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Research Article

Modeling for Growth and Forecasting of Pulse Production in Bangladesh

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Abstract: The present study was carried out to estimate growth pattern and examine the best ARIMA model to efficiently forecasting pigeon pea, chickpea and field pea pulse production in Bangladesh. It appeared that the time series data for pigeon pea, chickpea and field pea were 1storder homogenous stationary. Two types of models namely Box-Jenkins type Autoregressive Integrated Moving Average (ARIMA) and deterministic type growth models, are examined to identify the best forecasting models for pigeon pea, chickpea and field pea pulse production in Bangladesh. The study revealed that the best models were ARIMA (1, 1 and 1), ARIMA (0, 1 and 0) and ARIMA (1, 1 and 3) for pigeon pea, chickpea and field pea pulse production, respectively. Among the deterministic type growth models, the cubic model is best for pigeon pea, chickpea and field pea pulse production. The analysis indicated that short-term forecasts were more efficient for ARIMA models compared to the deterministic models. The production uncertainty of pulse could be minimized if production were forecasted well and necessary steps were taken against losses. The findings of this study would be more useful for policy makers, researchers as well as producers in order to forecast future national pulse production more accurately in the short run.

Keywords: ARIMA model, chickpea, field pea, forecasting, growth model, pigeon pea

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) (Bangladesh Economic Review, 2012). Pulses occupy about 4% of the total cropped area and contribute about 2 percent to the total grain production of Bangladesh (Bangladesh Bureau of Statistics, 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/ha. 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 and Rubinfeld, 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; Mahmud and Muqtada,

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1983; Jabber and Jones, 1997; Barua and Alam, 2000; Akter and Jaim, 2002). Rahman and Imam (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 *et al*. (2011) fitted deterministic model for innovative growth analysis and forecasting of grass pea, lentil and 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^2adjusted 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. Their study showed that ARIMA (1, 1, 1) and ARIMA (2, 1 and 2) were the appropriate models for wheat area and production respectively. Nikhil (2008) in his study on areca nut 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 areca nut. 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 and 1) and ARIMA (2, 1 and 2) for cultivation area and production respectively.

Pulses are one of the important segments of Bangladeshi Agriculture after cereals and oilseeds. These pulses constitute chick pea, pigeon pea, grass pea, lentil, mung bean, black gram and field pea. The split grains of these pulses called *dal* are excellent source of high quality protein, essential amino and fatty acids, fibers, minerals and vitamins. These crops improve soil health by enriching nitrogen status, long-term fertility and sustainability of the cropping systems. It meets up to 80% of its nitrogen requirement from symbiotic nitrogen fixation from air and leaves behind substantial amount of residual nitrogen and organic matter for subsequent crops. The water requirement of pulses is about one-fifth of the requirement of cereals thus effectively save available precious irrigation water. So, it is necessary to enhance the growth of pulse production through increasing land productivity to meet the increasing food demand for the vast population of the country as the country has serious land constraints. Significant differences in pulse productivity among the different regions are also barriers to the production growth (Hossain, 1980). Many steps to enhance the growth are being taken from the part of the government and non-government agencies since the independence of the country. For future planning, it is necessary to evaluate the growth pattern of pulse production that is achieved at the time in the country as a whole and also in the different varieties of the country. To reveal the growth pattern and to make best forecasts of pigeon pea, chick pea and field pea pulse in Bangladesh using appropriate time series models that can be able to describe the observed data successfully are necessary.

The aim of this study is to find the best deterministic model that estimate the growth pattern of Pigeon pea, Chick pea and Field pea pulses production; to develop appropriate ARIMA models for the time series of Pigeon pea, Chick pea and Field pea pulse production; to make five-year forecasts for all the time series with appropriate prediction interval; and compare the forecasting performance of ARIMA and deterministic models. Thus in this study, we modeled and forecasted the production of pulses in Bangladesh using ARIMA methodology. This would help predict future values of production in the country.

MATERIALS AND METHODS

Data: The present study was conducted mainly based on the secondary data. Majority of the information on the time series data of pigeon pea, chick pea and field pea 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) (2010).

Forecasting 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 ø (B) $(\Delta^d y_t-\mu) = \theta$ (B)ε_t. Here, y_t denotes pigeon pea, chick pea and field pea pulse production in metric tons, μ is the mean of $\Delta^d Y_t$, ø (B) is 1-øB----øB, θ (B) is 1-

$\theta_1 B$----$\theta_q B^q$, 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. The model used for ADF is y-yt-1=α+βt+ (ρ-1) yt-1+λΔy (Pindyck and Rubinfeld, 1991). 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. 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).

