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GROWTH AND FORECASTING OF BADC AND NATIONAL BORO SEED PRODUCTION IN BANGLADESH: AN EMPIRICAL STUDY

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ABSTRACT

The study focused on the analysis of growth and forecasting of BADC and national Boro seed production in Bangladesh. Time series data were obtained from the published annual reports of BADC covering the period from 1990-91 to 2019-20 and national Boro seed production data were collected from seed wing, Ministry of Agriculture for the period of 2005-06 to 2019-20. It was found from the growth analysis that the production of BADC and national Boro seed have been registered positive and significant growth during the above mention period. The exponential growth model revealed that BADC and national Boro seed production have been increased by 11.04% and 5.12% per annum, respectively and their trend coefficients were positive. The prediction of BADC and national Boro seed production were made for the next ten years (2020-21 to 2029-30). ARIMA (0, 2, 1) and the exponential growth model showed that if the present growth rate is continued, BADC and national Boro seed production will be 80447.35 MT and 203512.26 MT, respectively in the year 2029-2030. The study recommended that the adequate supply of Boro seed to the farmers have improved their socioeconomic condition through the increased production of Boro rice in Bangladesh.

Keywords: Boro seed, Growth, Forecasting, BADC, Bangladesh.

1. INTRODUCTION

Seed is the most valuable, basic and vital input for crop production. All other inputs and crop management practices create a favorable environment for this living input. Improved seed is the basic component of modern agriculture. Seed is a vehicle to deliver almost all agriculture based technological innovations to farmers (Sahu *et*

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al., 2015). To cope with the growing demand for food for the growing population of Bangladesh, it is necessary to bring about a qualitative change in agriculture production through extensive expansion of the use of improved seed along with appropriate technologies. The population of Bangladesh is increasing rapidly. At present population growth rate is 1.37% in Bangladesh (BER, 2020). In this situation, to maintain food security, it is essential to increase the productivity of rice throughout the country. Improved Boro seed plays an important role in higher Boro rice production in Bangladesh.

Boro rice occupies about 41.71% of total rice area but contributes 53.66% of total rice production (BBS, 2020). So, the food security in Bangladesh mostly depends on the higher Boro rice production. To increase the productivity as well as production of rice and to mitigate the national demand for food, the regular and timely supply of an adequate quantity of quality seed at affordable price at the local level is a prerequisite (Singh and Agrawal, 2018). In the financial year 2019-20, through public and private arrangement about 84% Boro seed of national demand has been supplied to the farmer (MoA, 2021). BADC, DAE, BMDA and private organizations have been supplied 46.03%, 1.75%, 0.32% and 35.88% Boro seed of national demand, respectively in 2019-20 Boro season (MoA, 2021). Government should take necessary steps through BADC and other seed producing organizations for enhancing improve Boro seed production and timely availability of seed in desired quantity at affordable price.

Growth and forecasting analysis are both important part of sound planning and policy- making. Growth rates are the measures of the past performance of economic variables. The policy decision is often made based on such growth rates (Ardeshna *et al.*, 2017). The growth rate and forecasting estimation of BADC and nationally produced Boro seed will be helpful for future planning and decision making in agriculture sector. The present study has been attempted to estimate the growth rate of BADC Boro seed production for the past 30 years (1990-91 to 2019-20) and national Boro seed production for the past 15 years (2005-06 to 2019-20) and forecasted BADC as well as national Boro seed production for the next 10 years (2020-21 to 2029-30).

A good number of studies have been done in the past to estimate the growth rates and forecasting of different agricultural crops through different growth models all over the world. Dey *et al.* (2020) examined the growth and instability of rice and wheat production in India. They revealed that the growth rates of rice in area, production and yield were 0.5, 2.4 and 1.9%, respectively and the growth rates of area, production and yield of wheat were 1.6, 4.1 and 2.3%, respectively over the whole study period. Divya and Pathak (2018) analyzed the growth performance of major food grains in the Chhattisgarh state of India and observed that the growth rates of paddy, wheat, gram, pigeon pea, mustard, and soybean production were 3.12, 6.53, 8.3, 9.72, 10.74 and 21.71%, respectively. Sharma (2015) studied the growth and variability in area, production, and yield of cotton crop in India and found that the growth rates of area, production and yield of cotton crop were 0.47, 2.97 and 2.49%, respectively over the period. Abdulla *et al.* (2015) analyzed growth and instability of rice production in Pakistan and revealed that the overall compound growth rates for rice production, area and yield were 6.81, 5.43 and 1.30%, respectively.

