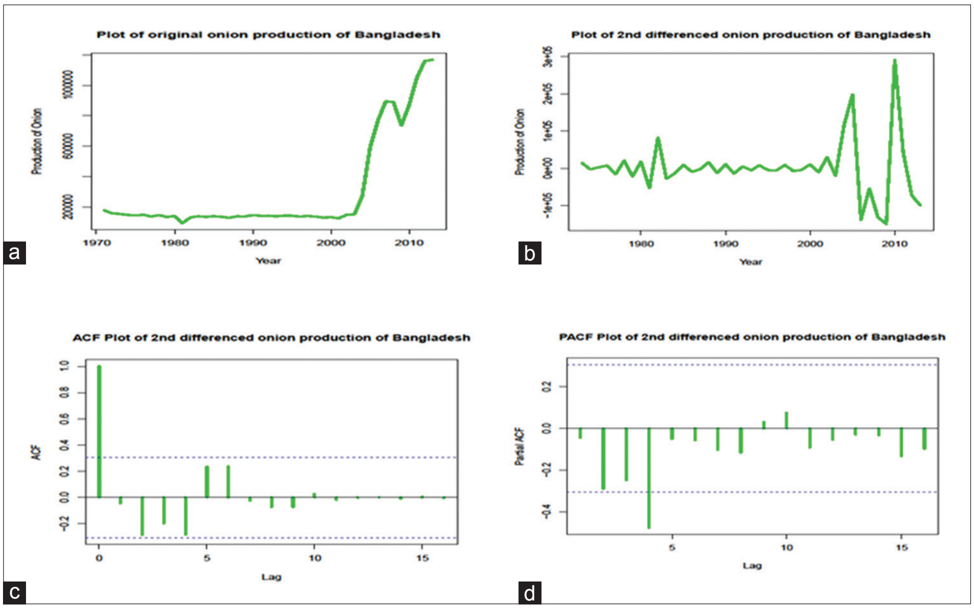

Fig. 1. (a) Time series (original series) plot, (b) time series (2nd differenced) plot, (c) autocorrelation functions and, (d) PACF of 2nd differenced onion production in Bangladesh

representations of the original and second differenced series are presented in Fig. 1a and b.

The onion production data series initially shows almost equal production and after the period 2003; the production increasing dramatically which make increasing trend. One of the main causes of this change may be due to the revolution in agricultural sector in Bangladesh. There is a slightly decreasing trend between the periods 2007 and 2009 and again after the period 2009; there is an increasing trend that is the variance is not stable which leads the onion production data series is not stationary (Fig. 1a). However, it is clear that the second differenced onion production data series shows stable variance which shows the data becomes stationary. To stabilize the variance and to make the data stationary second difference is enough that is difference order is 2, and it is said that integrated of order 2 (Fig. 1b). The alternative positive and negative ACF (Fig. 1c) and PACF (Fig. 1d) indicates the onion production follows ARIMA process. The PACF with a significant spike at lag 1 and ACF with significant spike at lag 1 suggest the first-order autoregressive and first-order moving average are effective for onion production in Bangladesh.

The best fitted ARIMA model is selected on the basis of the lowest value of AIC, $AIC_{C,}$ and BIC. With the help of these model, selection criteria ARIMA (0, 2, 1) model with AIC=1039.1, AIC_c=1039.41, and BIC=1042.52 is the best-selected model for forecasting the onion production in Bangladesh. The estimates of the parameters of the fitted ARIMA (0, 2, 1) model are shown in Table 1. In addition, the value of the most useful "forecasting criteria" of the fitted ARIMA (0, 2, 1) model are also presented in Table 1.

Table 1: Summary statistics and forecasting criteria of the fitted ARIMA (0, 2, 1) model

Coefficients	Estimates	SE	t-value	P-value
ma1	−0.8015	0.1297	−6.179645	0.05106673
Forecasting criteria	MASE	RMSPE	MPFE	TIC
Value	0.9086191	0.1558325	0.02654063	0.08058192

MPFE: Mean percent forecast error, RMSPE: Root mean square error percentage, TIC: Theil inequality coefficient

Several graphical test of the residuals for the fitted ARIMA (0, 2, 1) model are presented in Fig. 2 and suggests that there is no significant pattern in the residuals and hence, it may conclude that there is no autocorrelation among the residuals of the filled model. At 5% level of significance, from the Tables given by [23], we have the lower and upper values of the Runs and they are 16 and 28, respectively. Hence, the observed number of Runs is 28. Hence, the "Run" test with Pr (16≤R≤28) = 0.95 at 5% level of significance strongly suggest that there is no autocorrelation among the residuals of the fitted ARIMA (0,2,1) model. Here, "Histogram with Normal Curve" is used to check the normality assumption of the residuals of the fitted model. The Histogram with Normal Curve of the residuals of the fitted ARIMA (0, 2, 1) model is given in Fig. 2. Histogram with normal curve approximately suggests that the residuals of the fitted ARIMA (0, 2, 1) model are normally distributed. Therefore, it is clear that our fitted ARIMA (0, 2, 1) model is the best-fitted model and adequately used to forecast the onion production in Bangladesh. Using the best-fitted model ARIMA (0, 2, 1), the forecast value and 95% confidence level for 10 years are shown in Table 2.

