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Estimation of rabi sorghum yield by using statistical models in Bellary district of Karnataka

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Abstract
Sorghum (*Sorghum bicolor* Linn.) popularly known as Jowar, is the major cereal consumed in India after rice and wheat. India is the world's fifth biggest producer of sorghum. It is the primary food grain of most of the districts in northern Karnataka. The data on yield and area of *rabi* sorghum in Bellary district were collected for the period 1985-2017 for prediction purpose. The yield was predicted using different polynomial equations like linear and non-linear models for *rabi* sorghum crop and also forecasted for 2021 AD. The cubic model was found to be the best fitted model and it was used for forecasting of crop yield. The best-fitted model was chosen based upon the highest coefficient of determination (R^2), significant Adjusted R^2 with least MAPE, MAE and RMSE values.

Keywords: *Rabi* sorghum, linear and non-linear regression, yield prediction, accuracy

Introduction
Sorghum (*Sorghum bicolor* Linn.) popularly known as Jowar, is the major cereal consumed in India after rice and wheat. It is originated in Northern Africa. It is the staple food crop for millions of poor in the semi-arid tropics of Asia and Africa. It is the primary grain of northern Karnataka in most of the districts. In India, *rabi* sorghum is grown on an area of 46.39 lakhs ha and Karnataka occupies the second largest area (18%), whereas Maharashtra (54%) occupies first place. *Rabi* sorghum is grown in northern Karnataka mainly as rainfed crop and to a very little extent under irrigated conditions. It is grown in the districts of Bijapur, Bagalkote, Bellary, Belgaum, Bidar, Dharwad, Gadag, Gulbarga, Haveri, Koppal and Yadgir. The *rabi* sorghum area under rainfed condition in Bellary district of north Karnataka is 38,677 ha with a production 24,835 tonnes. It occupies sixth place in area and production in North Karnataka.

Material and Methods
The secondary data on yield and area of *rabi* sorghum crop in Bellary districts of Karnataka state were collected for the period of 33 years (1985-86 to 2017-18) from Directorate of Economics and Statistics, Government of Karnataka.

Linear and non-linear models
The simplest way of representing any relation is by fitting a linear equation using the variables under study. But, in all the cases it may not follow. In the present study, taking yield as dependent variable and time (years) as independent variable, non-linear and polynomial models were tried to fit the data of sorghum in Bellary district of Karnataka. Here the data from 1985 to 2016 was used in developing the model and the remaining two years' data 2016-17 and 2017-18 was used for validating the models.

Following models were tried to fit the data.

1. $Linear: Y_t = a + bT + e_t$
2. $Logarithemic: Y_t = a + bln(T) + e_t$
3. $Inverse: Y_t = a + {}^{b}/_{T} + e_t$
4. $Quadratic: Y_t = a + bT + cT^2 + e_t$
5. $Cubic: Y_t = a + bT + cT^2 + dT^3 + e_t$
6. $Compound: Y_t = ab^T + e_t$
7. $Power: Y_t = aT^b + e_t$
8. $Scurve: Y_t = \exp\left(a + {}^{b}/_{T}\right) + e_t$

9. $Growth: Y_t = \exp(a + bT) + e_t$
10. $Exponential: Y_t = ae^{bT} + e_t$

Where,
Y_t = Dependent variable
T = Independent variable, time in year
a, b, c, d = Coefficients of the model, estimated by applying ordinary least square method
e_t = error term in the model

Coefficient of Determination (R^2)

The statistic R^2 indicates the percentage of variation in the dependent variable explained by the independent variables included in the regression model. An R^2 of 1.0 shows that the line of regression fits the information perfectly. It offers a measure of how well the model is likely to predict future results. $R^2$is computed as

$$R^2 = \frac{RSS}{TSS} = 1 - \frac{ESS}{TSS}$$

Where,
ESS = Error sum of square
TSS = Total sum of square in the regression analysis

Where, $0 \leq R^2 \leq 1$
To test the significance of R^2, F-test is used

Adjusted R^2

Adjusted R^2 will always be less than or equal to R^2, showing how the adjusted R^2 penalizes for adding more regressors. Unlike R^2, the adjusted R^2will increases only if the absolute t value of the added variable is greater than one and it can be negative. For comparative purposes, adjusted R^2 is a better measure than R^2.

$$\text{Adjusted } R^2 = 1 - (1 - \frac{ESS/n - k}{TSS/n - 1})$$

Where,
n = Number of observations
k = Number of parameters in the model

Root Mean Square Error (RMSE)

It is also a measure for validation and comparing two models. The formula of RMSE is given by

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(O_i - E_i)^2}$$

Where,
O_i = Observed value
E_i = Forecasted value
n = Number of years for which forecasting has been done

Result and Discussion

Table 1: Statistical models for *Rabi* Sorghum yield in Bellary district of Karnataka