Sultana and Khanam (2020) conducted study on rice production in Bangladesh and found that the forecasted production of rice would be 33772.69, 34210.19 and 34647.56 thousand metric ton in 2021, 2022 and 2023, respectively. Hossain *et al.* (2017) analyzed onion production in Bangladesh and identified that ARIMA (0,2,1) was the best selected model. The forecasted production of onion would be 18.09 and 18.80 lakh metric ton in 2022 and 2023, respectively. Rahman *et al.* (2016) forecasted Aus rice area and production in Bangladesh and identified that forecasted area and production would be 499.31 thousand hectare and 1781.55 thousand metric tons in 2024. Hamjah (2014) employed an ARIMA model for forecasting rice production in Bangladesh and revealed that the best selected ARIMA model for Aus production is ARIMA (2,1,2), for Aman it is ARIMA (2,1,2) and for Boro it is ARIMA (1,1,3). Rahman (2010) studied on Boro rice production in Bangladesh and observed that forecasted Boro rice production would be 12180.79 thousand metric ton in the year 2012-13. The aforesaid discussion revealed that a lot of works have been done on the analysis of growth and forecasting of different crops' production, but no such type of work has been done so far on BADC and national Boro seed production in Bangladesh. However, the accurate growth rate and forecasting of BADC and national Boro seed production may help the policymakers, planners and researchers in making policy decision regarding the production and supply of Boro seed in the country. The specific objectives of this study were: (i) to analyze the growth rate of BADC and national Boro seed production; and (ii) to forecast BADC and national Boro seed production in Bangladesh.

II. METHODOLOGY

Data Source

The present study considered the secondary data of the annual Boro seed production of BADC and national level in Bangladesh. BADC Boro seed production data were obtained from the published annual reports of BADC during the period from 1990-91 to 2019-20 and national Boro seed production data were collected from seed wing, Ministry of Agriculture for the period of 2005-06 to 2019-20.

Estimation of Growth Rate

To analyze the growth rate of BADC Boro seed production for the past 30 years (1990-91 to 2019-20) and national Boro seed production for the past 15 years (2005-06 to 2019-20), nine types of different growth models (Haque *et al.*, 2004) were initially used. Finally, the statistically best fit model (i.e. exponential growth model) was chosen for estimating the growth rate of BADC and national Boro seed production. For simplicity and widely used even in the recent past (Das and Mishra 2020; Chaudhari *et al.*, 2016; Nandal, 2016), the compound growth rates of BADC and national Boro seed production were worked out for the past mention years by fitting an exponential or a semi-log function of the following type:

$$Y = ae^{bt} \text{ or } \ln Y = \ln a + bt$$

Where,
Y is the Boro seed production, 't' is the time and 'a' is the constant and e^b-1 is the compound growth rate which is expressed in percentage.

Forecasting Boro seed production

In order to forecast BADC Boro seed production in Bangladesh, Autoregressive Integrated Moving Average (ARIMA) model (Box and Jenkins, 1970) was used. On the other hand, to forecast national Boro seed production, fitted exponential growth model was used due to unavailability of required national Boro seed production data from reliable source. An ARIMA model is in-fact a combination of Autoregressive Model (AR) and Moving Average Model (MA) with integration. The theoretical aspects of the models are discussed as follows:

Autoregressive Model

The notation AR (p) refers to the autoregressive model of order p. The AR (p) model can be written as:

$$Y_t = \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \phi_3 Y_{t-3} + \dots\dots\dots + \phi_p Y_{t-p} + e_t$$

Where,
Y_t is the original series for every t and e_t is independent of $Y_{t-1}, Y_{t-2}, Y_{t-3}, \dots\dots Y_{t-p}$

Moving Average Model

The notation MA (q) refers to the moving average model of order q. The MA (q) model can be written as:

$$Y_t = e_t - \theta_1 e_{t-1} - \theta_2 e_{t-2} - \theta_3 e_{t-3} - \dots\dots\dots - \theta_q e_{t-q}$$

Where,
Y_t is the original series and e_t is the series of errors.

The Box and Jenkins (1970) procedure is the milestone of the modern approach to time- series analysis. Given an observed time series, the aim of the Box and Jenkins procedure is to build an ARIMA model. In particular, passing by opportune preliminary transformation of the data, the procedure focuses on stationary processes. In this study, it is tried to fit the Box-Jenkins ARIMA model. This model is the generalized model of the non-stationary ARMA model denoted by ARMA (p,q) can be written as

$$Y_t = \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \phi_3 Y_{t-3} + \ldots\ldots + \phi_p Y_{t-p} + e_t - \theta_1 e_{t-1} - \theta_2 e_{t-2} - \theta_3 e_{t-3} - \ldots - \theta_q e_{t-q}$$

Where,
Y_t is the original series for every t and e_t is independent of $Y_{t-1,}$ $Y_{t-2,}$ Y_{t-p}.

