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Modeling on Grass Pea and Mung Bean Pulse Production in Bangladesh Using ARIMA Model

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Abstract: *In this study an attempt has been made to examine the rate of growth, measure the instability as well as forecasting of grass pea and mung bean pulse production. For forecasting, deterministic and ARIMA model have been fitted and projections have been made on the basis of the best fitted deterministic and ARIMA model. The magnitude of instability in grass pea and mung bean pulse production was estimated by computing the coefficient of variation (CV) and the percentage deviations from three years moving average values. The study reveals that the grass pea pulse production was observed to be relatively stable (CV being 44.38%) compared to mung bean pulse production (CV being 52.87%). The variation of the growth rates in grass pea pulse production was -19.51% to 14.44% and mung bean pulse production was -21.55% to 20.26% during the study period. The projection of production indicated the vital potential of grass pea and mung bean pulse in Bangladesh. Thus, policy makers, stake holders and beneficiaries (farmers) should take necessary steps to check the decline in area under sugarcane without further delay.*
Keywords: *ARIMA model, Forecasting, Grass pea, Growth model, Mung bean.*

I. Introduction

Bangladesh is an agro-based developing country and still striving hard for rapid development of its economy. Agriculture is the mainstay of Bangladesh economy and it contributes about 20.01 percent of the gross domestic product (GDP) (BER, 2012). Pulses occupy about 4 percent of the total cropped area and contribute about 2 percent to the total grain production of Bangladesh (BBS, 2010). About a dozen pulse crops are grown in the winter and summer seasons. Among these, Pigeon pea, khesari, lentil, chickpea, black gram, mung bean, field pea, cowpea, and fava bean are grown during the winter season (November–March). Collectively, they occupy 82 percent of the total pulse-cultivation area and contribute 84 percent of the total pulse production. Pulses are excellent sources of protein, but they are treated as minor crops and receive little attention from farmers and policymakers. With the expansion of irrigation facilities, the area of production of cereal crops has increased significantly, while pulses have been pushed to marginal lands of low productivity. The area of pulse production has decreased continuously for the past 10 years. Cultivation of pulses is mainly concentrated within the Ganges floodplain areas of the northern districts and in some southern districts of the country. The average annual yield of the different pulses ranges from 700 to 800 kg per hectare. Bangladesh faces an acute shortage of pulses. The country produces a total of 0.53 million tons against the demand of almost 2 million tons (Razzaque, 2000).

Deterministic time series growth models are very common to use in practice for growth analysis and forecasting, as they are very quick to estimate and less expensive, although less efficient. They are very good in many situations for describing the growth pattern and the future movement of a time series (Pindyck and Rubinfeld, 1991). It is very important to note that these models are called deterministic in that no reference is made to the sources and nature of the underlying randomness in the series (Pindyck *et al.,* 1991). These models are widely used to estimate the growth rate of time series data. A very common practice to estimate the growth rate of rice production in Bangladesh is the use of exponential or compound model (Hossain, 1980, 1984; and Mahmud et al., 1983; Jabber et al., 1997; Barua et al., 2000; Akter et al., 2002). Rahman (2008), find out the appropriate models using latest model selection criteria that could describe the best growth pattern of pigeon pea, chickpea and field pea pulse production and to determine the efficient time series models, to forecast the future pigeon pea, chickpea and field pea pulse production in Bangladesh. Rahman (2011) fitted deterministic model for innovative growth analysis and forecasting of grass pea, lentil, black gram and mung bean pulses production in Bangladesh. This model is appropriate when the annual percent growth rate is constant over time. If the growth rate is not constant, but depends on time instead this model cannot describe the actual picture of growth scenario. So, before performing growth analysis it is necessary to estimate the growth model that best fits the time series. Here, an attempt is made to identify the best models for wheat production in Bangladesh using nine contemporary model selection criteria, such as R^2 adjusted R^2, RMSE, AIC, BIC, MAE, and MAPPE (Gujarati, 2003).

Forecasts have been also made using parametric univariate time series models, known as Autoregressive Integrated Moving Average (ARIMA) model popularized by Box and Jenkins (1976). These approaches have been employed extensively for forecasting economics time series, inventory and sales modeling (Brown, 1959). Ljung and Box (1978) and Pindyck and Rubinfeld (1981) have also discussed the use of univariate time series in forecasting. The ARIMA methodology have been used extensively by a number of researchers to forecast demands in terms of internal consumption, imports and exports to adopt appropriate solutions (Muhammed et al., 1992; Shabur and Haque, 1993; Sohail et al., 1994). Najeeb et al., (2005), employed Box-Jenkins model to forecast wheat area and production in Pakistan. They showed that ARIMA (1, 1, 1) and ARIMA (2, 1, 2) were the appropriate models for wheat area and production respectively. Nikhil (2008), in his study on arecanut marketing and prices under economic liberalization in Karnataka fitted an interactive Auto regressive Integrated Moving Average Process (ARIMA) to monthly average prices of two varieties of arecanut. Rachana et al. (2010), used ARIMA models to forecast pigeon pea production in India. Rahman (2010), fitted an ARIMA model for forecasting Boro rice production in Bangladesh. Badmus and Ariyo (2011), forecasted area of cultivation and production of maize in Nigeria using ARIMA model. They estimated ARIMA (1, 1, 1) and ARIMA (2, 1, 2) for cultivation area and production respectively.