Deterministic model: Nine deterministic types' growth models are also considered in this study for comprising the forecasting efficiency of stochastic models. The models are:

$$Y = a + bt + \varepsilon$$

$$Y = a + b\log_e t + \varepsilon$$

$$Y = a + b/t + \varepsilon$$

$$Y = a + bt + ct^2 + \varepsilon$$

$$Y = a + bt + ct^2 + dt^3 + \varepsilon$$

$$Y = at^b e^{\varepsilon}$$

$$Y = e^{a+b/t+\varepsilon}$$

$$Y = ae^{bt\varepsilon}$$

$$Y = ab^t e^{\varepsilon}$$

where, Y is the pigeon pea, chick pea and field pea pulse production in metric tons, 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. The above mentioned model selection criteria are used to select the best deterministic model forecasting purpose.

RESULTS AND DISCUSSION

Description of original series: The pigeon pea, chickpea and field pea pulses production in Bangladesh during the period of 1967-68 to 2010-2011 is presented in Fig. 1 with mixed (upward & downward) trend during the study period. The pigeon pea pulse production in Bangladesh was 2798 metric tons in 1967-68. In 1973-74 the production declined more sharply and became 2181 metric tons. Afterwards it increased steadily up to the year 1979-80. During the period 2000-01 to 2009-10 the pigeon pea pulse production decreased rapidly and the end of the study period 2010-11 the production was 2420 metric tons. For chick pea pulse , the production was 46555 metric tons in 1967-68 and it was fall slidly in 40200 metric tons in 1972-73 then it was grew an 43850 metric tons in 1977-78. This fluctuation was in the year 1978-79 to 2007-08. In 2010-11 the chickpea pulse production was observed 41083 metric tons. The field pea pulse production was 17760 metric tons in 1967-68 and it was fall more rapidly in 2006-07 was 7000 metric tons which is less than 2.54 times. In 2010-11 the field pea pulse production was observed 11913 metric tons.

Test of stationarity using ACF and PACF: Autocorrelation function is a very constructive tool to find out whether a time series is stationary or not. Both ACF and PACF are used to determine auto-regression and moving average orders of the models. ACF and PACF of pigeon pea, chickpea and field pea pulse production are shown in Fig. 2, 4 and 6. All the graphs