A time series $\{Y_t\}$ is said to follow an integrated autoregressive moving average (ARIMA) model if the d^{th} differences $W_t = \nabla^d Y_t$ 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. Fortunately, for practical purposes, we can usually take d =1or at most 2. Consider then an ARIMA (p,1,q) process with $W_t = Y_t - Y_{t-1,}$ we have

$$W_t = \phi_1 W_{t-1} + \phi_2 W_{t-2} + \ldots\ldots\ldots + \phi_p W_{t-p} + e_t - \theta_1 e_{t-1} - \theta_2 e_{t-2} \ \ldots\ldots - \theta_q e_{t-q}$$

Steps of Box and Jenkins procedure

The influential work of Box-Jenkins 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 consist of the following five steps (Gujarati, 2003):

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

This step involves the identification of ARIMA (p, d, q) model where, p denotes the number of auto regressive terms, d the number of times the time series data has to be differenced to become stationery and q indicates the number of moving average terms. Thus, this step is to find the appropriate values for p, d and q with the help of Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) and correlograms, which are the plots of ACF_S and $PACF_S$ against the lag length.

Estimation of the model

The Box-Jenkins (BJ) methodology is applicable to stationary time series; hence it is necessary to convert the non-stationary series into stationary series before estimation of the model. We identify the appropriate values for p and q, the next step is to estimate the parameters of the ARIMA model that has been selected provisionally with the help of the appropriate estimation methods.

Diagnostic checking

It is necessary to test whether the estimated model fits the data reasonably well or not based on the correlogram of the estimated residuals from the selected model. If the estimated residuals are white noise, then the chosen model may be accepted otherwise another ARIMA model may be selected starting over from the stage 'a'. Thus Box-Jenkins methodology is an iterative process. These three stages will be repeated until we get a satisfactory ARIMA model.

Forecasting

If the model is found satisfactory after diagnostic checking the chosen model will be used of forecasting future values. ARIMA model are popular because of their forecasting accuracy.

Evaluation of Forecasting Errors

Before forecasting it is necessary to check the accuracy (Hossain and Abdulla, 2016) of the fitted model. There are many summary statistics available in the literature for evaluating the forecast errors of any model, time series or econometric. Here, an attempt was made to identify the best models for Boro seed production in BADC using the following contemporary model selection criteria, such as Mean Absolute Scaled Error (MASE), Root Mean Square Percentage Error (RMSPE), Mean Percent Forecast Error (MPFE), Theil Inequality Coefficient (TIC), Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). The mathematical expressions of the contemporary model selection criteria are given below:

Mean Absolute Scaled Error (MASE)

The Mean Absolute Scaled Error (MASE) is defined as:

$$\mathrm{MASE} = \frac{\frac{1}{T}\sum_{t=1}^{T}\left|y_t^a - y_t^f\right|}{\frac{1}{T-1}\sum_{t=2}^{T}\left|y_t - y_{t-1}\right|}$$

Where,
y_t^a is the actual value at time t and y_t^f is the forecast value at time t.

Root Mean Square Percentage Error (RMSPE)

The Root Mean Square Percentage Error (RMSPE) is defined as:

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

Where,
y_t^f is the forecast value at time t and y_t^a is the actual value at time t.

Mean Percent Forecast Error (MPFE)

The Mean Percent Forecast Error (MPFE) is defined as:

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

Where,
y_t^a is the actual value at time t and y_t^f is the forecast value at time t

Theil Inequality Coefficient (TIC)

The Theil Inequality Coefficient (TIC) defined as:

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

Where,
y_t^f is the forecast value at time t and y_t^a is the actual value at time t.

Akaike Information Criterion (AIC)

The Akaike Information Criterion proposed by Akaike (1973), one of leading statisticians provides guidelines for choosing the best possible model from a set of competing models. It is defined as:

$$\text{AIC} = n \log(\text{MSE}) + 2K$$

Where,
n is the sample size, MSE is the mean square error, and k is the total number of estimable parameters.

Akaike mentioned that the model with minimum AIC is closer to the best possible choice.

Bayesian Information Criterion (BIC)

Schwartz (1978) developed this criterion which is alternatively called Bayesian Information Criterion (BIC). This is defined as:

$$\text{BIC} = n \log(\text{MSE}) + k \log n$$

Where,
n is the sample size, MSE is the mean square error and k is the total number of estimable parameters.

Schwartz shows that BIC is better than AIC. The model with minimum BIC is assumed to describe the data series more adequately.

