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Fitting of appropriate model to study growth rate and instability of mango production in India

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ABSTRACT

The growth rate and instability of mango production is studied for the period 1992-93 to 2013-14. For studying the growth rate, linear and compound models are fitted with and without spline. Spline model is fitted to take care of abrupt jumps in the data and evaluate the change in the trend of time series data.The entire period of study is divided into two sub-periods, 1992-93 to 2002-03 as sub period-I and 2003-04 to 2013-14 as sub-period-II as there is maximum percentage change in area, production and yield of mango in the year 2002-03. The best fitted model is selected by considering the model evaluation criteria, such as, Adj. R^2 and Root Mean Square Error (RMSE). The compound model without spline, compound model with spline and linear model with spline was found to be best fit forarea, production and yield respectively. The growth rate in area, production and yield is found by using the best fit model. The growth rate for area is found to be positive and significant but for yield it is found to be significantly negative for each sub period and for the entire period of study. For this, though the production shows positive growth rate but it is insignificant for sub-period-Iand also for the whole period. The instability in mango production is studied with the help of coefficient of variation.As coefficient of variation is affected by long term trend, it is computed after eliminating trend from the data.From study of instability, it is found that area under mango in India shows lesser instability than production and yield. Though there is increase in production of mango but the increase is mainly due to the positive growth in area under mango. The yield of mango is declining at a significant rate. Decomposition analysis carried out by hazel's decomposition technique reveals that change in mean area made a great positive contribution towards the change in mean production, whereas, change in mean yield and change in area – yield interaction both made negative contribution towards change in mean productionfrom sub-period I to II.

Key words: Adjusted R^2, Growth rate, Instability, Root Mean Square Error, Spline model, Trend.

INTRODUCTION

Mango (*Mangiferaindica* L.) belonging to Family Anacardiaceae is the most important commercially grown fruit crop of our country. It is called the king of fruits. It covers about 35 per cent of area and accounting for 22 per cent of total production of total fruits in the country. India ranks first among world's mango producing countries accounting for about 50% of the world's mango production. The fruit is cultivated in the largest area i.e. 2,312 thousand ha and the production is around 15.03 million tons, contributing 40.48 percent of the total world production of mango in 2013-14 (https://www.indiastat.in). The main mango producing states in India are Uttar Pradesh, Andhra Pradesh, Karnataka, Bihar, Gujarat and Tamil Nadu. The appropriate modeling approach to explain the behavior of the variables, viz, area, production and yield of mango in India, is of utmost importance. The spline models when fitted can take care of abrupt jumps in the data taken for a long period (Kagerer, 2013).The objective of the present study pertains to find the growth rate of mango w.r.t. area, production and yield by considering linear and compound model without spline and with spline technique. Spline technique is applied to evaluate the change in the trend of time series data. Also the instability in mango production is studied by help of coefficient of variation.

MATERIALS AND METHODS

The data regarding area, yield and production of mango in India were collected for twenty years from 1992-93 to 2013-14from various volumes of horticultural abstracts of India and analysed .The entire period of study is divided into two sub-periods, 1992-93 to 2002-03 as sub period-I and 2003-04 to 2013-14 as sub-period-II as there is maximum percentage change in area, production and yield of mango in the year 2002-03. This is done because as evident from the area, yield and production all the three shows maximum percentage change in 2002-03 as compared to the previous year. (Chand, 2009)

The following models fitted to Area/Production/Yield are:

1. Linear Model: $Y_t = b_0 + b_1 . t + e_t$; $1 \le t \le 22$

2. Compound Model: $Y_t = b_0 . b_1^t . e_t$; $1 \le t \le 22$

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3. Linear Spline Model with one knot placed at the year 2002-03 i.e., at t= 11 is as follows:

$Y_t = b_0 + b_1 . t + e_t$; $t \leq 11$;

$Y_t = b_0 + b_1 . t + a_1 (t-11) + e_t$; $11 < t \leq 22$ (Sarvida, 2010)

4. Compound Spline Model (with one knot at the year 2002-03 i.e., at t= 11)

$Y_t = b_0.b_1^t.e_t$; $t \leq 11$

$Y_t = b_0.b_1^t. a_1^{(t-11)} e_t$; $11 < t \leq 22$

Where,

Y_t is the dependent variable like Area/Production/ Yieldin time t;

't' refers to the time/year,

b_0 is the intercept, b_1 is the slope and e_t is the residual term.