Grass pea covered about 38 per cent of the total cultivated area of pulses and 40 per cent of the total production of pulses in Bangladesh (BBS, 2004). Grass pea is in the first position among all the pulses in Bangladesh in terms of production and area of cultivation. This is the lowest priced pulse in Bangladesh because of low demand and also supply is more than other pulses. Production of grass pea is scattered almost throughout the country. However, nearly one-third of the total area of grass pea production belongs to three southern districts: Patuakhali, Barisal, and Bhola. Other major grass pea -growing districts are Faridpur, Dhaka, Noakhali, Jessore, Rajshahi, Comilla, Tangail, and Pabna. Mung bean had 10 per cent share of the total cultivated area of pulses and nine per cent share in total production (BBS, 2004). This pulse is having more price than others. Rate of decrement of area cultivation is larger than the rate of decrement of production that means the productivity of mung bean had been increased in that period. About 70 percent of mung bean production is concentrated in the four southern districts of Patuakhali, Barisal, Bhola, and Noakhali. Patuakhali alone accounts for 30 percent of the area in which mung bean is grown.

For prediction purpose one or both of two types of models, usually known as structural regression models and time series models are often used in practice. The stochastic time series models ARIMA types are very powerful and popular as they can successfully describe the observed data and can make forecast with minimum forecast error. These types of models are very difficult to identify and estimate. They are also expensive, time consuming and possesses a complex model building mechanism. Another type of time series models, called deterministic growth models are also very common to use in practice for growth analysis and forecasting, as they are very quick to estimate and less expensive, although less efficient. So far, we know a few works have been undertaken for forecasting rice area, production and yield in Bangladesh using Growth and ARIMA models. Considering the above facts, the present study was carried out with the following objectives.

1. To measure the instability and growth rates of Grass Pea and Mung Bean Pulse Production in Bangladesh;
2. To identify the best fitted growth and ARIMA model;
3. To forecast Grass Pea and Mung Bean Pulse Production in Bangladesh using the best fitted growth and ARIMA models;
4. To compare with the forecasted results from deterministic (growth) and stochastic (ARIMA) model;

II. Methodology

Data

The present study was conducted mainly based on the secondary data. Majority of the information on the time series data of grass pea and mung bean pulse production pertaining to the period of 1967-68 to 2010-11 were generated and compiled from published volumes of Bangladesh Bureau of Statistics (BBS).

Measures of Instability

The measures of instability in time series data requires an explicate assumptions of what constitute the expectable and unacceptable components. A systematic component which can be predicted does not constitute instability and hence, it should be eliminated from data. The remaining unpredictable component represents the instability. Two methods, viz. moving average and trend fitting have been used in the literature to capture the predictable component. Here the preference is for three-year moving average since the form may more adequately keep in touch with influences on trend earnings, such as changing comparative advantage and policy changes. The estimate of the magnitude of instability in the time series data on productions has been attempted by computing the coefficient of variation (CV) and the percentage deviation from three-years moving average for each year.

$$\text{CV} = \frac{\sigma}{\overline{X_t}} \times 100\%$$

$$\text{Percentage deviation} = \frac{X_t - X_t^{*}}{X_t^{*}} \times 100$$

X_t = Observed value

X_t^{*} = Three years moving average

ARIMA Model

Inferential statistical tools were employed in analyzing the data. In order to forecast the pulse production was modeled by Box-Jenkins type stochastic autoregressive integrated moving average (ARIMA) process. The Box-Jenkins type ARIMA process (Box and Jenkins, 1978) can be defined as $\varphi(\mathrm{B})(\Delta^d y_t - \mu) = \theta(\mathrm{B})\varepsilon_t$, Here, y_t denotes pigeon pea, chick pea and field pea pulse production in metric tons, μ is the mean of $\Delta^d y_t$, $\varphi(\mathrm{B})$ is $1 - \varphi_1\mathrm{B} - \varphi_2\mathrm{B}^2 - ...... - \varphi_p\mathrm{B}^p$, $\theta(\mathrm{B})$ is $1 - \theta_1\mathrm{B} - \theta_2\mathrm{B}^2 - ...... - \theta_q\mathrm{B}^q$, θ denotes the moving average parameter, ø denotes the autoregressive parameter, *p, q,* and *d* denote the autoregressive, moving average and difference orders of the process, respectively, Δ and *B* denote the difference and back-shift operators, respectively. The estimation methodology of the above model consists of three steps, namely identification, estimation of parameters, and diagnostic checking. The identification step involves the use of the techniques for determining the value of p, d, and q. Here, these values are determined by using autocorrelation and partial autocorrelation functions (ACE and PACF) and Augmented Dickey-Fuller (ADF) test. Following (Pindyck and Rubinfeld, 1991) the model used for ADF is $y_t - y_{t-1} = \alpha + \beta t + (\rho - 1)y_{t-1} + \lambda\Delta y_{t-1}$. The second step is to estimate the parameters of the model. Here, the method of maximum likelihood is used for this purpose. The third step is to check whether the chosen model fits the data reasonably well. For this reason, the residuals are examined to find out if they are white noise. To test if residuals are white noise, the ACE of residuals and the Ljung and Box (1978) statistic are used.

Deterministic Model

Five deterministic types' growth models are also considered in this study for comprising the forecasting efficiency of stochastic models. The models are $Y = \alpha + \beta t + \varepsilon$, $Y = \alpha + \beta t + \gamma t^2 + \varepsilon$ $Y = \alpha + \beta t + \gamma t^2 + \delta t^3 + \varepsilon$, $Y_t = \alpha e^{\beta t \varepsilon}$ and $Y_t = \alpha\beta^t e^{\varepsilon}$ where, Y_t is the grass pea and mung bean production, t represents time taking integer values starting from 1, ε is the regression residual, a, b, c, and d are the coefficient of the models. In case of two or more competing models passing the diagnostic checks, the best model is selected using the criteria multiple R^2, Adjusted R^2, Mean Square Error (MSE), Root Mean Squared Error (RMSE), Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), Mean Absolute Error (MAE), and Mean Absolute Percent Error (MAPE).