Testing unit root/stationary

Although the time series data is generally non-stationary the model requires time series data is stationary. There are several procedures to investigate the stationary of any given time series data. In this study the three most commonly applied tests; the Augmented Dickey-Fuller (Dickey and Fuller, 1981), the Phillips-Peron (Phillips and Peron, 1988) and the Kwiatkowski-Phillips-Schmidt-Shin (Kwiatkowski *et al.*, 1992) test were used.

Augmented Dickey Fuller (ADF) Test

The ADF test is performed based on the following models (Kabir, 2018):

Model-1: The ADF test with constant only

$$\Delta Y_t = b_0 + b_1 Y_{t-1} + \sum_{i=1}^{p} b_2 \Delta Y_{t-1} + e_t$$

Model-2: The ADF test with constant and time trend effect

$$\Delta Y_t = b_0 + \delta t + b_1 Y_{t-1} + \sum_{i=1}^{p} b_2 \Delta Y_{t-1} + e_t$$

Where,
$\Delta Y_t = Y_t - Y_{t-1}$, Y_t = Time series (Boro seed production), t = Time trend effect, p = Optimal number of lags, e_t = disturbance term considered as a white noise error.

If the variable is stationary (no unit root), the ADF test should indicate that b_1 in both equation is significantly smaller than zero.

Phillips Peron (PP) test

The Phillips Peron (PP) test is based on the following model (Kabir, 2018):

Model-1: The PP test with constant only

$$\Delta Y_t = b_0 + b_1 Y_{t-1} + e_t$$

Model-2: The PP test with constant and time trend effect

$$\Delta Y_t = b_0 + \delta T + b_1 Y_{t-1} + e_t$$

Where,
ΔY_t = first differences of Y = ($Y_t - Y_{t-1}$), b_0 = constant t = Time trend effect, e_t = Error term and Y_t = Time series.

If the variable is non-stationary at level but stationary at first differences the variable is said to integration of order 1, I (1).

Kwiatkowski-Phillips-Schmidt-Shin (KPSS)

The KPSS test figures out if a time series is stationary around a mean or linear trend or is non-stationary due to a unit root (Hossain and Abdulla, 2015). A stationary time series is one where statistical property like the mean and variance are constant over time. The null hypothesis for the test is that the data is stationary. The alternate hypothesis for the test is that the data is not stationary. Assesses the null hypothesis that a univariate time series is trend stationary against the alternative that it is a non-stationary unit root process. The test uses the following structural models:

$$y_t = c_t + \delta_t + u_{1t}$$

$$c_t = c_{t-1} + u_{2t}$$

Where,

δ is the trend coefficient; u_{1t} is a stationary process; u_{2t} is an independent and identically distributed process with mean 0 and variance σ^2.

The null hypothesis is that $\sigma^2 = 0$, which implies that the random walk term (c_t) is constant and acts as the model intercept. The alternative hypothesis is that $\sigma^2 > 0$, which introduces the unit root in the random walk. The test statistic is as follows:

$$\frac{\sum_{t=1}^{T} S_t^2}{s^2 T^2}$$

Where,

T is the sample size, s^2 is the Newey-West estimate of the long-run variance and

$$S_t = e_1 + e_2 + \ldots\ldots + e_t$$

III. RESULTS AND DISCUSSION

Trend and growth of Boro seed production

The growth rate of BADC Boro seed production in Bangladesh for the last 30 years (1990-91 to 2019-20) and national Boro seed production for the last 15 years (2005-06 to 2019-20) were estimated by using the exponential growth model. Boro seed production in BADC and national level have been increased over the time with some fluctuations (Figure 1 & 2). The causes of these fluctuations were due to agronomic demand fluctuations of Boro seed in Bangladesh. The results of the exponential growth model for the production of BADC and national Boro seed during mention period were presented in Table 1. The results of exponential growth model such as trend coefficient, growth rate, F-statistic and t- statistic were found positive and significant. The results of F-static for BADC and national Boro seed production shows that the model was significant for the production of Boro seed. It was found from the growth analysis that the trend co-efficient and growth rate of BADC Boro seed production is higher than national Boro seed production. F-statistic and t-statistic of BADC Boro seed production also higher than national Boro seed production. The positive sign of exponential growth rate shows that Boro seed production in BADC has been increased at the rate of 11.04% per annum. This result is consistent with Abdulla *et al.* (2015) who found positive and significant growth rate of rice production in Pakistan. On the other hand, the exponential growth rate of national Boro seed production shows that national Boro seed production has been increased at the rate of 5.12% per annum. This result is relevant to Baksh *et al.* (2005) who found positive and significant growth rate of wheat production in Bangladesh.