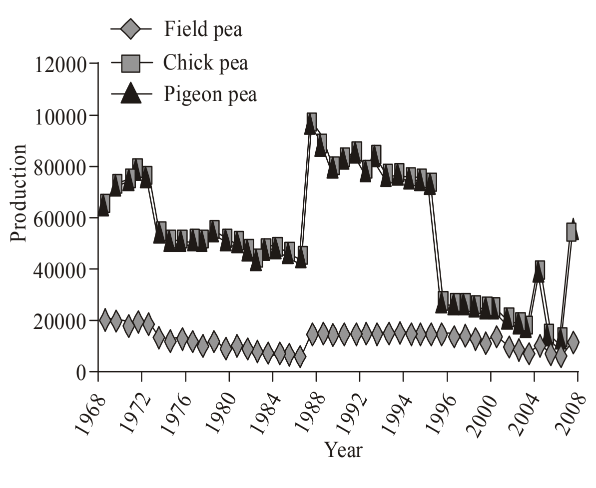

Fig. 1: Pigeon pea, chick pea and field pea pulse production in Bangladesh

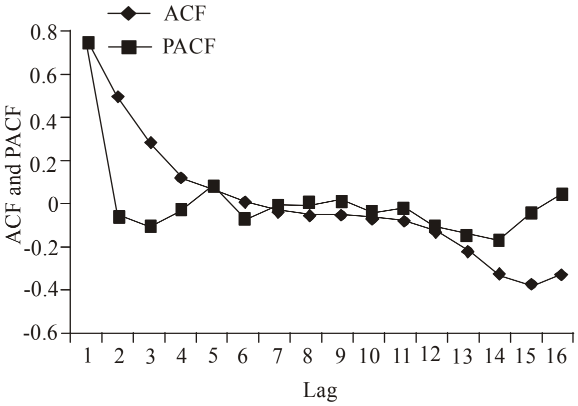

Fig. 2: Undifferenced pigeon pea pulse production in Bangladesh

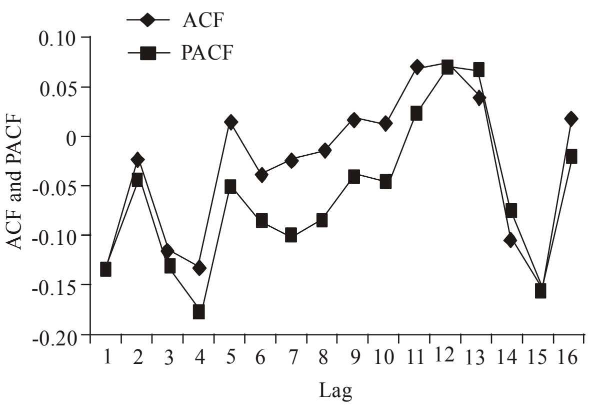

Fig. 3: 1st differenced pigeon pea pulse production in Bangladesh

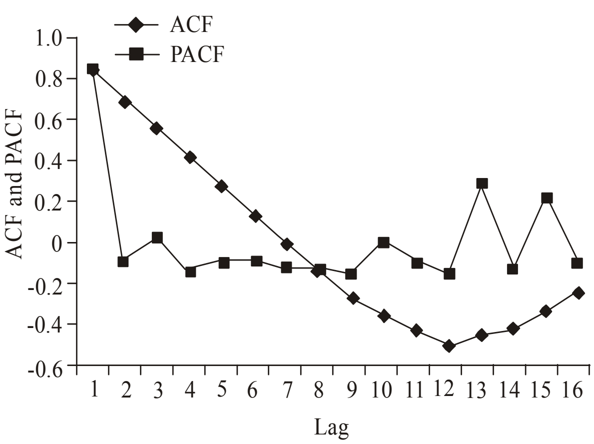

Fig. 4: Undifferenced chickpea pulse production in Bangladesh

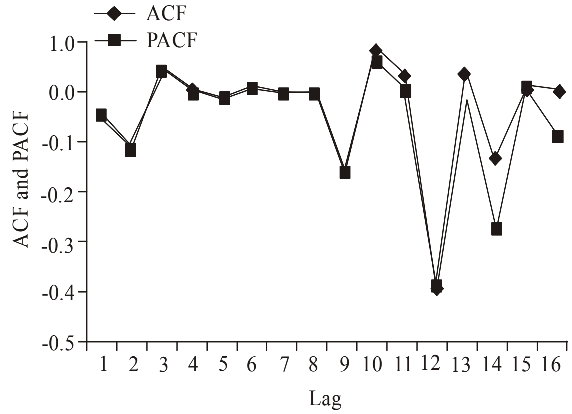

Fig. 5: 1st differenced chickpea pulse production in Bangladesh

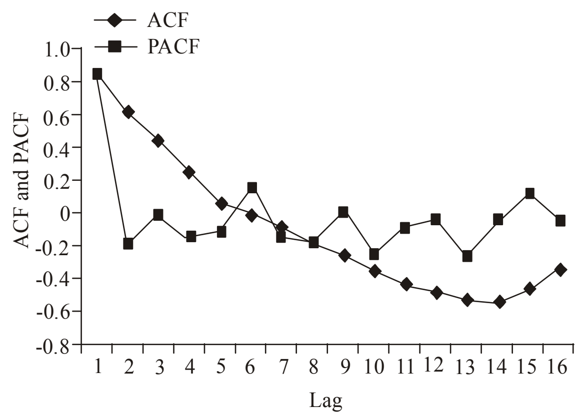

Fig. 6: Undifferenced field pea pulse production in Bangladesh

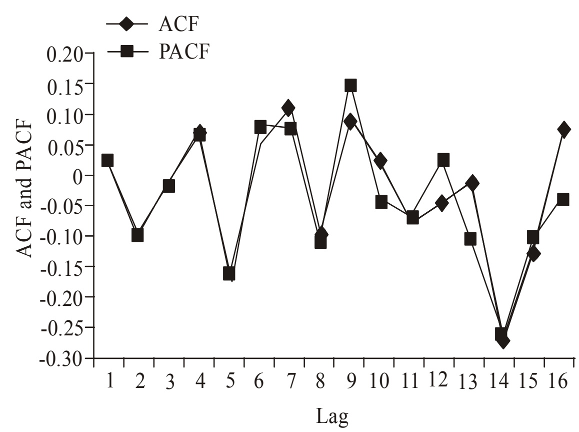

Fig. 7: 1st differenced field pea pulse production in Bangladesh

show that autocorrelations taper of very slowly is indicating that all the series are non-stationary. It is needed to take 1st-difference of all the time series and construct autocorrelation functions to examine whether they are stationary or not. The autocorrelation functions of 1st differenced time series of pigeon pea, chickpea and field pea pulse production are presented in Fig. 3, 5 and 7. The 1st differenced pigeon pea, chickpea and