Criteria Used for Selection of Model

Until the rules of model selection are strictly followed, the forecast generated with the assumed model may sound insipid or dry. In order to select the type of growth model of the best model fit for forecasting the data for a particular time series the latest available model selection criteria are $R^{2,}$ $\bar{R}^2$, RMSE, AIC, BIC, MAE, MSE and MAPPE (Gujarati, 2003). The definition and related materials are briefly given below:

Coefficient of Determination (R^2)

The coefficient of determination, proposed by Theil (1961), is the ratio of the regression sum of squares to the total sum of square i.e. $R^2 = \frac{\text{Regression sum of squqres}}{\text{Total sum of squares}} = \frac{RSS}{TSS} = 1 - \frac{ESS}{TSS}$

In interpreting R^2, it is generally considered that the more the value of R^2, the better is the fit. But there are some limitations in interpreting it in this way. One of the major objections is that R^2 can overstate the value of a regression fit since the error sum of squares (ESS) can be reduced simply by adding further explanatory variables, even if they are not relevant to explaining the dependent variable.

Adjusted Coefficient of Determination ($\bar{R}^2$)

An alternative to R^2 , denoted $\bar{R}^2$, which is adjusted for the degree of freedom associated with regression and total sum of squares, is defined as $\bar{R}^2 = 1-(1-R^2)\frac{n-1}{n-k}$, where n is number of observation and k is the number of parameter to be estimated. It is to be noted that in some cases particularly bad fit R^2 can be negative and it does not exist when the number of observations is less than or equal to the number of parameters to be estimated. Granger and Newbold (1986), Johnston and some other econometricians recommended this alternative. The greater the value of this criterion, the more is the accuracy of the model.

Root Mean Square Error (RMSE)

The root mean square error is defined as $RMSE = \sqrt{\frac{1}{n-k}\sum_{t=1}^{n}\varepsilon_t^2}$ where, n is the sample size and k is the total number of estimable parameters. The model with minimum RMSE is assumed to describe the data series more adequately.

Akaike Information Criterion (AIC)

Akaike information criterion, proposed by Akaike(1973), one of leading statisticians, provides guide lines for choosing the best possible model from a set of competing models. It is defined as $AIC = n\log(MSE) + 2k$ 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.

Schwartz Information Criterion (SIC)

Schwartz (1978) developed this criterion, which is alternatively called Bayesian Information criteria. This is defined as $BIC = n\log(MSE) + k\log n,$ 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.

Mean Absolute Error (MAE)

The mean absolute error is defined as $MAE = \frac{1}{n}\sum_{t=1}^{n}|\varepsilon_t|$. The model with minimum MAE is assumed to describe the data series adequately.

Mean Absolute Percent Prediction Error (MAPPE)

The Mean Absolute Percent Prediction Error is defined as $MAPPE = \frac{1}{n}\sum_{t=1}^{n}\frac{|\varepsilon_t|}{y_t}\times 100$

The model with minimum MAPPE is assumed to describe the data series adequately.

Growth Rate

The functional forms and formulas for calculating growth rates are Linear, Quadratic, Cubic, Exponential and Compound. One can easily see by looking into the natures of the different growth rate for different models are different.

Name of the Model	Monthly Growth Rate in Percentage	Meaning of Notation
Linear	$\frac{\beta}{Y_t}\times 100$	Y_t is the time series considered t represent time taking integers values starting from 1 ϵ is the regression residual α, β, γ are the coefficient of the model
Quadratic	$\frac{\beta+2\gamma t}{Y_t}\times 100$	
Cubic	$\frac{\beta+2\gamma t+3\delta t^2}{Y_t}\times 100$	
Exponential	$\beta\times 100$	
Compound	$(\beta-1)\times 100$	

III. Results And Discussions

Description of Original Series

The grass pea and mung bean pulses production in Bangladesh during the period of 1967-68 to 2010-2011 are presented in figure 1 with mixed (upward & downward) trend during the study period. The grass pea pulse production was 68647 metric tons in 1967-68 and it was grown more rapidly in 2007-08, the grass pea pulse production was 177433 metric tons which is more than 2.58 times and in 2010-11 the production was 113185 metric tons. The mung bean pulse production was 14330 metric tons in 1967-68 and it was fall more rapidly in 1985-86 which is 8593 metric tons, the mung bean pulse production is 20578 metric tons in 2010-11 which is more than 2.39 times higher. So this growth is significant to meet our increasing food requirement of the country.

