Research Article

Exponential Growth Model for Forecasting of Area and Production of Potato Crop in Pakistan

Saleem Abid[1]*, Nasir Jamal[2], Muhammad Zubair Anwar[3] and Saleem Zahid[4]

[1]Social Sciences Research Institute, National Agricultural Research Centre, Islamabad, Pakistan; [2]Department of Mathematics & Statistics, PMAS Arid Agriculture University, Rawalpindi; [3]Social Sciences Research Institute, NARC,Islamabad; [4]Institute of Business & Management Sciences, The University of Agriculture, Peshawar, Pakistan.

Abstract | The main focus of this study was to forecast area and production of potato crop in Pakistan using the best fitted model. Time series data of potato area and production in Pakistan from 1980-81 to 2012-13 (33 years) were used. Five different forecasting models such as Linear trend model, Quadratic trend model, Exponential growth model, S-curve trend model and double exponential smoothing model were used to find the best fitted model for area and production of potato in Pakistan. Forecasting errors namely mean absolute percentage error (MAPE), mean absolute deviation (MAD) and mean squared deviation (MSD) were used as model selection criteria. Lowest values of these errors indicated a best fitting model. The study showed that exponential growth model was appropriate for forecasting potato area and production in Pakistan due to lowest values of the forecasting errors. The forecasted values of both area and production of potato crop depicted increasing trend. The findings of this study would help the decision makers to make better policies regarding crop production, price structure as well as consumption of potato in the country.

Received | 12 September 2017; **Accepted** | 24 November 2017; **Published** | March 15, 2018
***Correspondence** | Saleem Abid, Planning and Development Division, Pakistan Agricultural Research Council, 20-Ataturk Avenue, Sector G-5/1, Islamabad, Pakistan; **Email:** saleemabidpk@gmail.com
Citation | Abid, S., N. Jamal, M.Z. Anwar and S. Zahid. 2018. Exponential growth model for forecasting of area and production of potato crop in Pakistan. *Pakistan Journal of Agricultural Research,* 31(1): 24-28.
DOI | http://dx.doi.org/10.17582/journal.pjar/2018/31.1.24.28
Keywords | Forecasting models, Potato, Area, Production, Exponential growth model

Introduction

Potato (L. *Solanum tuberosum*) belongs to Solanaceae family. It is the most important dicotyledonous tuber crop and possesses major socio-economic importance worldwide. It is the fourth most cultivated food crop after wheat, rice and maize in world. Potato is a good and cheaper source of carbohydrates, vitamins, minerals and proteins and also provides most of the trace elements, which can meet the energy requirement of the people living in the developing countries like Pakistan (Khan and Akhtar, 2006).

Nature has bestowed Pakistan with different agro-climatic situation. In the plains, we are raising two crops of potato namely spring and autumn crops while third one is grown in hilly areas during summer season. In Pakistan, currently potato is grown on 172.8 thousand hectares producing 3785.9 thousand tons annually with an average yield of 18.3 tons per hectare (GoP, 2014).

According to Agricultural Statistics of Pakistan, the area and production of potato have increased from 78.9 thousand hectares and 1063.5 thousands ton in 1995-96 to 172.8 thousand hectares and 3785.9 thousands ton in 2012-13, respectively. Similarly, the yield of potato crop has increased from 13.5 to 18.3 tons/

hectare during the same period (GoP, 2014). The increase in production can be attributed due to the corresponding increase in area under potato, availability of sufficient soil moisture, certified seed potato and optimal use of fertilizers and chemicals and improved crop management practices. It was also significant to note that merely the provision of information was not sufficient but also attractive that farmers must take on the most recent varieties of potato and other farming techniques. In the absence of sophisticated technologies, a country like Pakistan can only stay alive economically with the development of its agriculture into the most dynamic, well-organized and productive system possible (Khan and Akhtar, 2006).

The policy makers of the country needs an accurate and advance information about the status of different crops such as wheat, rice and potato etc ahead of harvest and till the availability of final estimates. Therefore, accurate forecasting of potato area and production may support the policy makers and planners for making policy decision regarding supply, demand and import/export of potato in the country. A lot of work has been done by researchers on forecasting of area and production of wheat, maize, sugarcane and rice crop but no work has been done so far on potato forecasting in Pakistan. A number of forecasting models for projecting the crop have been formulated/ used earlier. A few of them are by Azhar et al. (1974), Amir and Akhtar (1984), Sher and Ahmad (2008) for wheat crop and Khan and Khan (1988), Maria and Tahir (2011) for rice crop, Niaz et al. (2013) for lentil pulses, Asif and Anver (2004) for sugarcane crop, Badmus and Ariyo (2011) forecasted the cultivated area and Production of potato in Nigeria. Similarly, Abid et al. (2014) conducted a study on trend analysis and forecasting of maize area and production in Khyber Pakhtunkhwa province of Pakistan.