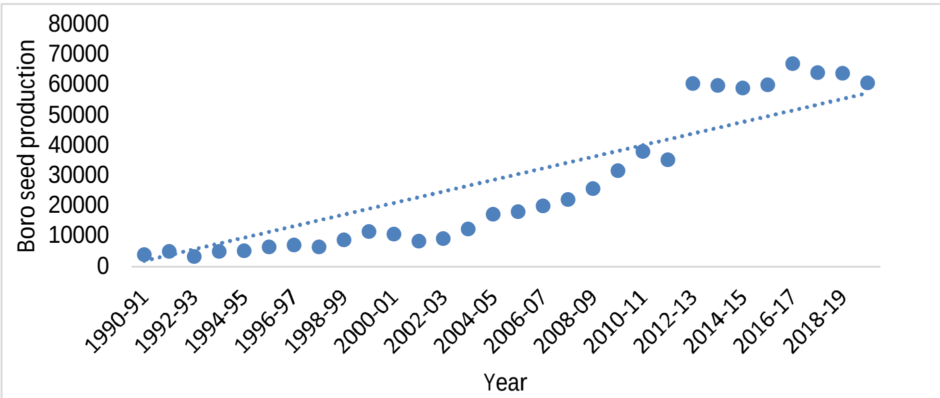

Figure 1. Trend of BADC Boro seed production

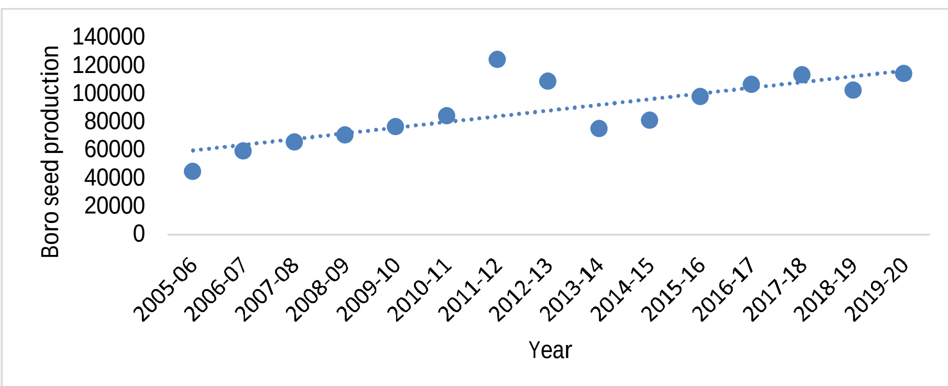

Figure 2. Trend of national Boro seed production

Table 1. Trend and growth rate of BADC and national Boro seed production

Particulars	Estimated values	
	BADC	National
Trend coefficient	0.1104	0.0512
Exponential growth rate (%)	11.04	5.12
F-statistic	751.99***	23.16***

t-statistic	27.42***	4.812***

Source: Authors' estimation, 2021.

Note: *** represent significant at 1% level.

Forecasting of Boro seed production in Bangladesh

In the case of BADC Boro seed forecasting, Augmented-Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root test were used to check whether the data series is stationary or not (Table 2). After second differencing BADC data series are stationary and suggest that there is no unit root. In the case of national Boro seed forecasting, the exponential growth model was used. The graphical representations of original, first and second differenced time series are given in Figure 3 to 6.

Table 2. Results of ADF, PP and KPSS test

Test	Differences	DF (τ)	Lag order	p-value	Decision
	No difference	-1.8006	3	0.6493	Non-stationary
ADF	1st difference	-1.1171	3	0.9043	Non-stationary
	2nd difference	**-3.7474**	**3**	**0.03877**	**Stationary**
	No difference	-5.85	2	0.72	Non-stationary
PP	1st difference	-33.9	2	0.01	Stationary
	2nd difference	**-37.8**	**2**	**0.01**	**Stationary**
	No difference	0.104	1	0.1	Non-stationary
KPSS	1st difference	0.124	1	0.09	Non-stationary
	2nd difference	**0.0378**	**1**	**0.01**	**Stationary**

Source: Authors' estimation, 2021.

