Environment and Ecology 39 (3) : 584—588, July—September 2021
ISSN 0970-0420

Quadratic Trend Model for Forecasting of Rice in Western Uttar Pradesh

Amar Singh, Bhim Singh

Received 27 March 2021, Accepted 30 June 2021, Published on 8 July 2021

ABSTRACT

The main focus of this study was to forecast rice yield in western Uttar Pradesh using the best fitted model. Time series data of rice crop of Meerut district of western Uttar Pradesh from 1997–98 to 2019–20 (23 years) were used. Three different forecasting models such as linear trend model, quadratic trend model and exponential growth model were used to find the best fitted model for area and production of rice of Meerut district of western Uttar Pradesh. Forecasting errors namely MAPE, MAD, MSD and RMSE were used as model selection criteria. The study showed that quadratic trend model was appropriate for forecasting rice area and production in that area due to lowest values the forecasting errors. Forecasting values of both area and production of rice crop depicted increasing trend after decreasing and equilibrium stage. The findings of this study would help the decision makers to make better policies for rice crop in western Uttar Pradesh.

Keywords MAD, MAPE, MSD, RMSE, Time series data.

Amar Singh*
Department of Agricultural Statistics, CSSS PG College, Machhra, Meerut 250106 (UP), India

Bhim Singh
Department of Basic Science, College of Agriculture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut 250110 (UP), India
Email: amaras.singhshakya@gmail.com
*Corresponding author

INTRODUCTION

Rice (*Oryza sativa*), one of the three most important food grain crops in world, forms the staple diet of 2–7 billion people. Its cultivation is of immense importance to food security of Asia, where more than 90% of the global rice is produced and consumed. India is one of the countries that took full advantage of the plant type based high yielding varieties of rice since their introduction in the mid-sixties. Spectacular production growth initially through combined growth of productivity enabled the country to attain self-sufficiency by the early eighties and sustain the same since them. Rice production in India is an important part of the national economy. India is an important part of the national economy. India is the world's 2nd largest producer with approximately 43 mha planted area, accounting for 22% of the World's rice production (Tiwari *et al*. 2019). Uttar Pradesh is fourth largest state in the country. State covers an area of about 243290 sq and possesses varied topographic features ranging from plain to Vindhyan hills. Uttar

Pradesh is divided in two physiographic regions viz. Gangatic plain and southern plateau. Agriculture is the most important occupation in the state as about 80% of its population resides in rural areas and 75% of the total workers are involved directly or in directly in farming which accounts for 27% of state's GDP (Tiwari *et al*. 2019). The State is divided into 4 regions, namely western (26 districts), Eastern (28 districts), central (13 districts) and bundelkhand (08 districts). At present state have 75 districts, 327 tehsils, 822 blocks and 107452 revenue villages. The important crops in include rice, wheat, maize, sugarcane, potato. Majority of the agricultural land is used to grow major cereal crops: Rice and Wheat. Rice is grown in Uttar Pradesh during *kharif* season from June to October/November. Rice is grown in all types of soils and is most suited for its cultivation. The traditional rice farming systems in India broadly include wetland (Lowland and upland) system. The life cycle can be divided into 3 important phases, i.e. vegetative, reproductive and ripening. Rice produces 32–59% of dietary energy and 25–40% of dietary protein in 39 countries. Annually rice is grown in 44.6 million hectares under 4 major ecosystems irrigated (21 million ha), rainfed lowland (14 million ha), rainfed upland (6 million ha) and flood prone (3 million ha), More than half of rice area (55%) is rainfed and distribution wise 80% of the rainfed rice area is in eastern India making its vulnerable to vagaries of monsoon (Singh *et al.* 2018).

The rice–wheat system is critical cropping system in the Meerut district of northern India. Irrigated rice is grown during the wet *kharif* season (June–October) and irrigated wheat cultivated during the dry *rabi* season (November–April). These lands have been continuous cultivation, along with imbalanced use of chemical fertilizer has caused soil health to deteriorate and yield levels to stagnate in recent history. Increasing temperatures have aggregated the problem. The increase in maximum and minimum temperatures has caused reductions in crop yields. Droughts and rainfall inconsistencies have also increased, posing threat to future water supply, though irrigation (which accounts for 95% of the district) has limited these impacts. Current farms exposed to climate changes could experience a decline in net farm returns of 4% to 14% and a decline in per capita income by 3% to 7% (Antle *et al*. 2015). As a result, population poverty rates may increase by 1% to 2%. Though the magnitude of decline in net farm returns and per capita income may seem small, these will adversely affect a large proportion of farms nearly 49% to 74% of the population (Rosenzweig *et al*. 2013).