Table 1: ADF test of stationarity of pulses production

Area	Model	α	β	(ρ – 1)	λ	RSS	DF	DW	F	$F_{05, 41}$
Pigeon pea pulse production	UnrestrictedSE	857.90416.96	-4.547.23	-0.3110.134	0.0250.186	82813331	35	1.90	2.92	6.91
	RestrictedSE	-29.0181.81			-0.1590.175	95864665	37	1.85		
Chickpea pulse production	UnrestrictedSE	11048.117358.54	-158.04183.97	-0.1910.102	0.0410.179	4833952635	35	1.95	1.84	
	RestrictedSE	-728.701925.86			-0.0570.169	5315938742	37	1.96		
Field pea pulse production	UnrestrictedSE	2225.771378.98	9.6925.97	-0.2150.091	0.1260.172	112539253	35	1.96	3.29	
	RestrictedSE	-192.18306.89			0.0220.175	132549775	37	1.87		

Table 2: ADF test of stationarity of pulses production (1st difference)

Area	Model	α	β	ρ-1	λ	RSS	DF	DW	F	$F_{05, 40}$
Pigeon pea pulse production	UnrestrictedSE	15.18195.79	-1.757.92	-1.230.286	0.063.186	9428545	34	1.87	9.88	6.93
	RestrictedSE	37.16103.33			-0.550.144	14605951	36	2.21		
Chickpea pulse production	UnrestrictedSE	-398.874607.97	-24.96185.78	-1.200.26	0.127.176	5223974869	34	1.92	11.57	
	RestrictedSE	315.822505.01			-0.470.15	8583055686	36	2.35		
Field pea pulse production	UnrestrictedSE	-699.13727.14	21.6928.81	-1.090.249	0.1190.180	128689713	36	1.89	10.33	
	RestrictedSE	95.19384.88			-0.4250.159	202573443	34	2.15		

Table 3: Diagnostic tools and model selection criteria for the best fitted models

Area	Model	MAE	RMSE	AIC	BIC	MAPPE	R^2	R^2	χ^2 (BL at 16 lag)	p-value
Pigeon pea	ARIMA(1,1,1)	324.37	635.71	537.29	544.14	13.27	0.070	0.005	4.687	0.997
	Cubic	314.06	482.54	514.68	521.54	14.71	0.516	0.477		
Chickpea	ARIMA(0,1,0)	6224.80	13586.50	784.38	787.81	20.06	0.593	0.566	13.33	0.648
	Cubic	12570.99	15612.12	799.78	806.63	50.20	0.496	0.455		
Field pea	ARIMA(1,1,3)	1458.17	3292.30	676.15	686.43	11.46	0.033	0.106	9.814	0.876
	Cubic	1355.53	1928.79	628.30	635.16	13.48	0.700	0.676		

field pea pulse production seems to be stationary, as the autocorrelation decline faster than that of undifferenced series. Now it is clear that ACFs of all the 1^{st}differenced series decline rapidly. So, it is revealed that pigeon pea, chick pea and field pea time series are stationary of order one. Before taking the decision about stationarity of the series the study needs to carry out the ADF (Augmented Dickey-Fuller) test of stationarity.

Test of stationarity using ADF: Apart from the graphical methods of using ACF 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 pigeon pea. Chick pea and field pea pulses production are presented in Table 1.

The empirical analysis revealed that the hypothesis of random walk as underlies in the process of generating the time series is non-stationary and this cannot be rejected, since the F statistics is insignificant at 5% level. So, all the undifferenced time series are non-stationary and they must be 1^{st} differenced to examine if 1^{st} differenced are non-stationary.

The ADF test for the 1^{st} differenced time series of pigeon pea, chick pea and field pea pulse production are presented in Table 2. The test analysis illustrated that pigeon pea, chick pea and field pea pulse production, the 1^{st}differenced time series are stationary since the F statistics are significant at 5% level. The ACFs and ADF test indicated that pigeon pea, chick pea and field pea time series are stationary of order one.