Grass pea and Mung bean Pulse Production Instability

The percentage deviation from three year moving averages, mean positive and negative deviation and coefficient of variation in pulses production from grass pea and mung bean are presented in Table 1 .It is revealed that year to year fluctuations in pulses production from grass pea and mung bean in terms of percent change from three year moving average. For the total time series, a very high coefficient of variation was found for mung bean and grass pea pulse production, as during the initial year of the time series i.e. in 1967-68 merely 14330 metric tons of mung bean pulse and 68647 metric tons were grass pea produced which during the terminal year of the series 2007-08 increased 33800 metric tons of mung bean pulse and 177433 metric tons grass pea pulse production respectively. However, during the period the grass pea pulse production was observed to be relatively stable (CV being 44.38%) compared to mung bean (CV being 52.87%). It is expected as over a long period of about 44 year lots of institution and technologies change must have taken place which should have influenced the production situation of grass pea and mung bean cultivation. Reduction of production instability would reduce area instability largely. The case of grass pea pulse production the large positive fluctuations were observed during 2007-08 (82.28%), 1987-88(39.44%), 1986-87(34%). The negative fluctuations in grass pea were more deep in the year 1985-86 (-52.42%), 1984-85(-43.91%) and 1983-84(-42.17%). Fluctuations around plus 12% point were observed during 1972-73 whereas around minus 12% point it was nil. In the other years deviations were either small or moderate and for mung bean pulse production the negative fluctuation more deep during 1984-85 (-47.71%), 1983-84 (-43.71%) and 1982-83 (-40.29%) respectively. The large positive deviations were observed during 2007-08 (89.09%), 1986-87(66.31%) and 1987-88 (46.93%). Fluctuations around plus 12% point were observed during 1974-75 whereas around minus 12% point were observed during 2006-07. In the other years deviations were either small or moderate. The positive and negative fluctuations in pulses production in grass pea and mung bean has more or less approximately similar trend over the year. If a comparison is made between mean negative and positive deviations of grass pea and mung bean, it is seen that mean negative deviations is more deep in chickpea pulse production (-49.66%) as compared to pigeon pea (-15.08%), grass pea (-18.23%), lentil (-21.94%), black gram (-23.14%), field pea (-14.99%) and mung bean (-19.21%) respectively. The mean positive deviation is large in chickpea pulse production (85.34%) as compared to pigeon pea (15.18%), grass pea (17.00%), lentil (11.97%), black gram (10.19%), field pea (10.34%) and mung bean (22.61%) respectively. In the absence of decomposition analysis the causes of instability in production may not be identified. However, the plausible explanation for the small fluctuations were observed in the study period may be introduced modern technologies. It was observed that after 1967-68 period, leveling 2008-09, the fluctuations of pigeon pea, chickpea, grass pea, lentil, black gram, field pea and mung bean pulse production in Bangladesh were of small magnitude indicating thereby some sort of stabilization.

Selection Deterministic Models for Grass pea and Mung bean Pulses Production in Bangladesh:

All the models considered for this study, are estimated for the time series of grass pea and mung bean pulses production in Bangladesh during the period of 1967-68 to 20010-11 and shown in Table 2 and Table 3. The parameters those are significant at 1% level are marked by double star and single star is used to show the coefficients those are significant at 5% level. The analysis shows that maximums coefficients of all the models are highly significant at 1% level. We have to examine the model selection criteria discussed in the methodology section. All the model selection criteria that have been used in this study to identify the best fitted model for forecasting purpose and also for explaining the growth pattern are calculated and give in Table 4 and 5. In interpreting the model selection criteria we consider that the more the value of R^2 and $\overline{R^2}$ are the better is the fitness of the model. On the other hand, the smaller is the value of RMSE, AIC, BIC, MAE or MAPPE; the better is the fitness of the model. It is obvious that a better model yields smaller forecasting error.

Grass pea Pulse Production:

According to table 2, the analysis reveals that, constant term and all the regression coefficient of linear, cubic, exponential and compound models are highly significant at 1% level. The constant terms of the coefficient of quadratic model are also highly significant at 1% level and coefficients of the coefficient of quadratic model are significant at 5% level.

So we may place the cubic model in 1st position of our choice for describing the growth pattern of grass pea pulse production in Bangladesh and making forecast with minimum forecasting error. The second best model may be considered as the exponential model. So to estimate the growth rates, using both cubic and exponential models and they will be discussed and compared in the growth analysis section.

Mung bean Pulse Production:

According to table 4, the analysis reveals that, constant term and all the regression coefficient of linear, cubic, exponential and compound models are highly significant at 1% level. The one of the coefficients of quadratic model is significant at 5% level and the constant term of quadratic and one of the coefficients of quadratic models are insignificant.

Now we will have to take a decision in spite of this situation. The significance of cubic model stronger support of selecting cubic model against the compound model. So, we may place the cubic model in 1st position for describing the growth pattern of mung bean pulse production in Bangladesh and making forecast with minimum forecasting error. For estimating the growth rate of mung pulse production, the second best model may be considered as compound model. A comparison between the growth rates obtained from cubic and exponential models will be made in the growth analysis section.

Functional Form of the Model

Grass pea pulse production	Cubic Model	$101170.5 - 13250.4t + 1092.97t^2 - 18.83t^3$
Mung bean pulse production	Cubic Model	$21677.39 - 3607.39t + 266.14t^2 - 4.40t^3$

Growth Analysis

The growth rates are calculated using the best selected models for each of the time series during the study period are given in table 6. It appears from the table that the best fitting model for grass pea and mung bean pulses production are the cubic model, which assumes that the growth of the series was not constant throughout the study period instead it was dependent on time with a quadratic nature of variation. Taking a close look at the annual cubic growth rates of grass pea and mung bean pulses production in Bangladesh given in table will reveal a different picture of the growth scenario.

It appears from the table that the growth rate of grass pea pulse production varied from -19.51% to 14.44% and from table 6, the growth rate of grass pea pulse production was negative and minimum during the year 1967-68 to 1973-74 and 1998-99 to 2010-11. After 1973-74 the growth started to rise maintained increasing up to 14.44% in the year of 1985-86 and the growth rates are positive in the year of 1974-75 to 1997-98. It appears from the table that the growth rate of mung bean pulse production varied from -21.55% to 20.26% and the growth rate of mung bean pulse production was negative and minimum during the year 1967-68 to 1974-75 and 1998-99 to 2010-11. After 1974-75 the growth started to rise maintained increasing up to 20.26% in the year of 1985-86 and the growth rates are positive in the year of 1975-76 to 1997-98.