Keeping in view the importance of potato crop for producers as well as consumers of the country there is a need to forecast cultivation area and production of potato in Pakistan. The finding of this study would help the decision makers to make better policies regarding crop production, price structure and consumption of potato crop. The main objective of this study was to forecast area and production of potato crop in Pakistan using the best fitted model.

Materials and Methods

The present study was conducted using time series data of potato area and production in Pakistan from 1980-81 to 2012-13 (33 years). The secondary data were collected from various issues of Agricultural Statistics of Pakistan (Goverment of Pakistan,1992, 2000 and 2014). Data was analyzed in Minitab Version 16 Statistical software.

Analytic techniques

Five different forecasting models such as Linear trend model, Quadratic trend model, Exponential growth model, S-curve model and double exponential smoothing model were used to find the best fitted model for area and production of potato in Pakistan. Forecasting models used (Abid et al., 2014; Karim and Akhter, 2010; Tahir and Habib, 2013) were given below:

Linear Trend Model:

$$Y = b_0 + b_1 \times t$$

Quadratic Trend Model:

$$Y = b_0 + b_1 \times t + b_2 \times t^2$$

Exponential Growth Model:

$$Y = b_0 \ e^{b1 \times t}$$

S Curve Model (Pearl-Reed logistic trend model**):**

$$Y_t = \frac{10^a}{b_0 + b_1 \times b_2^t}$$

Where:
Y: area and production of potato crop in Pakistan; t Trend which determines the tendency of time series data to increase or decrease over time; b_0, b_1 and b_2: Parameters of the model.

Double Exponential Smoothing Model

Suppose S' denotes the singly smoothed series obtained by applying simple exponential smoothing to series Y (Abid et al., 2014) . That is, the value of S' at period t is given by:

$$S'(t) = \alpha Y(t) + (1-\alpha)S'(t-1)$$

Let S" denote the doubly smoothed series obtained by applying simple exponential smoothing

$$S''(t) = \alpha S'(t) + (1-\alpha)S''(t-1)$$

Finally, the forecast Ý(t+1) is given by:

$$Ý(t+1) = a(t) + b(t)$$

where:
a(t) = 2S'(t) - S"(t) the estimated level at period t.
b(t) = (a/(1-α))(S'(t) - S"(t)) the estimated trend at period t.

Diagnostic measures for selection of best forecasting model

Reliability of the forecasting methods was based on three accuracy measures also termed as forecasting errors. These measures include Mean Absolute Percentage error (MAPE), Mean Absolute Deviation (MAD) and Mean Squared Deviation (MSD). Mean Absolute Percentage Error measures the accuracy of fitted time series values. It expresses accuracy as a percentage. Mean Absolute Deviation measures the accuracy of fitted time series values. It expresses accuracy in the same units as the data, which helps conceptualize the amount of error. Mean Squared Deviation is always computed using the same denominator, regardless of the model. It is more sensitive measure than mean absolute deviation especially in case of abnormally large forecast error. Smaller values of all these measures indicate a good fitted model with minimum forecasting errors (Karim and Akhter, 2010). The best fitted Model for this study was exponential growth model; and the stationary series of the data was used in the model identification.

Results and Discussion

Diagnostic measures for the selection of best fitted model

The performance of the model is related with how close are the prediction values for test data and the observed values. Three different prediction consistency criteria are used in order to compare the performances of the models. These are mean absolute percentage error (MAPE), mean absolute deviation (MAD) and mean squared deviation (MSD) (Aydin, 2007). Five forecasting models such as Linear trend model, Quadratic trend model, Exponential growth model, S-curve model and double exponential smoothing model were used to find the best fitted model for area and production of potato in Pakistan. The Exponential growth model was best fitted for trend analysis of potato area and production in Pakistan on the basis of smaller values of accuracy measures (Abid et al., 2014; Karim and Akhter, 2010; Tahir and Habib, 2013; Aydin, 2007). The Exponential growth model shows the small values of all accuracy measures like MAPE, MAD, MSD, so therefore this model is best fitted model and is being selected as a best model for forecasting. The diagnostic measures for the selection of best forecasting model for potato area and production in Pakistan were summarized in Table 1 and 2.