Pigeon pea pulse production: The ACF and PACE of pigeon pea time series data as shown in Fig. 3 indicated that the autoregressive order (p) and moving average order (q). It is evident that the ACF plots show exponentially declining values when the PACF has only one significant spike, this suggests that the maximum order of auto regression should be considered to be 1. So the order of p can be testing ARIMA models with p = 0 and 1 and the ACF plots show exponentially declining values when the PACF has two significant spike, this suggests that the maximum order of moving average should be considered to be 2. So the order of q can be testing ARIMA models with q = 0, l and 2. So, the tentative specifications of the model may be ARIMA (0, 1 and 0), ARIMA (0, 1 and 1), ARIMA (0, 1 and 2), ARIMA (1, 1 and 0), ARIMA (1, 1 and 1) and ARIMA (1, 1 and 2). All these models are estimated and their diagnostic checks are done using ACFs of residuals and Ljung and Box (1978) chi-squares test. In addition, the minimum values of RMSE, MSE, MAE, AIC, BIC, MAPPE and maximum values of R^2, $R^2$are used to select the best model which are presented in Table 3. The value of chi-square with the P-value and the values of model selection criteria are presented in Table 3 only for the best model. It was found that the best ARIMA specification for pigeon pea pulse production is ARIMA (1, 1 and 1) model with estimated parameters, standard errors: t and P-values are presented below:

$$(1-0.757B)(\Delta Y_t+16.808)=(1-0.981B)\varepsilon_t$$
$$SE=(0.21)\quad(21.80)\quad(0.39)$$
$$t=(2.799)(0.901)(0.694)$$

According to the model selection criteria, the cubic model can be considered as the best deterministic model for pigeon pea pulse production. It denoted that the growth rate of pigeon pea pulse production was not constant during the study period. The estimated model with necessary statistics is as follows:

$$Y = 2852.995-121.47t+10.11t^2-0.203t^3$$
$$SE = (369.750)\ (70.36)\ (3.61)\ (0.053)$$
$$t = (6.935)\ (-0.435)\ (1.120)\ (-1.833)$$

Chickpea pulse production: For selecting ARIMA model for chickpea pulse production series a routine test of identification applied before using Box-Jenkins methodology. Figure 4 shows the ACF and PACF plots of chickpea pulse production series at the level up to 16 lags. From this Fig. 4, the facts stand out that at the beginning ACF has four significant spikes and PACE has only one significant spike .On the other hand, the ACF plots and PACF plots in the Fig. 5 show a different configuration. The ACF plots of 1st difference show one significant spike and PACF plots show four significant spikes. Observing the nature of ACF and PACF plots of the series and their theoretical properties, the order of auto-regression and moving average process of chickpea pulse production series are selected by estimating the ARIMA models at p = 0, 1 and q = 0, 1, 2, 3 and 4. So, the tentative specifications of the model may be ARIMA (0, 1, 0), ARIMA (0, 1 and 1), ARIMA (0, 1 and 2), ARIMA (0, 1 and 3), ARIMA (0, 1 and 4), ARIMA (1, 1 and 0), ARIMA (1, 1 and 1), ARIMA (1, 1 and 2), ARIMA (1, 1 and 3) and ARIMA (1, 1 and 4). So, the same specifications are considered for chick pea pulse production. It appeared from the analysis that the specification ARIMA (0, 1 and 0) is the best. The chi-square tests for diagnostic checking for this model can be viewed in Table 3. The estimated models with necessary statistics are presented below:

$$(\Delta Y_t+465.635)=\varepsilon_t$$
$$SE=(1860.68)$$
$$t=(-0.113)$$

According to the model selection criteria the cubic model can be considered as the best deterministic model for chick pea pulse production in Bangladesh. The estimated model with necessary statistics is as follows:

$$Y = 55142.96-2925.88t+243.21t^2-5.10t^3$$
$$SE = (11489.441)\ (2186.385)\ (112.220)\ (1.640)$$
$$t = (3.950)\ (0.077)\ (0.315)\ (-0.866)$$

Field pea pulse production: The ACF and PACF of the 1st differenced of Boro pulse production as shown in Fig. 7 revealed that all the autocorrelations are too small and the Box and Ljung test find all autocorrelation are insignificant. So, the best model for field pea pulse production is ARIMA (1, 1 and 3). The chi-square tests for residual and the value of model selection criteria R^2, Adjusted R^2, RMSE, MSE, AIC, BIC, MAE and MAPPE can be viewed in Table 3. The estimated models with necessary statistics are presented below:

$$(1+0.596B)(\Delta Y_t+182.95)=(1+0.668B+0.065B^2-0.234B^3)\varepsilon_t$$
$$SE=(0.58)\quad(263.09)\quad(0.56)\quad(0.21)\quad(0.17)$$
$$t=(-0.004)(-0.806)(0.092)(0.877)(-0.627)$$