The most widely used measure of instability, coefficient of variation, is used for measuring instability in area, yield and production. The coefficient of variation is found for detrended values of area/production/yield.

C.V. $= \frac{\sigma_y}{\bar{y}} X\ 100$; $\acute{o}_y$ Standard deviation of detrended area/ production /yield.

Model: $Y_t = T_t . C_t . I_t$ (multiplicative model);

Where, Y_t - area/production /yield for time t; T_t - Trend value for time t; C_t- Cyclic variation for time t; I_t Irregular Variation for time t. Since yearly data has been considered in the study, seasonal variations are absent in the data.

To detrend the data, 4- yearly moving average is found for entire period of 22 years, whereas 2-yearly moving average is found for each sub-period consisting of 11 years.Thedetrended values are obtained by dividing (since multiplicative model is assumed) the actual values with the trend values obtained by moving average method.

The effect / contribution of change in mean area and change in mean yield towards change in mean production is determined by using Hazell's Decomposition Technique (Hazel, 1984).

The average area and yield period - I was taken for period - I and symbolised as A_1 and Y_1 respectively. The average area and yield period - II was taken for period - II and symbolised as A_2 and Y_2

Change in mean area, $\Delta A = A_2 - A_1$;

Change in mean yield, $\Delta Y = Y_2 - Y_1$

Change in mean production, $\Delta P = P_2 - P_1$;

Where,. $P_2 = A_2 \times Y_2$ and $P_1 = A_1 \times Y_1$

Area effect = $\Delta A \times Y_1$; Yield effect = $\Delta Y \times A_1$;

Interaction effect = $\Delta A \times \Delta Y$

Per centcontribution of area towards change in mean production = (Area effect / ΔP) x100

Per cent contribution of yield towards change in mean production = (Yield effect / ΔP) x100

Per cent contribution of area-yield interaction towards change in mean production = (Interaction effect / ΔP)*100

RESULTS AND DISCUSSION

From Table-1 it is found that the compound model is best fit for area under mango as this model has the highest adjusted R^2 and lowest RMSE among the other models considered whereas in Table -2 it is found that the compound model with spline is found to be best fit for production of mango as this model has the highest adjusted R^2 and lowest RMSE among the other models considered. It was also observed from Table-3 it is found that the linear model with spline is best fit for yield of mango as this model has the highest adjusted R^2 and lowest RMSE among the other

Table 1: Fitting of Linear and Non-linear (Compound) Model with and without spline for Area under Mango

Model	Linear	Linear (With Spline)	Compound	Compound (WithSpline)
b_0	0.991**	1.098**	**1.098****	1.117
b1	0.069**	0.047**	**1.04****	1.035
a_1	-	0.049**	-	1.014
F Value	903.822**	590.239**	**904.089****	357.293**
R^2	0.955	0.967**	**0.978**	0.947
Adj. R^2	0.945	0.966**	**0.977**	0.944
RMSE	0.069	0.084	**0.064**	0.108

* Significant at 5 % level of probability** Significant at 1 % level of probability

Table 2: Fitting of Linear and Non-linear (Compound) Model with and without spline for Production of Mango

Model	Linear	Linear (With Spline)	Compound	Compound (With Spline)
b_0	8.222**	9.665**	8.736**	**9.631**
b1	0.349**	0.123**	1.027**	**1.011**
a_1	-	0.384**	-	**1.028**
F Value	58.706**	108.824**	71.296**	**121.698****
R^2	0.746	0.845	0.781	**0.859**
Adj. R^2	0.733	0.837	0.769	**0.852**
RMSE	1.355	1.059	1.259	**1.01**

* Significant at 5 % level of probability** Significant at 1 % level of probability

Table 3: Fitting of Linear and Non-linear (Compound) Model with and without spline for Yield of Mango