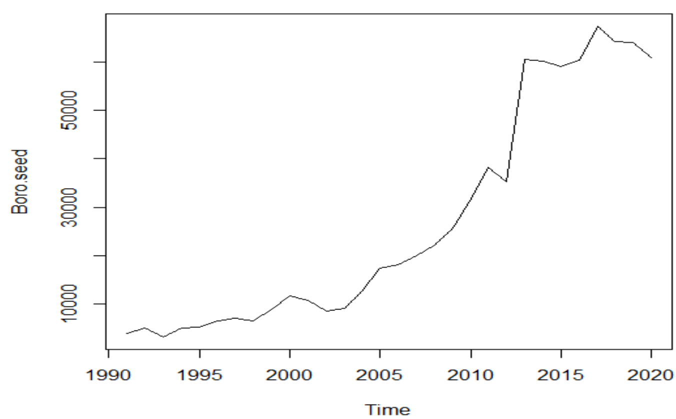

Figure 3. Plot of original Boro seed production in BADC

Figure 3 represents the time series plot of BADC Boro seed production for the period of 1990 to 2020. BADC Boro seed production data series initially depicted increasing trend. But Boro seed production in BADC is decreasing trend from the year 2000 to 2003. From the year 2004 Boro seed production is increasing trend up to 2011. Figure 3 represents from the year 2013 Boro seed production in BADC drastically increased that is the variance is not stable which leads the Boro seed production data series is not stationary because its mean and variance depends on time. It also visual that the mean and variance is not remains constant from time to time, so the figure 3 indicates that BADC Boro seed production data series is non-stationary.

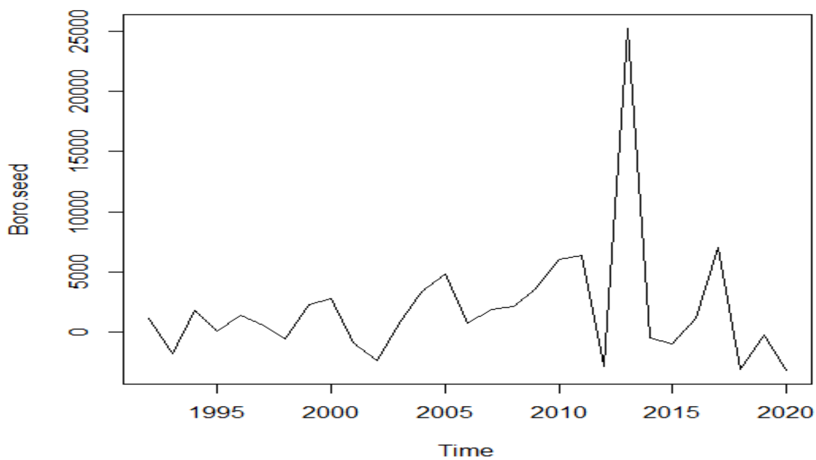

Figure 4. Plot of first differenced Boro seed production in BADC

Figure 4 narrates first differenced plot of Boro seed production of BADC for the period of 1990 to 2020. From the Figure 4 it is clear that, the mean and variance are not remains constant from time to time. So, first differenced plot of BADC Boro seed indicates that data series is non-stationary.

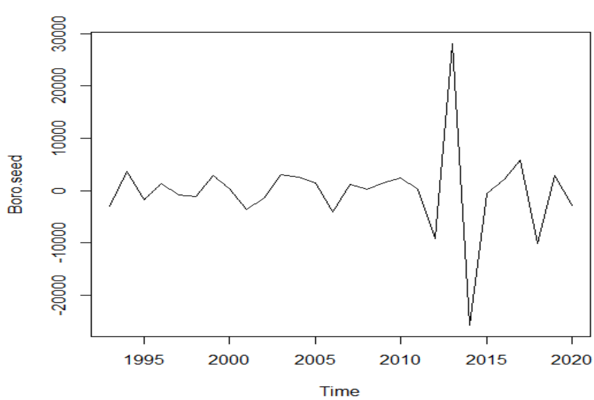

Figure 5. Plot of second differenced Boro seed production in BADC

Figure 5 illustrate second differenced plot of BADC Boro seed production for the period of 1990 to 2020. From the Figure 5, it is clear that the mean and variance remain constant from time to time. So, BADC Boro seed production data series is stationary after taking second difference. Figure 6 and 7 represents plot of Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) of second differenced of Boro seed production in BADC. The second differenced of BADC Boro seed production data series shows stable variance which shows the data series becomes stationary. To stabilize the variance and to make the data series is stationary second difference is enough that is difference order is 2 and it is said that integrated of order 2. The alternative positive and negative ACF and PACF indicates that Boro seed production follows ARIMA process. It is evident from the ACF and PACF plot of the Boro seed production of BADC are showed that autocorrelation coefficients at various lags are very high. The autocorrelation coefficient starts at a very high value and declines slowly towards zero. The ACF with a significant spike at lag 0 and PACF with significant spike at lag 1 suggest the zero-order autoregressive and first-order moving average are effective for Boro seed production in BADC.

Using the tentative procedure, AIC= 566.31, AIC_C= 566.7857 and BIC= 568.9701 it is clear that ARIMA (0, 2, 1) model is the best selected model for forecasting Boro seed production in BADC. This result is similar to Hossain *et al.* (2017) who identified the best selected ARIMA (0,2,1) 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 3.