Parameter estimates					Goodness of fit			
Models	**a**	**b_1**	**b_2**	**b_3**	**R^2**	**Significance Level**	**Adj. R^2**	**RMSE**
Linear	131.303	27.074			0.418	0.000	0.398	285.491
Logarithmic	-33.818	237.506			0.284	0.002	0.259	316.868
Inverse	664.905	-773.602			0.150	0.031	0.121	345.158
Quadratic	483.549	-36.971	2.001		0.564	0.000	0.533	247.105
Cubic	31.405	120.242	-10.088	0.252	0.706	0.000	0.673	203.091
Compound	211.172	-1.048			0.312	0.001	0.288	218.175
Power	124.826	0.507			0.320	0.001	0.297	317.266
S-curve	6.399	-2.278			0.323	0.001	0.300	351.228
Growth	5.353	0.047			0.312	0.001	0.288	281.175
Exponential	211.172	0.047			0.312	0.001	0.288	281.175

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

Estimated Model is

$\hat{Y} = 31.405 + 120.242^{*}X - 10.088^{**}X^2 + 0.252^{**}X^3$
(177.336) (47.234) (3.401) (0.070)

Figures in parentheses denote standard error of co-efficient. * and ** indicate significance at 5 per cent and 1 per cent, respectively.

Using cubic model, the yield was estimated for 2016-17 and 2017-18 and it was compared with actual values. It was observed that they are in close agreement with RMSE value of 137.7. Further the yield was forecasted using the same model for next three years *i.e.* 2018-19 to 2020-21. The results were presented in Table 2. The graph of the observed and expected values is given in fig.1.

Table 2: Cubic model validation as well as forecasts of yield of *rabi* sorghum

Year	Actual yield (kg/ha)	Forecasted yield (kg/ha)	RMSE
2016-17	1624	1802	137.70
2017-18	1985	2064	
2018-19		2357	
2019-20		2680	
2020-21		3036	

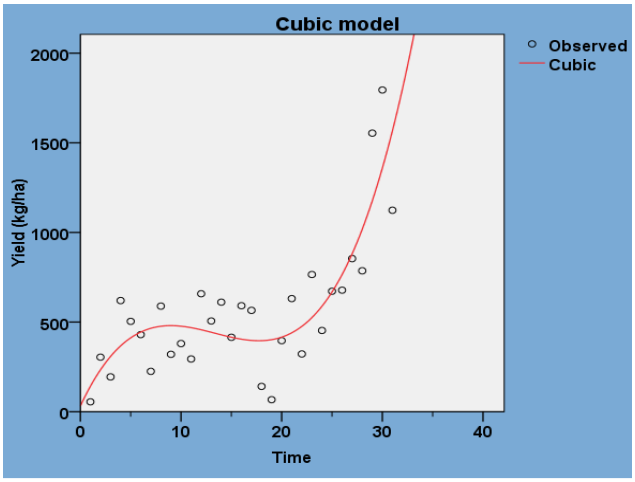

Fig 1: Fitted cubic model for yield of *rabi* sorghum in Bellary district

Conclusion

The present investigation has been undertaken to identify the best linear and non-linear growth models. The model was fitted by using yield data from 1985-86 to 2015-16 and the model was validated using the data of 2016-17 and 2017-18. The yield was also forecasted up to 2021. The highest coefficient of determination (R^2), Adjusted R^2 and least MAPE value were used for selecting the best model.

Among other models it was found cubic model was best fit, with R^2 value of 70.6 per cent, adjusted R^2 value of 67.3 per cent and RMSE value of 203.091. Based on this model prediction was made.

References

1. Acharya SP, Basavaraja H, Kunnal LB, Mahajanashetti SB, Bhat ARS. Growth in Area, Production and Productivity Trends of Castor Crop. Asian Journal of Applied Sciences, 2012;4(1):42-52.
2. Gaind L, Pandey KK. Development of Pre Harvest Forecasting Model for Chhattisgarh Plain Zone On Pigeon Pea by Principal Component Analysis. International Journal of Environmental Science and Natural Resources. 2017;5(4):555-667.
3. Goyal M. Use of Different Multivariate Techniques for Pre-Harvest Wheat Yield Estimation in Hisar (Haryana). International Journal of Computer and Mathematical Science. 2016;12(5):2347-8527.
4. Khan S, Bhardwaj RK, Saxena RR, Bhagat RK, Jatav GK. Non-Linear Statistical Modelling for Area, Production and Productivity of Rice Crop in Chhattisgarh. An Asian Journal of Soil Science. 2013;8(1):98-102.
5. Kumar TLM, Gowda CSS, Munirajappa R, Surendra HS. Nonlinear Statistical Growth Models for Describing Trends in Area under Coffee Production in India. Mysore Journal of Agricultural Sciences. 2012;46(4):745-750.