The best deterministic model for field pea pulse production is the cubic model presented bellow:

$$Y = 23682.50-2456.85t+128.58t^2-1.91t^3$$
$$SE = (1474.943)\ (280.675)\ (14.406)\ (0.211)$$
$$t = (15.320)\ (-7.536)\ (7.346)\ (-7.190)$$

Diagnostic checking: For diagnostic checking, the ACF of residuals and Ljung and Box (1978) chi-square statistics are widely used in practice. The chi-square statistics are presented in Table 3 for all best selected stochastic models with P-values. All the chi-square values are insignificant. It implied that the residuals of the respective time series are white noise implying that the model fitness is acceptable. The estimated values of other model selection criteria for both best selected stochastic and deterministic models are also shown in Table 3. The table revealed that ARIMA models are superior to the respective deterministic models.

Forecasting: Five year forecasts of pigeon pea, chickpea and field pea pulse productions are estimated using the best selected models and are given in Table 4, 5 and 6 respectively. Prediction intervals of forecasts are also given.

The empirical analysis illustrated that short-term forecasts are more efficient for ARIMA models compared to the deterministic models. In case of pigeon pea pulse production, ARIMA model forecast is higher compared to the cubic model and also MAPPE (14.71%) of cubic model is higher than MAPPE (13.27%) ARIMA model. Less MAPPE (%)provided more accurate results than higher MAPPE (%). So, ARIMA model produced more accurate results than deterministic model. However, the ARIMA model estimated that the pigeon pea pulse production 2029 metric tons in 2011-12 and if the present pigeon pea pulse production continues the pigeon pea pulse production of Bangladesh would be 1331 metric tons in the year 2015-2016.

Table 4: Pigeon pea pulse production forecasts

	ARIMA(1,1,1)			Cubic		
Year	Forecast	LPL	UPL	Forecast	LPL	UPL
2011-12	2029	933	3125	1881	449	3314
2012-13	1770	492	3047	1857	420	3294
2013-14	1587	248	2926	1833	391	3275
2014-15	1447	85	2809	1808	362	3255
2015-16	1331	0	2703	1784	333	3235

LPL: Lower Predictive Value; UPL: upper predictive value

Table 5: Chickpea pulse production forecasts

	ARIMA(0,1,0)			Cubic		
Year	Forecast	LPL	UPL	Forecast	LPL	UPL
2011-12	41356	14755	67957	22566	0	63489
2012-13	41647	4028	79266	21730	0	62778
2013-14	41956	0	88030	20893	0	62071
2014-15	42283	0	95485	20056	0	61369
2015-16	42628	0	102110	19218	0	60672

LPL: Lower predictive value; UPL: Upper predictive value

Table 6: Field pea pulse production forecasts

	ARIMA(1,1,3)			Cubic		
Year	Forecast	LPL	UPL	Forecast	LPL	UPL
2011-12	11068	6622	15513	9845	2756	16934
2012-13	10413	4487	16338	9753	2643	16863
2013-14	11455	4745	18165	9661	2529	16793
2014-15	11762	4025	19500	9569	2414	16723
2015-16	12093	3451	20735	9477	2299	16655

LPL: Lower predictive value; UPL: Upper predictive value

Table 7: Diagnostic tools and model selection criteria for pigeon pea pulse production of best fitted models

	Values of selection criteria							
Model	MAE	MSE	RMSE	AIC	BIC	MAPPE	R^2	$\overline{R^2}$
ARIMA(0,1,0)	327.00	430654.37	656.24	**535.90**	**539.32**	14.33	0.009	0.016
ARIMA(0,1,1)	332.32	424555.33	651.58	537.31	542.45	13.71	0.023	0.028
ARIMA(0,1,2)	337.15	420594.30	648.53	538.93	545.78	14.59	0.032	**0.046**
ARIMA(1,1,0)	329.30	425488.94	652.30	537.40	542.54	13.57	0.021	0.031
ARIMA(1,1,1)	**324.37**	**404131.25**	**635.71**	537.29	544.14	**13.27**	**0.070**	0.005
ARIMA(1,1,2)	329.64	404681.66	636.15	539.35	547.91	14.51	0.069	0.035

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

Table 3 indicated that cubic model produced higher AIC (799.78), BIC (806.63), RMSE (15612.12), MAPE (50.20) and MAE (12570.99) compared to ARIMA (0, 1, 0). Therefore, ARIMA Model is more appropriate for forecasting compared to deterministic model. The ARIMA model forecasted that the chick pea pulse production is 41356 metric tons in 2011-12 and if the present chick pea pulse production continues the chick pea pulse production of Bangladesh would be 42628 metric tons in the year 2015-2016.