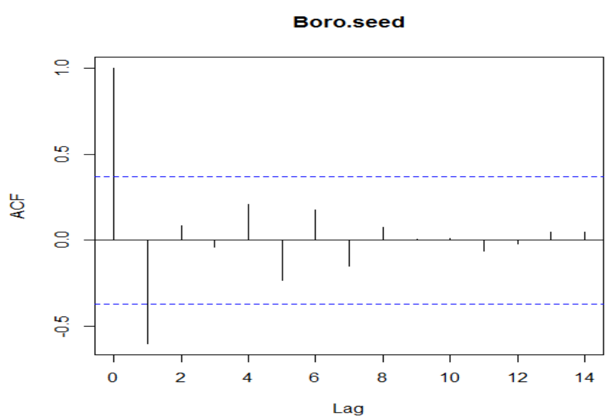

Figure 6. ACF Plot of second differenced Boro seed production in BADC

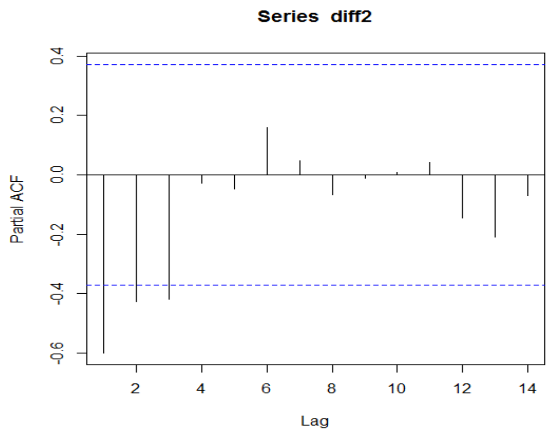

Figure 7. PACF plot of second differenced Boro seed production in BADC

Table 3. Summary statistics of the fitted ARIMA (0, 2, 1) model

Particulars	Estimated values
Coefficients	ma 1
Estimates	-0.999
Standard Error	0.3132
t-statistic	-3.1925
p-value	0.00141

Source: Authors' estimation, 2021
Note: ma 1 indicates Moving Average 1

Several graphical tests of the residuals for the fitted ARIMA (0,2,1) model are presented in Figure 8, suggesting that there is no autocorrelation among the residuals. 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 the Figure 9. "Histogram with Normal Curve" approximately suggests that the residuals of the fitted ARIMA (0,2,1) model are normally distributed. So, it is clear that ARIMA (0,2,1) model is the best fitted model and is adequate to forecast Boro seed production of BADC in Bangladesh.