Selection ARIMA Models for Grass pea and Mung bean Pulses Production in Bangladesh:
Determining Stationarity using ACF and PACF

The time series plot of ACF and PACF of grass pea and mung bean pulse production, Fig. 2 and Fig. 3 showed that the series were not stationary. The data was differenced to make it stationary. The first difference was enough to make the data stationary. The rapid decay in the autocorrelation function and the partial autocorrelation function of the differenced series for production Fig. 4 and Fig. 5 indicates that the series was stationary.

Test of Stationarity using ADF

Apart from the graphical methods of using ACF and PACF for determining stationarity of a time series, a very popular formal method of determining stationarity is the Augmented Dickey-Fuller test. Here, this test is done for all the time series. The estimates of necessary parameters and related statistics for the time series of grass pea and mung bean pulses production are presented in Table 7 and Table 8.

The analysis reveals that first differences of grass pea and mung bean pulses production are stationary, as the F-values were significance at 5% level. The 1st-differenced series is found to be evolutionary.

Modeling Time Series of Grass pea and Mung bean Pulse Production

The autocorrelation function and the partial correlation function were examined and different models for grass pea and mung bean pulse production were fitted using different significant values of p and q. ARIMA (0, 1, 8) and ARIMA (0, 1, 2) was selected as the best model for grass pea and mung bean pulse production based on the minimum values of RMSE, MSE, MAE, MAPE, BIC, AIC and highest R-square & Adjusted R-square value as shown in Table 9.

Residual Analysis

The residuals for those models were diagnosed to see if they were normally distributed using the Kolmogorov-Smirnov normality test. The Kolmogorov-Smirnov statistics for the residuals of ARIMA (0, 1, 8) and ARIMA (0, 1, 2) was 1.078 and 1.525 respectively with an observed significance level of 0.05 indicating that the residuals for the model was normally distributed at the 5% (0.05) significance level. In addition, the modified Box-Pierce statistic were used to check the overall model adequacy for grass pea and mung bean pulse production. For grass pea and mung bean pulse production, the modified Box-Pierce statistic is 8.826 at 12 degrees of freedom which has observed significance level 0.718 and 3.954 at 12 degrees of freedom which has observed significance level 0.984 respectively indicating that it is insignificant at 5% significance level, hence the fit is good. Hence, the diagnostic test indicates that ARIMA (0, 1, 8) and ARIMA (0, 1, 2) model were appropriate for grass pea and mung bean pulse production.

Functional form of the Model

Grass Pea

$$(\Delta Y_t - 3055.667) = (1 - 0.128B - 0.357B^2 - 0.004B^3 - 0.126B^4 + 0.002B^5 - 0.191B^6 - 0.099B^7 - 0.096B^8)\,\varepsilon_t$$

$$SE = (1175.36) \qquad (72.45)(63.16)(37.30)(36.99)(27.88)(27.99)(14.17)(7.06)$$

Mung Bean

$$(\Delta Y_t - 428.50) = (1 - 0.030B - 0.138B^2)\varepsilon_t$$

$$SE = (726.01) \quad (0.18) \quad (0.18)$$

Forecasting

Finally, five years ahead forecast was made for grass pea and mung bean pulse production using ARIMA (0, 1, 8) and ARIMA (0, 1, 2). Table 10, shows the forecast for grass pea and mung bean pulse production at the 95% confidence limit. From Table 10, the forecast for the year 2011-2012 for grass pea pulse production was 73529 metric tons with a 95% confidence limit of (13074, 133983) metric tons and mung bean pulse production was 20407 metric tons with a 95% confidence limit of (8702, 32112) metric tons. For the year 2015-2016, the forecast for grass pea and mung bean pulse production was 72574 metric tons and 18791 metric tons with a 95% confidence limit of (0, 172614) and (0, 39149) metric tons respectively.

Rachana Wankhade et. al. (2010), forecasts of pigeon pea pulse production in India using ARIMA model in the year 2008/09 to 2014/15. In his study ARIMA (1, 1, 1) model was best suited for estimation of Pigeon pea pulse production data. From the forecast values obtained the developed model, it can be said that forecasted production will increases to some extent in future i.e. 2008-09 is 2.49479 million tones up to the year 2014-2015 it will be accepted 2.73452million tones. With lower and upper limits of 2.05787 million tones and 3.41116million tones respectively. **Sonal (2010),** forecasts of chickpea pulse production in India using ARIMA model in the year 2008/09 to 2019/20. Chickpea production data for the period of 1950-51 to 2007-08 of India were analyzed by time-series methods. Appropriate Box-Jenkins autoregressive integrated moving average model ARIMA (1,2,1) was fitted. Validity of the model was tested using standard statistical techniques. Thus the study has been made to forecast the production of chickpea in India up to the year 2020.