Deeply observing the forecasted values and confidence intervals presented in Table 6 reveal that forecasting error sufficiently small and consequently the intervals are too large. The forecasting found that if the existing field pea pulse production continues, Bangladesh would obtain 11068 metric tons in the year 2011-12 and it would increase 12093 metric tons in the year of 2015-16. Therefore, the Government of Bangladesh should take input subsidiary policy for the increase of productivity of this crop. The production uncertainty of field pea was minimized if pulses were forecasted well ahead so that necessary step could be taken against losses.

Rachana *et al*. (2010) forecasts of pigeon pea pulse production in India using ARIMA model in the year 2008/09 to 2014/15 (Table 7). In his study ARIMA (1, 1 and 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 2.73452 million tones. With lower and upper limits of 2.05787 million tones and3.41116 milliontones respectively. Sonal *et al*. (2010) forecasts of chickpea pulse production in India using ARIMA model in the year 2008/09 to 2019/20 (Table 8). 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

Table 8: Diagnostic tools and model selection criteria for chickpea pulse production of best fitted models

Model	Values of selection criteria MAE	MSE	RMSE	AIC	BIC	MAPPE	R^2	$\overline{R^2}$
ARIMA(0,1,0)	**6224.80**	184592930.64	13586.50	**784.38**	**787.81**	**20.06**	**0.593**	**0.566**
ARIMA(0,1,1)	6239.62	184089448.17	13567.96	786.27	791.41	20.61	0.578	0.556
ARIMA(0,1,2)	6246.35	182468123.75	13508.08	787.91	794.76	21.29	0.582	0.548
ARIMA(0,1,3)	6275.03	182283811.08	13501.25	789.86	798.43	21.49	0.582	0.536
ARIMA(0,1,4)	6275.72	182283605.16	13501.24	791.86	802.15	21.50	0.582	0.523
ARIMA(1,1,0)	6242.11	184207897.40	13572.32	786.29	791.44	20.51	0.578	0.556
ARIMA(1,1,1)	6506.16	**177512855.54**	**13323.40**	786.78	793.63	22.83	0.577	0.560
ARIMA(1,1,2)	6273.02	182316652.94	13502.47	789.87	798.44	21.42	0.582	0.536
ARIMA(1,1,3)	6275.24	182283787.20	13501.25	791.86	802.15	21.49	0.582	0.523
ARIMA(1,1,4)	6467.51	180001144.01	13416.45	793.35	805.34	21.74	0.588	0.515

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

Table 9: Diagnostic tools and model selection criteria for field pea pulse production of best fitted models

Model	Values of selection criteria MAE	MSE	RMSE	AIC	BIC	MAPPE	R^2	$\overline{R^2}$
ARIMA(0,1,0)	1486.16	10950164.71	3309.10	**668.56**	**671.99**	11.64	0.023	0.002
ARIMA(0,1,1)	1478.04	10948247.34	3308.81	670.56	675.70	11.57	0.023	0.028
ARIMA(0,1,2)	1465.61	10917191.50	3304.12	672.44	679.29	11.50	0.026	0.053
ARIMA(0,1,3)	1465.70	10906375.63	3302.48	674.40	682.97	11.50	0.027	0.081
ARIMA(1,1,0)	1479.28	10948681.67	3308.88	670.56	675.70	11.58	0.023	0.029
ARIMA(1,1,1)	1497.76	10896871.43	3301.04	672.36	679.22	11.67	0.028	0.051
ARIMA(1,1,2)	1464.12	10912686.22	3303.44	674.42	682.99	11.50	0.026	0.082
ARIMA(1,1,3)	**1458.17**	**10839263.61**	**3292.30**	676.15	686.43	**11.46**	**0.033**	**0.106**

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

Table 10: Criteria of model selection for the pigeon pea pulse rice production in Bangladesh

