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REVIEW ARTICLE

NONLINEAR GROWTH MODEL IN AGRICULTURE

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ABSTRACT

To develop appropriate nonlinear statistical models with a view to provide analytical approach to describe the agricultural production trends in India. Reviews were made to study the various nonlinear statistical growth models. The parameters of each model were estimated using Levenberg - Marquardt (LM) iterative method. The main assumptions of 'independence' and 'normality' of error terms were examined by using the 'Run-test' and 'Shapiro-Wilk test' respectively. Measure the accuracy of the model fitting, we considered the performance of several model goodness of fit criteria viz., R^2, MAE, MSE, RMSE, MAPE, AIC and BIC. Nonlinear model discussed important five points of consideration 1. Parsimony, 2. Parameterization, 3. Range of applicability, 4. Stochastic specification and 5. Interpretability.

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INTRODUCTION

Statistical modelling basically consists in constructing model, represent by equations to explain the input-output relationship between the variables. From a sensible point of view, such as association among variables in agricultural production are 'non linear' in nature. In nonlinear models, a unit increase in the value of agriculture production (independent variable) may not result in an equivalent unit increase in the dependent variable (Venugopalan and Sharmasundaran, 2003).

What is Linear Relationship?

Any equation of linear relationship is that, when graphed the variables, gives you a straight line. Linear relationships are simple in this way. If you get a straight line and you have done the whole thing correctly, it is linear relationship.

What is Linear Model?

Output is directly proportionate to input which model is a linear model. In such a model, all the parameter appears linearly. Generally use the estimation of parameters by 'Method of least squares' method. Linear model is especially used in Industry, Agriculture, Medicine, Education *etc.*

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Nonlinear Model in Agriculture

Nonlinear models play significant role to understand the complex inter-relationships among variables. A nonlinear model is one in which at least one of the parameters appears nonlinearly. While a linear equation has one basic form, nonlinear equations can take many different forms. If the equation does not meet the criteria for a linear equation, it's nonlinear. Some nonlinear regression problems can be moved to a linear domain by a suitable transformation of the model formulation. Leaf growth of maize and tobacco, yield growth of Oil palm, growth rates of agricultural production, crop yield forecasting, and growth pattern of insect population are usually non-linear in nature.

Research issue in Agriculture?

Accurate and appropriate analysis of agricultural research findings, we often ask the following questions: Which is the best model to describe our agricultural production? Which is the best statistical technique to evaluator the goodness of fit? How do we choose best among various models? There are no easy answers to these questions. Our main purpose of this study is; 1. To give a brief review of nonlinear models and 2. To develop a guideline to understand the family of functions used in agricultural applications.

For what reason should Utilize Nonlinear Models in Agriculture?

The most main advantages of nonlinear models in are parsimony, interpretability, and prediction (Bates and Watts, 2007). The nonlinear models are able of helpful a huge range of mean functions, while each nonlinear model can be less flexible than linear models (i.e., polynomials) and variety of agricultural production data they can describe; While, nonlinear models appropriate for a given application can be more parsimonious (i.e., there will be less parameters involved) and more simply interpretable.

Application of various nonlinear models in agriculture- A brief review

Shadmehri (2008) estimated growth rates and decomposition analysis of agricultural production in Iran. Compound growth rates of area, production and yield were estimated by fitting semi-log trend equation using time series secondary data for the period of 1970 to 2000. He was found that the pattern of growth can no longer continue due to the lack of adequate water resources. Linear rates of growth are not found very convenient for any comparisons of growth between two period and two crops.

Kumar *et al.* (2012) proposed the suitable nonlinear growth models to provide analytical approach and to explain the coffee production trends in India. Agriculture production data used to describe the pattern of growth behaviour and the parameters of all models were estimated using Levenberg - Marquardt (LM) iterative method. Four main methods are commonly used to obtain estimates of the unknown parameters of a nonlinear regression models which are: (i) Linearization method, (ii) Gradient method, (iii) Does not use derivatives (DUD) method, and (iv) Levenberg-Marquardt (LM) method. It may be noted that various models are 'nonlinear', as each one of these involves at least one parameter in a nonlinear manner. Based on the performance of model fit and goodness of fit criteria, two best (Logistic and MMF) nonlinear models were chosen for future projection of coffee production in India.

Khan *et al.* (2013) applied nonlinear growth models to describing area, production and productivity of rice crop for agro-climatic zones wise and as well as complete Chhattisgarh State. Five different nonlinear statistical models *viz.,* Logistic, Monomolecular, Richards, MMF and Gompertz were considered for study. Appropriateness of a model was selected by sign of the parameter estimates; run test and Shapiro-Wilk test were in use to test the assumptions of randomness and normality of residuals, respectively. Levenberg -Marquardt (LM) iterative method used estimation of parameters of models. The suitable model found for agriculture production data of Chhattisgarh State in India were Logistic and Monomolecular models. Panwar *et al.* (2014) fitted model by 'method of least squares' method. Agriculture production data of wheat in different years is taken into consideration and different statistical models were fitted. The non-linear models, *viz.* Logistic, Gompertz and Monomolecular models were applied for wheat production of Uttar Pradesh, and comparative study, growth rate, forecasting was conducted for these models. Five most commonly methods are used to obtain estimates of the unknown parameters of a nonlinear regression model. These are (i) Gradient method, (ii) Gauss Newton method, (iii) Steepest-descent method, (iv) Levenberg-Marquardt technique and (v) Do not-Use- Derivatives method. They were found that logistic model performed better followed by Gompertz and Monomolecular in agricultural production. Sotirios *et al.* (2015) fitted nonlinear models by a flow diagram and discuss each step separately providing examples and updates on procedures used. The following steps are considered: (i) choose candidate models, (ii) set starting values, (iii) fit models, (iv) parameter estimates after check convergence (v) select the "best" model, after that (vi) check model assumptions (residual analysis), and (vii) calculate confidence intervals and statistical descriptors. The associated feedback mechanisms are also addressed (i.e., model variance homogeneity). Choose candidate models by provided that an extensive library of nonlinear functions (associated parameter meanings with the 77 equations) and examples of typical applications in agriculture. Basak *et al.* (2017) studied various statistical models namely; logistic, Gompertz, linear, cubic, and other model to describing pattern of growth of the insect population over time data at West Bengal in 2015. Suitable models identified by using goodness of fit criteria *viz.*, R^2, MAE, MSE, MAPE, ARPE, AIC, and BIC values. The Cubic model found that the best fit among a choice of fitted model and the occurrence of pest to estimate helpful.

Conclusion

In study the various view of the researcher used nonlinear model in agricultural production that better adjust the growth of agricultural production. Various iterative procedures viz. Taylor series method, Gradient method, Do not-Use-Derivatives method, Steepest descent, and Levenberg-Marquardt method were used most commonly to solving nonlinear normal equations. The most appropriate method found the 'Levenberg-Marquardt method' which was incorporates the best feature. Starting values of parameters were computed by different methods and various models is judge by the magnitude and sign of the parameter estimates, various goodness of fit viz. R^2, RMSE, MAE and by examination of residuals. Run test and Shapiro-Wilk test was employed to test the assumptions of randomness and normality of residuals.

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