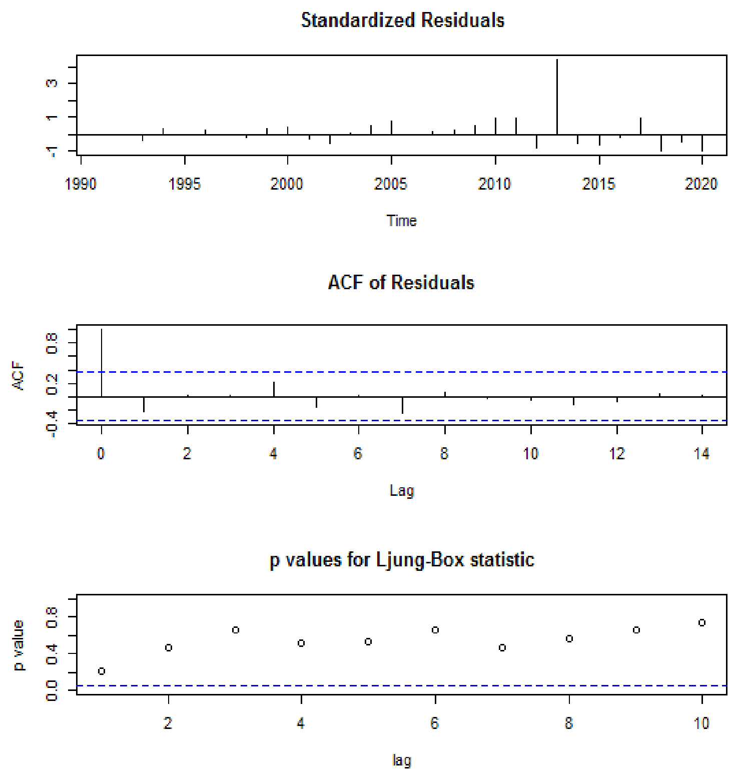

Figure 8. Several plots of residuals

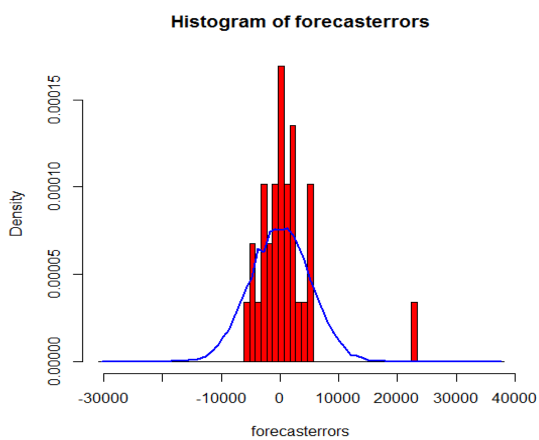

Figure 9. Histogram with normal curve

The values of the most useful forecasting criteria of the fitted ARIMA (0, 2, 1) model are MASE= 0.9559161, RMSE= 5052.417, MPFE= 13.49378 and TIC= 3.741e^{-03}. By using the best fitted model ARIMA (0, 2, 1), the forecasted value for the year 2020-21 to 2029-30 are shown in Table 4.

Table 4. Forecasted Boro seed production (MT) in BADC and national level

Year	BADC	National
2020-21	62807.03	128371.22
2021-22	64767.07	135114.99
2022-23	66727.10	142213.04
2023-24	68687.14	149683.97
2024-25	70647.17	157547.38
2025-26	72607.21	165823.87
2026-27	74567.24	174535.16
2027-28	76527.28	183704.09
2028-29	78487.31	193354.68
2029-30	80447.35	203512.26

Source: Authors' estimation, 2021

From the Table 4 and Figure 10, it is clear that forecasted Boro seed production in BADC and national level is depicted increasing trend. Therefore, BADC will be able to supply sufficient quantity of Boro seed to the farmers and nationally sufficient amount of Boro seed also supply to the farmers. As a result, productivity of Boro rice will be increased in Bangladesh. Increased productivity of Boro rice will be improved farmer's socioeconomic condition and livelihood as well as food security situation in Bangladesh which is also a desire target of Sustainable Development Goal (SDG).

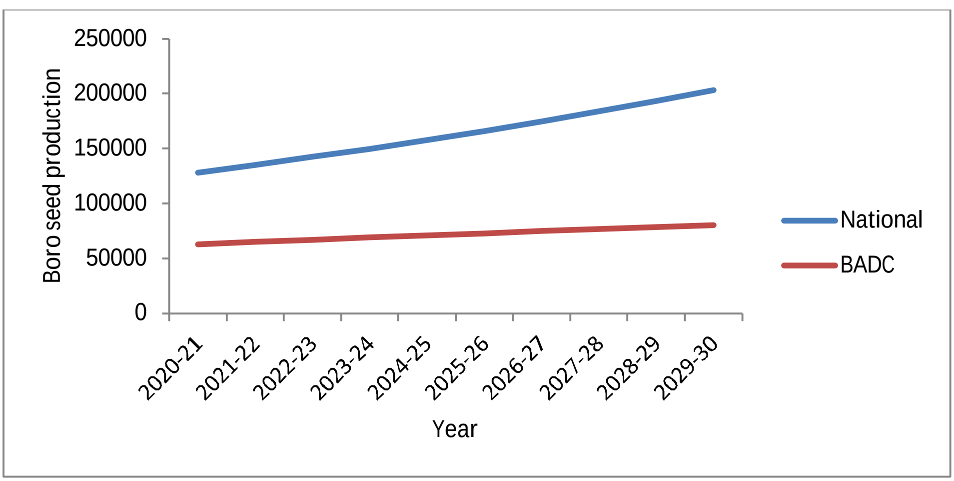

Figure 10. Forecasted trend of BADC and national Boro seed production

IV. CONCLUSION AND POLICY RECOMMENDATIONS

The present study estimated the growth rates and short-run forecasting of BADC and national Boro seed production in Bangladesh. The exponential growth rates indicate that the production of BADC and national Boro seed have been increased during the period (1990-91 to 2019-20). The growth rates of BADC and national Boro seed production have been increased by 11.04% and 5.12% per annum, respectively. The forecasting of BADC and national Boro seed production were made for the years of 2020-21 to 2029-30. The forecasted amounts of BADC and national Boro seed production in 2029-30 will be 80447.35 MT and 203512.26 MT, respectively. The empirical findings of the study will help the researcher, policymakers, planners, seed producers and other stakeholders regarding the production and distribution of Boro seed to the farmers. However, the BADC authority should strengthen their seed production program for ensuring the projected amounts of Boro seed for the coming years. Finally, BADC and other seed producing organizations should ensure the adequate supply of Boro seed to the farmers to improve their socioeconomic condition through the increased production of Boro rice in Bangladesh.

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