Model	R^2	R^2	RMSE	AIC	BIC	MAE	MSE	MAPPE
Linear	0.094	0.071	643.37	534.27	537.70	495.58	413921.55	24.31
Logarithmic	0.035	0.010	664.15	536.88	540.30	399.77	441092.44	25.36
Inverse	0.015	-0.011	677.78	537.71	541.14	516.95	450175.17	25.82
Quadratic	0.357	0.323	549.31	523.31	528.45	437.09	232847.94	20.35
Cubic	**0.516**	**0.477**	**482.54**	514.68	521.54	**314.06**	**301738.44**	**14.71**
Power	0.068	0.038	670.95	-91.98	-88.55	499.37	0.096	24.60
Exponential	0.147	0.125	663.80	**-95.85**	**-92.43**	516.53	0.088	23.72
S	0.023	-0.002	680.81	-90.27	-86.85	522.51	0.100	25.53
Compound	0.147	0.125	663.80	**-95.85**	**-92.43**	516.95	0.088	23.72

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

Table 11: Criteria of model selection for the chick pea pulse production in Bangladesh

Model	R^2	$\overline{R^2}$	RMSE	AIC	BIC	MAE	MSE	MAPPE
Linear	0.177	0.156	19432.57	813.73	817.15	16467.82	377624893	63.39
Logarithmic	0.082	0.058	20525.64	818.21	821.64	16739.11	421301882	72.54
Inverse	0.021	-0.004	22924.90	820.84	824.27	17174.43	449214827	79.40
Cubic	**0.496**	**0.455**	**15612.12**	799.78	806.63	**12570.99**	243738341	**50.20**
Quadratic	0.396	0.364	16868.36	804.12	809.26	15402.67	284541714	51.58
Power	0.168	0.146	21194.69	-33.64	-30.21	16910.67	0.399	56.24
Exponential	0.327	0.310	21994.30	**-42.36**	**-38.94**	17074.09	0.323	48.09
S	0.044	0.020	22795.77	-27.96	-24.53	18222.57	0.459	67.93
Compound	0.327	0.310	21994.30	-42.33	-38.91	17074.09	0.323	48.09

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

Table 12: Criteria of model selection for the field pea pulse production in Bangladesh

Model	R^2	$\overline{R^2}$	RMSE	AIC	BIC	MAE	MSE	MAPPE
Linear	0.032	0.007	3364.91	669.00	672.43	2832.85	11068320	27.32
Logarithmic	0.185	0.164	3098.34	663.17	666.59	2708.52	9599699	26.71
Inverse	0.236	0.216	3000.09	660.52	663.95	2541.63	9000564	24.90
Cubic	**0.700**	**0.676**	**1928.79**	628.30	635.16	**1355.53**	3720243	**13.48**
Quadratic	0.151	0.106	3204.17	667.92	673.06	2824.08	10266716	27.48
Power	0.119	0.097	3102.57	-94.25	-90.82	2727.85	0.08284	25.92
Exponential	0.060	0.036	3326.97	**-98.12**	**-94.70**	2787.58	0.091	26.61
S	0.163	0.141	3097.65	-100.19	-96.77	2653.98	0.079	24.81
Compound	0.050	0.026	3226.87	-97.13	-92.50	2687.60	0.087	24.63

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

ARIMA (1, 2 and 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. Rahman and Imam (2008) tried to 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. Among the deterministic type models for pigeon pea, chickpea and field pea pulse production the cubic model is found to be the most appropriate one. For forecasting purposes, he forecasted the pigeon pea, chickpea and field pea pulse production in Bangladesh in the year of 2008-09 to 2012-2013 (Table 9 to 12).

CONCLUSION

This study made the best effort to develop a short run forecasting model of pulse production in Bangladesh. The empirical analysis indicated that ARIMA(1, 1 and 1), ARIMA (0, 1, 0) and ARIMA (1, 1 and 3) were best fitted model for short run forecasting of pigeon pea, chick pea and field pea pulse production, respectively. However, the ARIMA model estimated that the pulse production of Bangladesh were 2029, 41356 and 11068 metric tons in 2011-12 and if the trend in present pulse production to be continued, the total pulse (pigeon pea, chick pea and field pea) production of Bangladesh would be 1331, 42628 and 12093 metric tons in the year 2015-2016. To increase pulse production of Bangladesh, the government should put emphasis on adopting of high yielding pulse varieties in pulse seasons and take proper input subsidiary programme in order to achieve food security. The production uncertainty of pulse could be minimized if production were forecasted well and necessary steps were taken against losses. For this purposes, the findings of this study would be more useful for policy makers, researchers and producers for future national pulse production policies.

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