IV. Figures And Tables

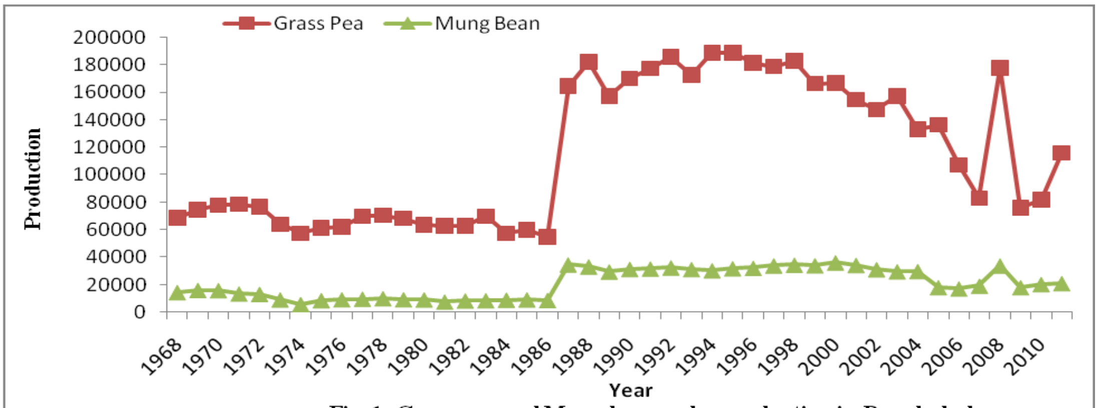

Fig. 1: Grass pea and Mung bean pulse production in Bangladesh

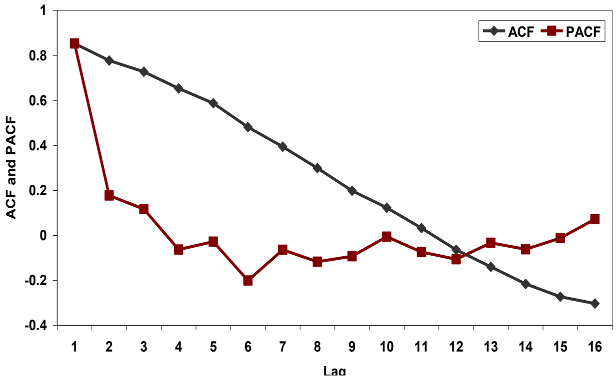

Fig. 2: Undifferenced grass pea pulse production

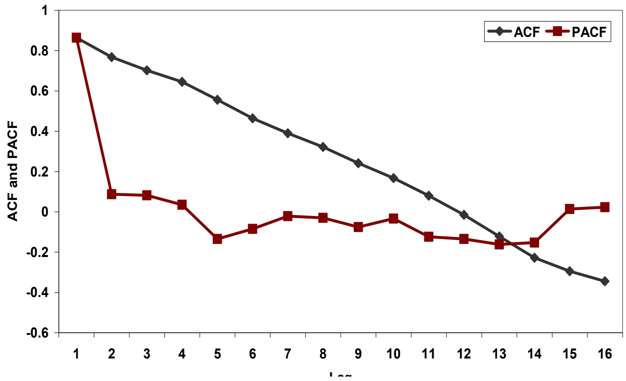

Fig. 3: Undifferenced mung bean pulse production

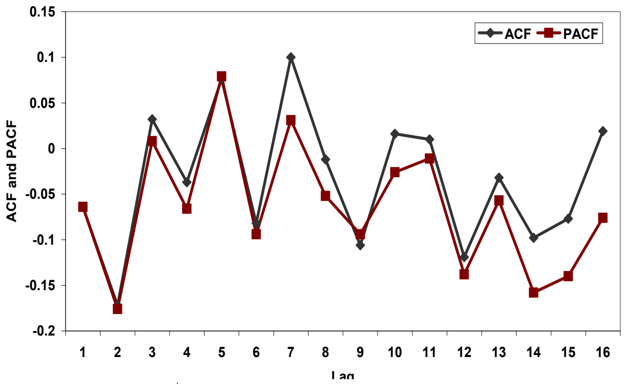

Fig. 4: 1st differenced grass pea pulse production

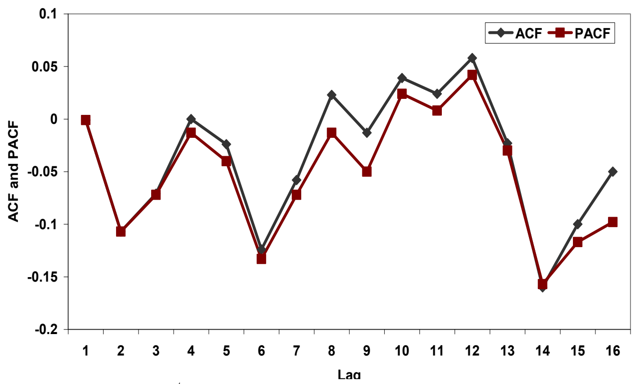

Fig 5: 1st differenced mung bean pulse production

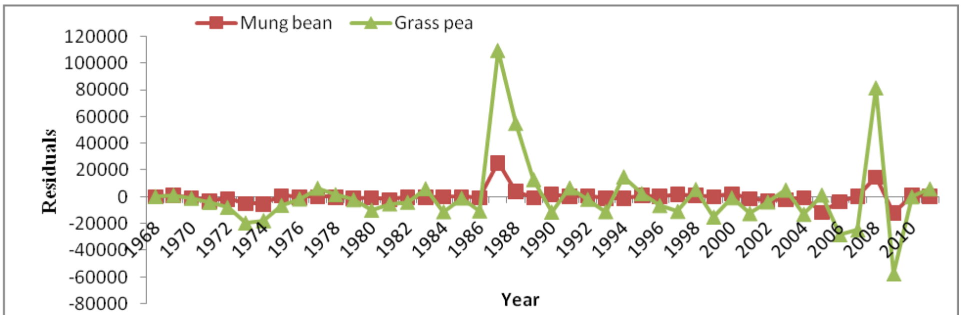

Fig. 6: Residuals of ARIMA (0, 1, 8) and ARIMA (0, 1, 2)