MATERIALS AND METHODS

The present study was conducted using time series data of rice area and production in Meerut district of western Uttar Pradesh from 1997–1998 to 2019–2020 (23 years). The secondary data were taken from Crop Production Statistics Information System, Ministry of Agriculture and Farmer Welfare, New Delhi. Three different forecasting models such as Linear trend model, Quadratic trend model and Exponential growth model were used to find the best fitted model for area and production of rice in Meerut district. Forecasting models used (Abid *et al.* 2018, Karim and Akhter 2010, Tahir and Habib 2013) were given below: Three different models are

Linear trend model: $Y=b_0 + b_1 t$

Quadratic trend model: $Y=b_0 + b_1 t + b_2 t^2$

Exponential growth model : $Y=b_0 e^{b1t}$

Where:

Y: Area and production of rice crop; 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.

Trustworthiness of the forecasting methods was based on three accuracy measures also known as forecasting errors (Abid *et al*. 2018). These measures include mean absolute percentage error (MAPE), mean absolute deviation (MAD), mean squared deviation (MSD) and root mean square error (RMSE). Mean absolute percentage error 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, in spite 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 mea-

Table 1. Diagnostic measures for selection of best fitted model for rice area in Meerut district of western Uttar Pradesh.

Forecasting models	Criteria			
	MAPE	MAD	MSD	RMSE
Linear trend model	12.10	4636.57	35920625.52	5993.38
Quadratic trend model	10.70	4123.36	25837674.39	5083.07
Exponential growth model	11.84	4581.26	35369096.64	5947.19

Table 2. Diagnostic measures for selection of best fitted model for rice production in Meerut district of western Uttar Pradesh.

Forecasting models	Criteria			
	MAPE	MAD	MSD	RMSE
Linear trend model	10.86	1714.39	4537644.13	2130.17
Quadratic trend model	10.60	1682.14	3919030.46	1979.65
Exponential growth model	10.82	1728.14	4542369.86	2131.28

sures indicate a good fitted model with minimum forecasting errors.

RESULTS AND DISCUSSION

The efficiency of the model is related with how close are the prediction values for test data and observed values. Four different prediction consistency criteria are used to order to compare the performances of the models. These are mean absolute percentage error (MAPE), mean absolute deviation (MAD), Mean squared deviation (MSD) and root mean square error (RMSE). Three forecasting models such as Linear trend model, Quadratic trend model and Exponential growth model were used to find the best fitted for trend analysis of rice area and production data in Meerut district of western Uttar Pradesh from 1997–1998 to 2019–2020 on the basis of smaller values of accuracy measures. The quadratic trend model shows the smallvalues of all accuracy measures like MAPE, MAD, MSD and RMSE, 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 rice area and production in Meerut district of western Uttar Pradesh were summarized in Tables 1, 2.

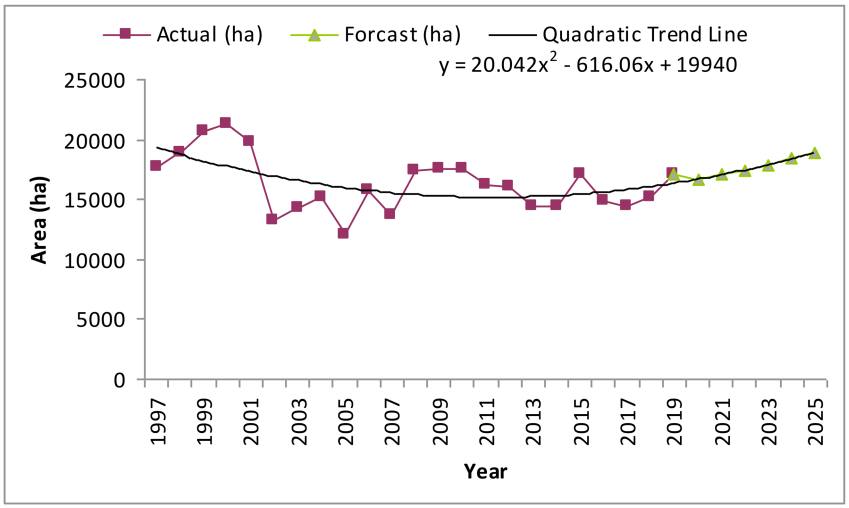

Fig. 1. Quadratic trend model for rice area.

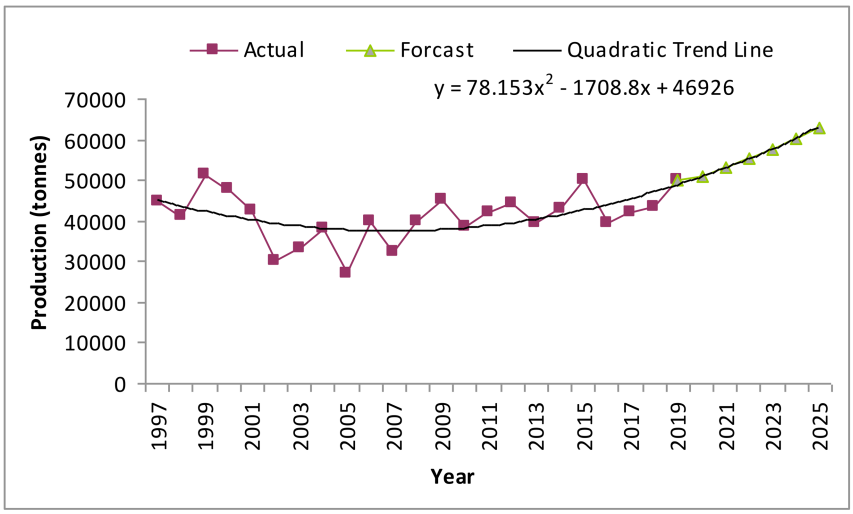

Fig. 2. Quadratic trend model for rice production.