Model	Linear	Linear (With Spline)	Compound	Compound (With Spline)
b_0	8.023**	**8.641****	2.079**	8.622**
b1	-0.091	**-0.175****	-0.013*	0.977**
a_1	-	**0.118**	-	1.014**
F Value	13.243	**22.774****	14.075**	22.029**
R^2	0.398	**0.532**	0.413	0.524
Adj. R^2	0.368	**0.509**	0.384	0.5
RMSE	0.743	**0.655**	0.734	0.661

*** Significant at 5 % level of probability** Significant at 1 % level of probability**

Table 4: Growth Rates of Area, Yield and Production

	Compound Growth Rate (in %)		
	Sub-Period I	**Sub-Period II**	**Whole period**
Area	**3.49****	**4.99****	**4.03****
Production	**1.12**	**3.99****	**2.73**
Yield	**-2.29***	**-0.89***	**-1.3***

* Significant at 5 % level of probability** Significant at 1 % level of probability

models considered. Thus it is found that spline technique shows improvement in model fitting in production and yield of mango but not in area under mango.

From Table -4 it is revealed that the growth rate for area under mango is found to be positive and highly significant for both the sub-periods and also for the whole period. The growth rate for yield of mango is found to be significantly negative for both the sub- periods and also for the whole period. The production shows positive growth rate which is non-significant for subperiod I and for the whole period but significantly positive for sub period II. The negative growth rate of yield is counterbalanced by the positive growth rate of area due to which the production of mango shows positive growth rates though non-significant in sub period I and in the whole period and significant in sub period II.

In Table-5 it is revealed that the C.V. was highest for production followed by yield for both the sub-periods and also for the whole period. Area shows low C.V. in both the sub-periods and also for the whole period. This shows that production shows higher instability than yield and area for both the sub-periods and also for the whole period.

Table 5.: Coefficient of Variation of detrendedArea, Yield and Production

	Coefficient of Variation (in %)		
	Area	**Yield**	**Production**
Sub-Period I	**0.84**	**1.81**	**2.35**
Sub-Period II	**3.08**	**3.47**	**5.79**
Whole period	**3.03**	**4.02**	**7.03**

Table 6: Percentage contribution in area, yield and their interaction towards change in production

Components	% Contribution
Area	278.43
Yield	-114.44
Area – Yield Interaction	-63.99

Instability in sub –period I is very low as compared to sub-period II and the whole period.

From Table-6 it is revealed that change in mean area made a great positive contribution (278.43%) towards the change in mean production from sub-period I to II, whereas change in mean yield and change in area – yield interaction both made negative contribution towards change in mean production out of which change in mean yield has the greatest negative contribution of -114.44%.

From Table-7 it is revealed that the simple correlation coefficient between yield and production is negative and significant but the partial correlation coefficient between them is highly positive and significant which shows whatever increase in production is observed is due to area expansion.

From Fig-1, .it is clear that area shows the highest increase, yield and production shows the highest decrease during the year 2002-03 as compared to the previous year 2001-02.

Figures 2,3 and 4 shows the actual and fitted lines (on basis of the four models considered in the study) for area, production and yield respectively. In fig -2, the line fitted for area under mango in India obtained from the compound model best fits the data than the fitted lines obtained from other models considered in the study. In fig -3, the line that best fits the data regarding the production of mango in India, is the one that is obtained from the compound model with spline. In fig -4, the line fitted for yield of mango in India obtained from the linear model with spline best fits the data than the fitted lines obtained from other models considered in the study.

CONCLUSION

In estimating growth rates, spline models are found to be more efficient than without spline models in case of

Table 7: Simple and partial correlation coefficients between area-production and yield –production

Variables	Correlation Coefficient
Yield - Production	-0.53*
Yield – Production after eliminating the effect of Area	0.88**
Area - Production	0.82**
Area – Production after eliminating the effect of Yield	0.95**

* Significant at 5 % level of probability** Significant at 1 % level of probability