The graphical comparison of the original series and the forecast series of onion production in Bangladesh is presented in Fig. 3. It is apparent that the forecast data series (blue-color) fluctuate from the original data series (dark-green-color) with a very small amount (Fig. 3). Therefore, the forecasted series is really better representation of the original onion production series in Bangladesh.

CONCLUSIONS

A time series model is used to identify the patterns in the past movement of a variable and uses that information to forecast the future values. This study tried to fit the best model to forecast the onion production in Bangladesh, with the help of the latest available

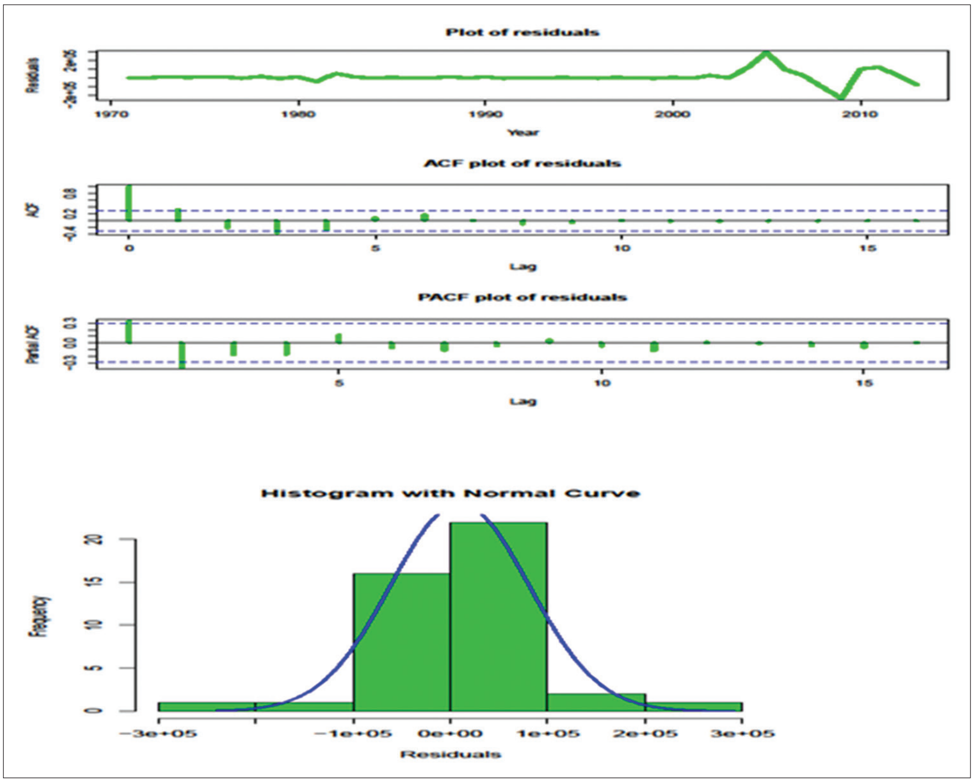

Fig. 2: Several plots of residual plots and Histogram with normal curve

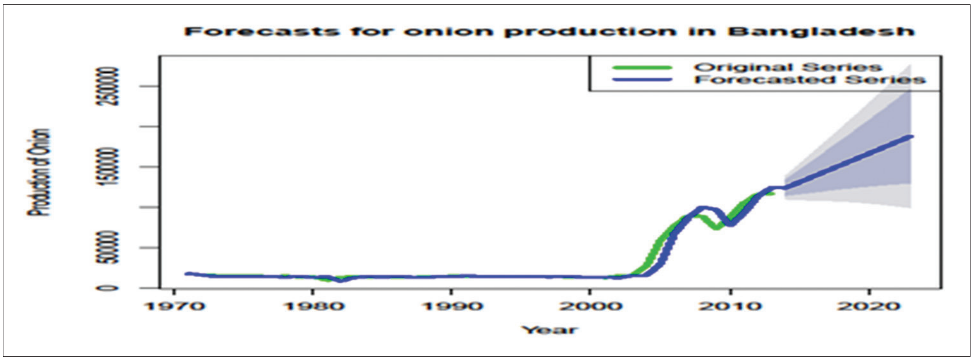

Fig. 3: Comparison between original and forecasted onion production in Bangladesh

Table 2: Forecasted onion production in Bangladesh

Year	Forecast	LCL[a]	UCL[b]
2014	1239235	1097095.6	1381374
2015	1310470	1088602.4	1532338
2016	1381705	1083951.1	1679459
2017	1452940	1078650.6	1827229
2018	1524175	1071269.7	1977080
2019	1595410	1061235.9	2129584
2020	1666645	1048307.5	2284983
2021	1737880	1032391.9	2443368
2022	1809115	1013469.7	2604760
2023	1880350	991560.2	2769140

[a]LCL: Lower confidence limit, [b]UCL: Upper confidence limit

model selection criteria such as AIC, AIC_C, etc. The best selected Box-Jenkins ARIMA model for forecasting the onion productions in Bangladesh is ARIMA (0, 2, 1). From the comparison between the original series and forecasted series shows the same manner indicating fitted model are statistically well-behaved to forecast onion productions in Bangladesh, i.e. the models forecast well during and beyond the estimation period which reached at a satisfactory level. Thus, this model can be used for policy purposes as far as forecasts the onion production in Bangladesh.