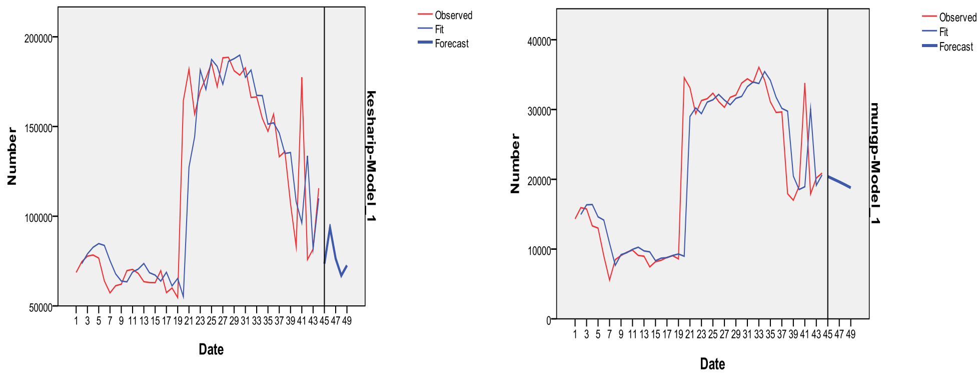

Fig. 7: Observed, fitted and forecasted value of grass pea and mung bean pulse production

Table 1: Instability in pulses production in Bangladesh

Year	Grass pea	Mung bean
1968	-22.86	-21.82
1969	-5.41	2.86
1970	9.88	19.98
1971	21.63	18.68
1972	28.04	33.51
1973	12.25	4.23
1974	3.15	-30.06
1975	10.43	11.68
1976	9.47	20.02
1977	17.85	22.04
1978	12.38	18.07
1979	1.70	-0.21
1980	-12.09	-11.05
1981	-19.41	-33.85
1982	-25.74	-35.02
1983	-24.12	-40.29
1984	-42.17	-43.71
1985	-43.91	-47.71
1986	-52.42	-54.85
1987	34.00	66.31
1988	39.44	46.93
1989	13.54	21.16
1990	16.80	20.55
1991	16.18	14.45
1992	16.73	11.25
1993	4.64	2.25
1994	11.07	-4.31
1995	8.58	-2.99
1996	2.41	-4.44
1997	-.13	-1.13
1998	1.66	-0.32
1999	-7.32	-2.01
2000	-6.16	5.08
2001	-11.19	1.45
2002	-12.80	-5.12
2003	-3.17	-5.87
2004	-13.17	-0.00
2005	-4.58	-34.65
2006	-17.55	-31.34
2007	-27.65	-11.95
2008	82.28	89.09
2009	-43.27	-40.58
2010	-0.21	5.45
2011	5.17	1.27
Mean Positive Deviation (%)	17.00	22.61
Mean Negative Deviation (%)	-18.23	-19.21
Mean of Absolute Value	17.57	20.79
CV (%)	44.38%	52.87%

Table 2. Parameter estimates of the models of grass pea pulse production in Bangladesh

	Parameter			
Model	**α**	**β**	**γ**	**δ**
Linear	54458.38**	2999.39**		
Quadratic	26351.21	6921.32**	-393.38*	
Cubic	101170.50**	-13250.40**	1092.97**	-18.83**
Exponential	58749.34**	0.028**		
Compound	58749.34**	1.028**		

(**, * indicate significance at 1% and 5% level of probability respectively)

Table 3. Criteria of model selection for the local grass pea pulse production in Bangladesh

Model	R^2	$\overline{R^2}$	RMSE	AIC	BIC	MAE	MSE	MAPPE
Linear	.475	.462	38236.55	869.23	872.65	31385.79	1462034056	31.62
Cubic	**.752**	**.732**	**26995.46**	844.68	851.54	**19183.34**	728754742	**19.85**
Quadratic	.527	.502	36786.59	868.06	873.20	31001.35	1353253208	34.16
Exponential	.504	.491	41036.22	**-85.19**	**-81.76**	32276.77	.11356	29.35
Compound	.504	.491	41036.22	-85.03	-81.61	32276.77	.114	29.35

(The value of the criterion for a model with bold shows that the model is better than the other models with respect to that criterion)

Table 4. Parameter estimates of the models of Mung bean pulse production in Bangladesh

	Parameter			
Model	**α**	**β**	**γ**	**δ**
Linear	7530.81**	640.71**		
Quadratic	4193.43	1106.35*	-11.03	
Cubic	21677.39**	-3607.39**	266.14**	-4.40**
Exponential	8517.41**	0.035028**		
Compound	8517.41**	1.04**		

(**, * indicate significance at 1% and 5% level of probability respectively)

Table 5. Criteria of model selection for Mung bean pulse production in Bangladesh

Model	R^2	$\overline{R^2}$	RMSE	AIC	BIC	MAE	MSE	MAPPE
Linear	.479	.465	8114.50	742.12	745.54	7008.59	65815062	47.62
Cubic	**.766**	**.747**	**5583.23**	715.46	722.31	**3675.83**	31172506	**24.28**
Quadratic	.494	.468	8093.31	743.90	749.04	6990.20	65501725	49.68
Exponential	.471	.458	8774.22	-61.53	-58.10	7340.51	.202	42.30
Compound	.472	.458	8774.22	**-61.58**	**-58.15**	7340.51	.202	42.30

(The value of the criterion for a model with bold shows that the model is better than the other models with respect to that criterion)