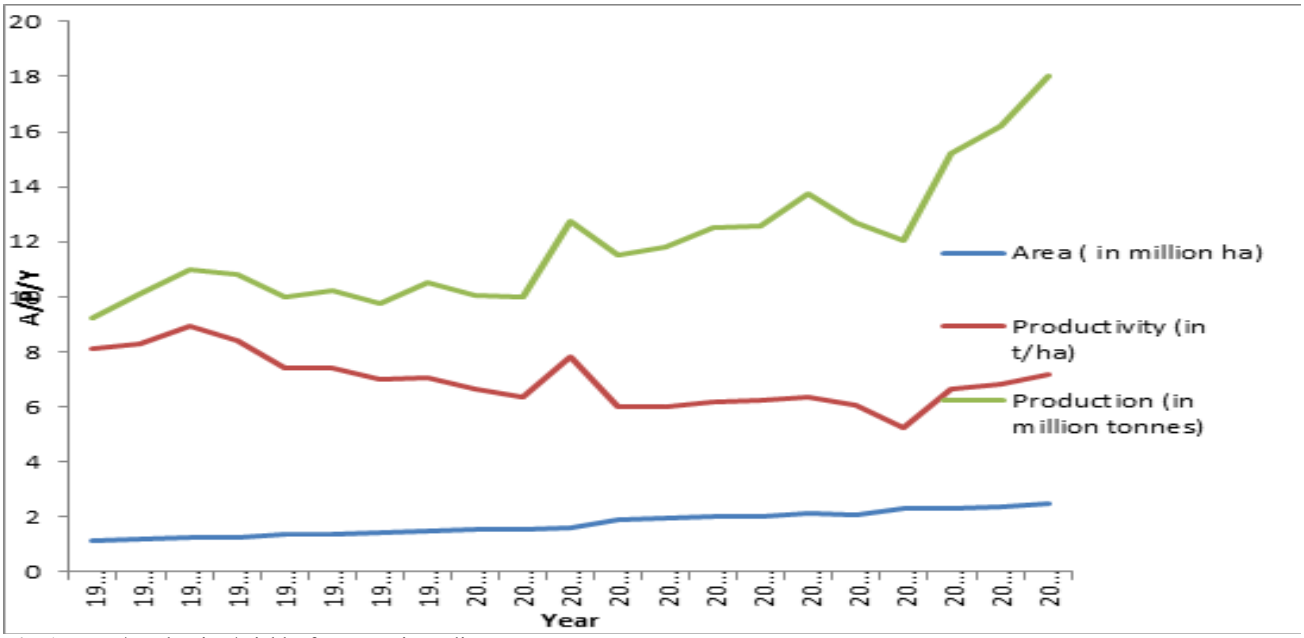

Fig 1: Area/Production/Yield of Mango in India

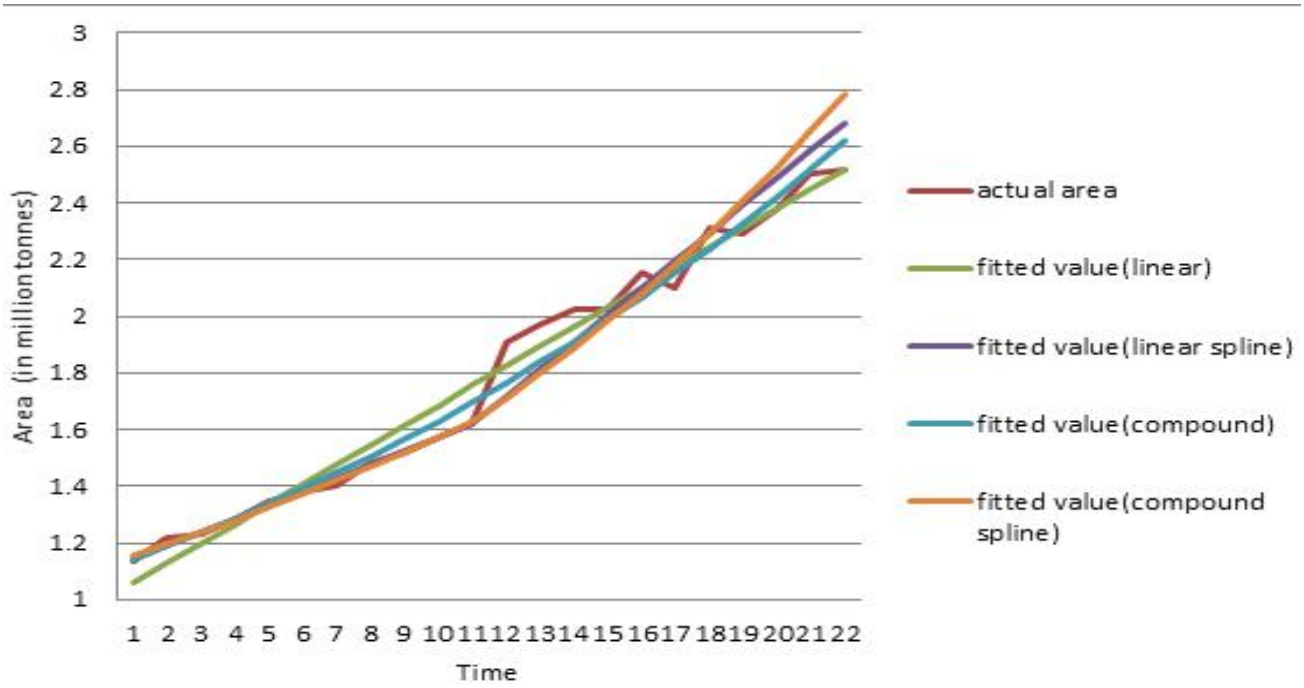

Fig 2: Models fitted to Area under Mango

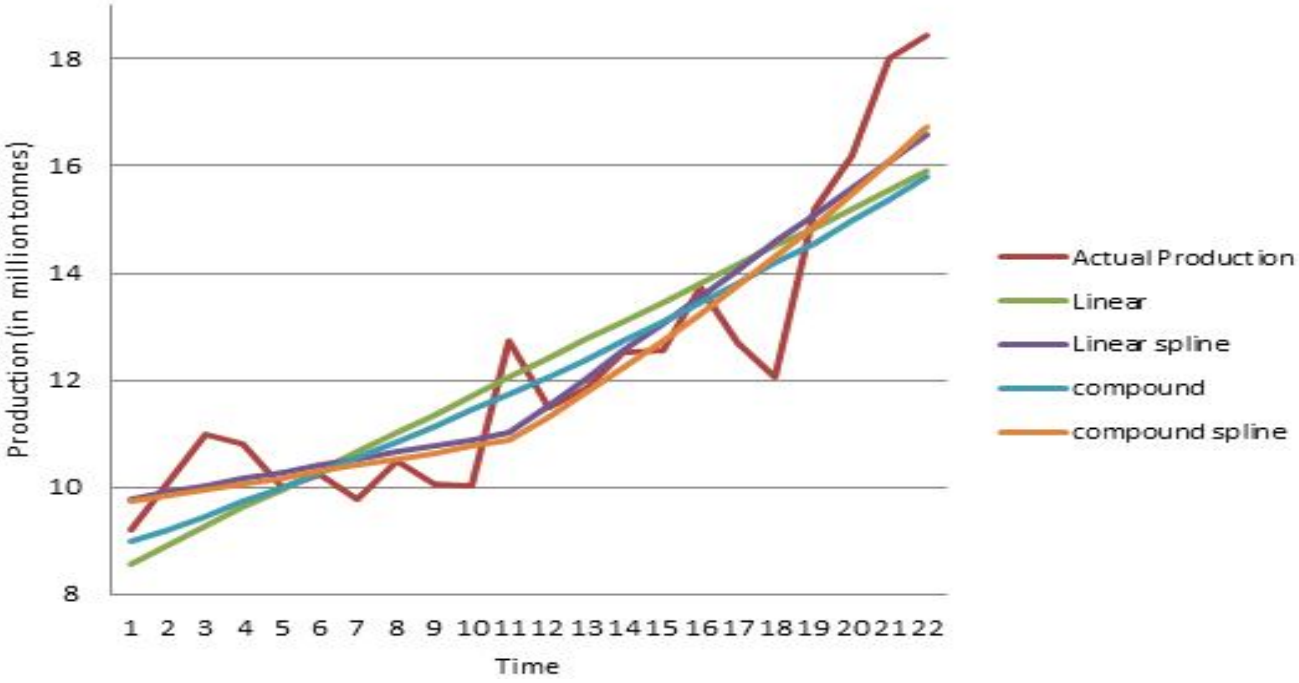

Fig 3: Models fitted to Production of Mango

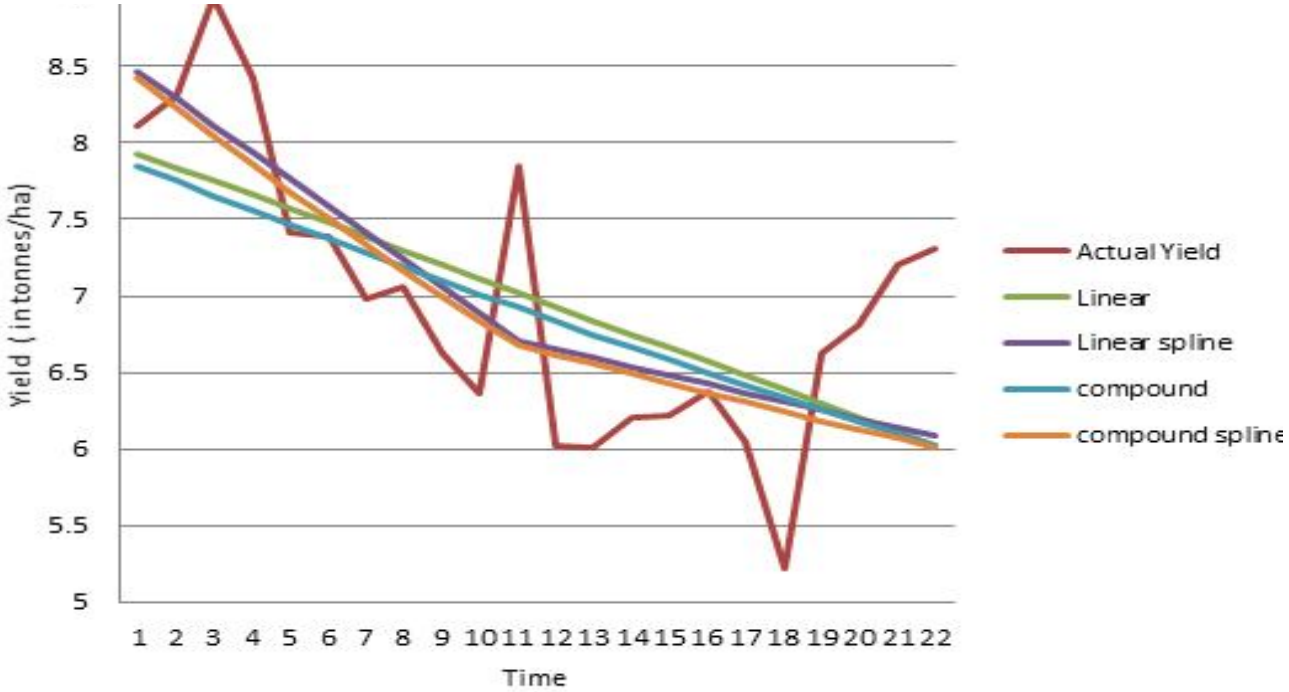

Fig 4: Models fitted to Yield of Mango

production and yield, but in case of area, without spline model fits better than with spline model. Though there is increase in production of mango but the increase is mainly due to the positive growth in area under mango. The yield of mango is declining at a significant rate which is a matter of great concern. Production also showed the highest instability followed by yield and are shows the least instability.This decline in yield may be due to climatic factors or may be due to poor cultivation practices like poor plant population, growing of traditional low yielding varieties, poor nutrient and water management are the key factors of low yield. Production also showed the highest instability followed by yield and are shows the least instability

REFERENCES

Chand, R. and Raju, S.S. (2009). Instability in Indian agriculture during different phases of technology and policy.*Indian Journal. of Agricultural. Economics,* **64**(2) : 283-285.

Hazel, P.B.R., (1984). Sources of increased instability in Indian Cereal product.*American Journal.of Agricultural. Economics*, **32**(20): 302-311.

Kagerer, K., (2013). A short introduction to splines in least square regression analysis.*University of Regensburg Working Papers in Business, Economics and Management Information Systems.*

Sarvida, R.L. and Baguio, C.B., (2010). On the efficiency of spline regression for time series data. 11th National Convention on Statistics (NCS) EDSA Shangri-La Hotel.