REFERENCES

1. Ali MK, Alam MF, Alam MN, Islam MS, Khandaker SM. Effect of nitrogen and potassium level on yield and quality of seed production of onion. J Appl Sci Res 2007;3(12):1889-99.
2. BBS. Monthly (February) Statistical Bulletin of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning, Government of the People's Republic of Bangladesh. Dhaka, Bangladesh: BBS; 2008.
3. Brewster JL. Onions and Other Vegetable Alliums. UK: CAB International; 1994.
4. Hossain AK, Islam J. Status of *Allium* production in Bangladesh. Acta Hortic 1994;358:33-6.
5. Tomar BS, Singh B, Hassan M. Effect of irrigation methods on seed yield and seed quality in onion cv. Pusa Madhavi. Seed Res 2004;32:72-81.
6. Roy DK, Biswas SK, Akanda AR, Sarker KK, Khatun A. Effect of irrigation at different growth stages on yield, water productivity and seed production of onion (*Allium cepa* L. CV BARI Piaz-1). Am J Agric Forestry 2014;2(6):256-61.
7. Patel IJ, Patel AT. Effect of nitrogen and phosphorus levls on growth and yield of onion (*Allium cepa*) cultivar Pusa red Gujarat. Agric Univ Res 1990;15:1-5.
8. Vachhani MU, Patel ZO. Effect of nitrogen, phosphours and potash on bulb yield and quality of onion (*Allium cepa*). Indian J Agron 1993;3:333-4.
9. Ami EJ, Islam MT, Farooque AM. Effect of vernalization on seed production of onion. Agric Forestry Fish 2013;2(6):212-7.
10. Baree MA. Measuring technical efficiency of onion (*Allium cepa* L.) Farms in Bangladesh. Banglad J Agric Res 2012;37(1):171-8.
11. Biswas SK, Akanda MAR, Uddin MR, Sarker PK. Effect of irrigation frequency and fungicide spray on yield and disease infection of onion. Banglad J Agric Res 2009;34(3):417-24.
12. Biswas SK, Khair A, Sarker PK, Alom MS. Yield and storability of onion (*Allium cepa* L.) As affected by varying levels of irrigation. Banglad J Agric Res 2010;35(2):247-55.
13. Haque MA, Miah MA, Hossain S, Rahman MS, Moniruzzaman M. Profitability of onion cultivation in some selected areas of Bangladesh. Banglad J Agric Res 2011;36(3):427-35.
14. Maniruzzaman M, Haque ME, Haque MM, Sayem MA, Al-Amin M. Molecular characterization of onion (*Allium cepa*) using RAPD markers. Banglad J Agric Res 2010;35(2):313-22.
15. Nasreen S, Haque MM, Hossain MA, Farid AT. Nutrient uptake and yield of onion as influenced by nitrogen and sulphur fertilization. Banglad J Agric Res 2007;32(3):413-20.
16. Rashid MH, Islam AK, Mian MA, Hossain T, Kabir ME. Multivariate analysis in onion (*Allium cepa* L.). Banglad J Agric Res 2012;37(4):573-82.
17. Sultana S, Paul AK, Sultana D, Sarker JR. Influence of integrated organic-inorganic nitrogen on growth and nutrient concentration of summer onion (*Allium cepa*). Banglad J Agric Res 2014;39(3):529-45.
18. Ud-Deen MM. Effect of mother bulb size and planting time on growth, bulb and seed yield of onion. Banglad J Agric Res 2008;33(3):531-7.
19. Ullah MH, Huq SM, Alam MD, Rahman MA. Impacts of sulphur levels on yield, storability and economic return of onion. Banglad J Agric Res 2008;33(3):539-48.
20. Yousuf MN, Akter S, Haque MI, Mohammad N, Zaman MS. Compositional nutrient diagnosis (CND) of onion (*Allium cepa* L.). Banglad J Agric Res 2013;38(2):271-87.
21. Box G, Jenkins G. Time Series Analysis: Forecasting and Control. San Francisco: Holden-Day; 1970.
22. Theil H. Applied Economic Forecasting. Amsterdam: North-Holland Publishing Company; 1966.
23. Swed FS, Eisenhart C. Tables for testing randomness of grouping in a sequence of alternatives. Ann Math Stat 1943;14(1):66-87.