It was revealed from the results that the value of forecasting errors were lowest for quadratic trend model and was consequently selected as a best fitting model for predicting rice area in Meerut district of western Uttar Pradesh. The area and production of rice crop in Meerut district of western Uttar Pradesh is increasing as quadratic trend (Figs.1, 2). Similarly the quadratic trend model was also best fitted for rice production in Meerut district of western Uttar Pradesh as the value of forecasting errors were lowest so selected as best fitting model for predicting rice production in Meerut of western Uttar Pradesh. Results showed that quadratic trend model was fit well to data. Using the quadratic trend model, we have forecasted the rice area and production for next six years from 2020-21 to 2025-26 (Table 3). The forecast values of rice area were 16699.04, 17065.00, 17471.04, 17917.16, 18403.36 and 18929.64 hectares and production were 50948.40, 53069.75, 55347.40, 57781.35, 60371.60 and 63118.15 tonnes for the year 2020-21 to 2025-26 respectively. Thus, it is expected to increase in the area by 10.30% where as in the production increment will be 25.82% by 2025-26 in the Meerut of western Uttar Pradesh. The results indicated that area and production of rice crop is increasing quadratic trend. The result of the study showed quadratic trend model was best fitted to area and production of rice crop of Meerut of western Uttar Pradesh.

Table 3. Six years forecast area and production of rice crop in Meerut district of western Uttar Pradesh.

Year	Area (Hectare)	Production (Tonnes)
2020-21	16699.04	50948.4
2021-22	17065	53069.75
2022-23	17471.04	55347.4
2023-24	17917.16	57781.35
2024-25	18403.36	60371.6
2025-26	18929.64	63118.15

CONCLUSION

The study showed that quadratic trend model was appropriate for predicting future estimates of rice area and production in Meerut district of western Uttar Pradesh due to lowest values of the forecasting errors. The forecast values of the area of rice continuously increasing tend from 2013–14 to 2019–20 perhaps it was in decreasing trend form 1997–98 to 2009–10 after that it was in equilibrium stage from 2010–11 to 2013–14 while production of rice continuously increasing trend from 2010–11 to 2019–20 perhaps it was in decreasing trend form 1997–98 to 2009–10. The production of rice crop is increasing again due to corresponding increase of rice area after approximate-

ly three years equilibrium stage in Meerut district of western Uttar Pradesh making timely forecast of the crop will enable the policy makers and government to take wiser steps for enhancing rice production in Meerut and as a result increased production of rice will definitely contribute in meeting the demands of this crop at state levels.

ACKNOWLEDGEMENT

Authors greatly acknowledge to the Crop Production Statistics Information System, Directorate of Economics and Statistics, Ministry of Agriculture and Farmer Welfare, New Delhi for providing online database to carry out the research work.

REFERENCES

Abid S, Jamal N, Anwar MZ, Zahid S (2018) Exponential growth model for forecasting of area and production of potato crop in Pakistan. *Pak J Agric Res*1(1): 24-28.

Antle JM, Valdivia RO, Boote KJ, Janseen S, Jones JW, Porter CH, Rosenzweig C, Ruane AC, Thorburn PJ (2015) AgMIP'stransdisciplinary agricultural systems approach to regional integrated assessment of climate impacts, vulnerability and adaptation. In: Rosenzweig C, Hillel D (eds). Handbook of climate change and Agroecosystems: The Agricultural Model Intercomparison and Improvement Project (AgMIP). ICP Serieson climate change impacts Adaption and Mitigation Vol. 3. part 1, Imperial College Press, pp 27-44.

Karim R, Akhter M (2010) Forecasting of wheat production in Bangladesh. *Bangladesh J Agric Res* 35(1): 17-28.

Rosenzweig C, Jones JW, Hatfield JL, Ruane AC, Boote KJ, Thorburn P, Antle JM, Nelson GC, Porter C, Janssen S, Asseng S, Basso B, Ewert F, Wallach D, Baigorria G, Winter JM (2013) The agricultural Model Intercomparison and Improvement project (AgMIP): Protols and Pilot studies. *Ag For Meteor* 170: 166-182.

Singh N, Singh PK, Kumar S (2018) Growth Rate of wheat crop in Azamgarh division of Eastern Uttar Pradesh, India. *Int J Curr Microbiol Appl Sci* 7 (03): 3348-3352.

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

Tiwari GK, Kumar S, Singh A, Babulal (2019) A statistical study of trend of rice–Wheat production on districts of western UP, India. *Int J Curr Microbiol Appl Sci* 8 (06): 2430-2443.