Table 1: *Diagnostic measures for selection of best fitted model for potato area in Pakistan*

Forecasting models	Criteria		
	MAPE	MAD	MSD
Linear trend model	8.42	7.97	99.14
Quadratic trend model	6.32	5.97	63.41
Exponential growth model	6.01	5.70	59.15
S curve model	6.20	6.25	71.50
Double exponential smoothing model	8.19	7.69	95.71

Source: *Author's own calculation*

Table 2: *Diagnostic measures for selection of best fitted model for potato production in Pakistan*

Forecasting models	Criteria		
	MAPE	MAD	MSD
Linear trend model	25.0	267.0	107479.0
Quadratic trend model	8.6	117.2	36840.0
Exponential growth model	8.0	112.8	33146.4
S curve model	8.8	138.7	45354.9
Double exponential smoothing model	10.5	159.3	53297.7

Source: *Author's own calculation*

It was revealed from the results that the value of forecasting errors were lowest for exponential growth model and was consequently selected as a best fitting model for predicting potato area in Pakistan. The area and production of potato crop in Pakistan is increasing exponentially and that is visible from Figure 1. Similarly the exponential growth model was also best fitted for potato production in Pakistan as the value of forecasting errors were lowest so selected as a best fitting model for predicting potato production in Pakistan. Results showed that Exponential growth trend model was fit well to data. Some studies have been conducted for predicting future estimates of major and minor crops in Pakistan using the same model selection criteria. For instance Abid et al. (2014) used quadratic trend model to forecast maize area and production in Khyber Pakhtunkhwa, Pakistan. Similarly, Tahir and Habib (2013) used trend analysis technique

to forecast maize area and production in Pakistan. The results of the study showed that exponential growth model was fit well to the data.

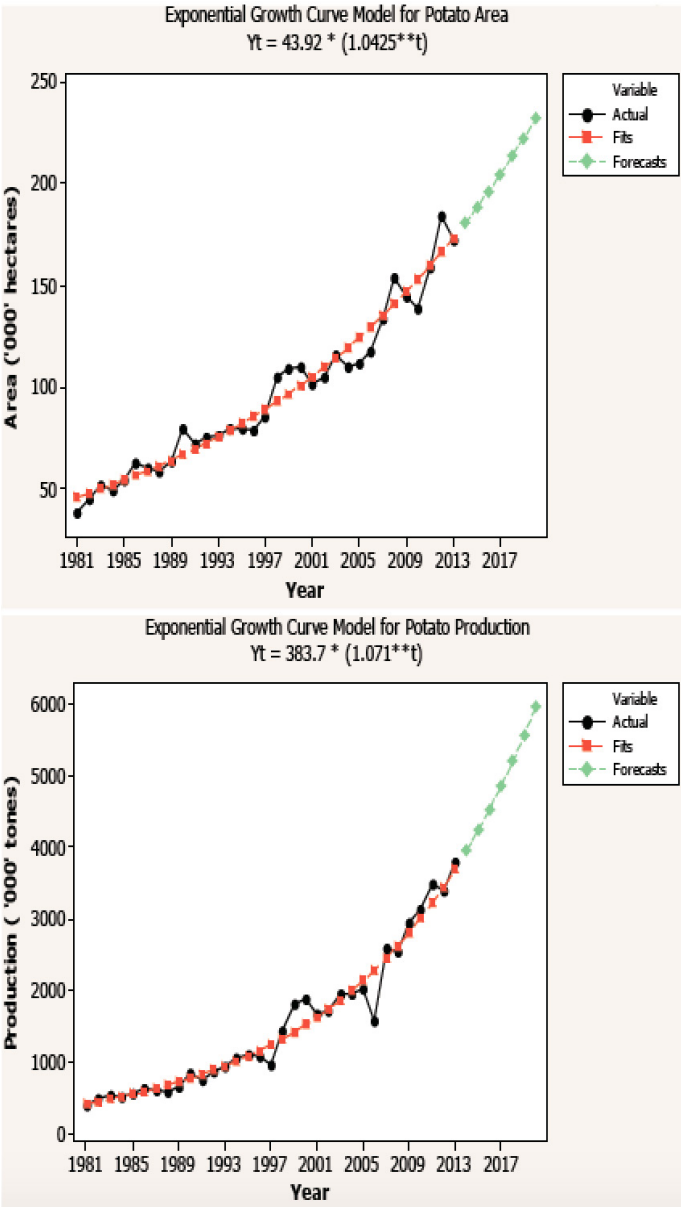

Figure 1: *Exponential growth curve model for area and production of potato in Pakistan*

Table 3: *Seven years forecast of area and production of potato crop in Pakistan*