Table 6: Cubic annual growth rates in %

	Grass pea	Mung bean	Year	Grass pea	Mung bean
1968	-16.20	-21.55	1990	4.20	5.28
1969	-12.20	-16.29	1991	3.77	4.96
1970	-9.26	-13.52	1992	3.29	4.48
1971	-6.90	-12.68	1993	3.13	4.20
1972	-4.87	-9.81	1994	2.44	3.77
1973	-3.39	-9.84	1995	1.95	2.99
1974	-1.25	-9.49	1996	1.45	2.27
1975	1.01	-2.29	1997	.83	1.42
1976	2.98	1.26	1998	.12	.60
1977	4.25	4.14	1999	-.69	-.27
1978	5.63	6.60	2000	-1.58	-1.16
1979	7.11	9.67	2001	-2.74	-2.25
1980	8.85	12.05	2002	-4.03	-3.69
1981	9.96	16.88	2003	-4.95	-5.25
1982	10.85	17.19	2004	-7.29	-6.69
1983	10.42	18.21	2005	-8.64	-13.61
1984	13.21	18.47	2006	-13.01	-17.21
1985	12.99	18.75	2007	-19.51	-18.09
1986	14.44	20.26	2008	-10.48	-11.75
1987	4.79	5.09	2009	-4.32	-18.32
1988	4.25	5.28	2010	-4.58	-18.53
1989	4.78	5.83	2011	-3.65	-20.20

Table 7: ADF test of stationarity of grass pea and mung bean pulses production

Area	Model	α	β	$(\rho-1)$	λ	RSS	DF	DW	F	$F_{05,41}$
Grass pea pulse production	Unrestricted SE	13075 10415.70	850.26 531.84	-0.249 0.117	0.099 0.218	22479335325	35	1.77	2.40	6.91
	Restricted SE	2671.92 4195.85			-0.097 0.201	25396337996	37	1.72		
Mung bean pulse production	Unrestricted SE	1328.54 1950.92	215.16 106.82	-0.270 0.112	0.165 0.186	957882780	35	1.93	3.18	
	Restricted SE	458.32 882.35			-0.002 0.182	1122752681	37	1.82		

Table 8: ADF test of stationarity of grass pea and mung bean pulses production (1st different)

Area	Model	α	β	$(\rho-1)$	λ	RSS	DF	DW	F	$F_{05,40}$
Grass pea pulse production	Unrestricted SE	3563.96 10704.52	-28.92 404.09	-1.36 0.294	0.267 0.211	24242883247	34	1.71	11.73	6.93
	Restricted SE	2069.43 5412.01			-0.423 0.187	40038872394	36	1.93		
Mung bean pulse production	Unrestricted SE	1145.90 2069.20	-.293 0.127	-0.763 0.30	-0.058 0.196	951279589	36	1.92	13.72	
	Restricted SE	398.75 1107.07			-0.437 0.157	1676620718	34	2.15		

Table 9: Diagnostic tools and model selection criteria for the best fitted models

Area	Model	MAE	MSE	RMSE	AIC	BIC	MAPPE	R^2	$\overline{R^2}$	χ^2 (BL at 16 lag)	P-value
Grass pea	ARIMA (0,1,8)	Not satisfied	654710288.40	25587.31	Not satisfied	Not satisfied	12.98	0.753	0.719	4.658	0.997
Mung bean	ARIMA (0,1,2)	2728.56	Not satisfied	5424.49	Not satisfied	Not satisfied	15.29	0.755	0.725	5.140	0.995

Table 10: Grass pea and Mung bean pulse production forecasts

Year	ARIMA(0,1,8)			ARIMA(0,1,2)		
	Forecast	LPL	UPL	Forecast	LPL	UPL
2011-12	73529	13074	133983	20407	8702	32112
2012-13	93640	22416	164864	20020	5227	34813
2013-14	76368	0	153980	19633	2779	36486
2014-15	66917	0	158969	19223	535	37911
2015-16	72574	0	172614	18791	0	39149

LPL: Lower Predictive Value; UPL: Upper Predictive Value

V. Conclusion

This study revealed the magnitude of the instability in grass pea and mung bean pulses production is estimated by computing the coefficient of variation (CV) and the percentage deviation from three years moving average for each year. The study also showed that different models are suitable for different pulses production. The model ARIMA (0, 1, 8) was found appropriate for grass pea pulse, while ARIMA (0, 1, 2) model was appropriate for mung bean pulse. On the other hand, cubic model was found appropriate for both grass pea and mung bean pulse production in Bangladesh. It meant that the annual growth rates were significantly different from time to time for production. Five-year' forecasts of grass pea and mung bean pulse production in Bangladesh in 2011-12 were 73529 and 20407 metric tons, respectively. If the present growth rates continue, grass pea and mung bean pulses production in Bangladesh would be 72574 and 18791 metric tons, respectively, in 2015-16. The forecasting results revealed an increasing decreasing pattern for grass pea and decreasing pattern for mung bean pulse production over the forecasted period. In the light of the forecast results, policy-makers should gain insight into more appropriate investment promotion strategies. The production uncertainty can be minimized if the productions are forecasted well ahead so that necessary steps could be taken against losses. For this purpose, the government and policy makers as well use ARIMA model, which is good enough to forecast future grass pea and mung bean pulse production more accurately in the short run. The empirical findings of study could help to forecast any such commodities. The researchers and policy makers will thus get access for making further extensive research work.

We firmly believe that this research has shed some important light on the subject area encompassing time series modeling of selected agricultural crops in Bangladesh. These empirical findings can be an important source of information to many researchers and policy formulators as far as agricultural crops in Bangladesh are concerned.

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