Years	Area ('000' hectares)	Production ('000' tones)
2013-14	181.02	3953.74
2014-15	188.72	4234.50
2015-16	196.74	4535.21
2016-17	205.11	4857.27
2017-18	213.84	5202.19
2018-19	222.93	5571.61
2019-20	232.41	5967.27

Source: *Author's own calculation*

Seven years forecast of area and production of potato crop in Pakistan was presented Table 3. The forecast values of potato area were 181.02, 188.72, 196.74, 205.11, 213.84, 222.93 and 232.41 thousand hectares and production were 3953.74, 4234.50, 4535.21, 4857.27, 5202.19, 5571.61 and 5967.27 thousand tones for the year 2013-14 to 2019-20 respectively. The results indicated that the area under potato crop is increasing exponentially till 2019-20. The production of potato is also increasing due the corresponding increase of potato area in Pakistan. The results of the study showed that exponential growth model was best fitted to area and production of potato crop of Pakistan.

Conclusions and Recommendation

The study showed that Exponential growth model was appropriate for predicting future estimates of potato area and production in Pakistan due to lowest values of the forecasting errors. The forecast values of both area and production of potato depicted increasing trend. The production of potato is increasing due the corresponding increase of potato area in Pakistan. Making timely forecast of this crop will enable the policy makers and government to take wiser steps for enhancing potato production in Pakistan and as a result increased production of potato will definitely contribute in meeting the demands of this crop at national level.

Author's Contribution

SA conceived the idea, wrote the manuscript. NJ provided technical input at every step. MZA helped in writing of introduction and provided technical input. SZ collected time series data, review of literatureand references.

References

Abid, S., I. Raza, A. Khalil, N. Khan, A. Saqib and M. A. Masood. 2014. Trend analysis and forecasting of maize area and production in Khyber Pakhtunkhwa, Pakistan. European Academic Res. 2(4): 4653-4664.

Amir, P. and M.R. Akhtar. 1984. A model for forecasting wheat production in the four provinces of Pakistan. Social Sciences Division, PARC, Islamabad.

Asif, M. and A. Javed. 2004. Forecast models for sugarcane in Pakistan. Pak. J. Agric. Sci., 41:

1-2.

Aydin, D. 2007. A comparison of the nonparametric regression models using smoothing spline and kernel regression. Int. J. Math. Comput. Phys. Electr. Comput. Engineer. 12:588-592.

Azhar, B.A., G.M. Chaudhry and M.A. Shafique. 1974. A model for forecasting wheat production in the Punjab. Pak. Dev. Rev. 13(1):407-415.

Badmus, M.A. and O.S. Ariyo. 2011. Forecasting cultivated areas and production of potato in Nigerian using ARIMA Model. Asian J. Agric. Sci. 3(3): 171-176.

Sher, F. and E. Ahmad. 2008. Forecasting wheat production in Pakistan. Lahore J. Econ. 13 (1): 57-85.

Government of Pakistan. 2014. Agricultural Statistics of Pakistan. Finance Division. Economic Adviser's Wing, Islamabad.

Government of Pakistan. 1992. Agricultural Statistics of Pakistan. Finance Division, Economic Adviser's Wing, Islamabad.

Government of Pakistan. 2000. Agricultural Statistics of Pakistan. Finance Division, Economic Adviser's Wing, Islamabad.

Karim, R. and M. Akhter. 2010. Forecasting of wheat production in Bangladesh. Bangladesh J. Agric. Res. 35(1): 17-28. https://doi.org/10.3329/bjar.v35i1.5863

Khan, M.I. and N.A. Khan. 1988. Rice forecast model of Pakistan. Gomal Univ. J. Res. 8(1):95-105.

Khan, N.P. and J. Akhtar. 2006. Competitiveness and policy analysis of potato production in different agro-ecological zones of Northern Areas: Implications for food security and poverty alleviation. Pak. Dev. Rev. 1137-1154.

Maria, I., M. Irfan, and M. Tahir. 2011. Modeling the province wise yield of rice crop in Pakistan Using GARCH model. Int. J. Sci. Technol. 1(6):224- 228.

Minitab. 2015. Minitab statistical software features (http://www.minitab.com/en-US/products/minitab/features/)

Niaz M., M. Azizul Baten, A. Roy, M. Monir. 2013. Forecasting of lentil pulse production: An econometric analysis. Australian J. Basic Appl. Sci. 7(2):819-824.

Tahir, A. and N. Habib. 2013. Forecasting of maize area and production in Pakistan, ESci J. crop prod. 2(2): 44-48.