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TEMPORAL VARIATIONS IN AREA, PRODUCTION AND PRODUCTIVITY OF TURMERIC CROP IN INDIA

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ABSTRACT

Attempts have been made to examine the trends and forecasting in area, production and productivity of Turmeric crop in India. Linear and compound growth rates were calculated for this purpose. Ten growth models were fitted to the area, production and productivity of Turmeric crop and best- fitted model for future projection was chosen based upon least Residual Mean Square (RMS) and significant Adj Besides, the important assumption of randomness of residuals was tested using one sample run test. The reference period of study was from 1950-2015 and it was carried out in India. future projections indicated that area, production and productivity of turmeric crop in India, indicated that an increasing trend with area of 215.97 thousand hectares, production of 1247.05 thousand tonnes and productivity of 5.3 tonnes/ha by 2018 AD.

KEYWORDS: productivity of Turmeric crop, Residual Mean Square (RMS)

INTRODUCTION

India is apparently the largest producer, consumer and exporter of turmeric in the world. Turmeric is the third largest spice produced in the country and it accounts for about 80% of the World's production and 14% of total spices produced in India. In 2015-16 Turmeric was exported quantity of 88,500 Tonnes with cost of Rs. 92,165 Lakhs. In 2015-16 Turmeric was imported quantity of 15,330 Tonnes with cost of Rs. 14,634 Lakhs.

Growth models are useful in drawing inferences like the exact relationship between time and growth, the rate of growth at each point of time, the turning points in the growth, growth rates are considered as the best indices of growth. Rao and Reddy (2005) worked out the growth rates of area, production and productivity of groundnut for the period I (1988-89 to 2002-03) and period II (1953-56 to 2002-03) in the three geographical regions of Andhra Pradesh and also Andhra Pradesh state as a whole. The compound growth rate of area is significant only in Rayalaseema, production is significant in all three regions and Andhra Pradesh state as a whole and productivity is significant in coastal Andhra and Andhra Pradesh state as a whole. Mathur (2005) computed the compound growth rates of area, production and productivity of Turmeric, during the high yielding variety period (1966-67 to 2000-01) in India by the least square technique of fitting of exponential function y=a bt.Aparnaet al., (2008) examined the trend in growth rates of major vegetables in Visakhapatnam district with the help of compound growth rates.Pandey (2004) calculated the area, production, productivity and exports of vegetables in India in the 1990s and also the demand projections for vegetables up to the year, 2021. Sharma Amod Kalita (2008) examined trends in area, production and productivity of major fruit crops in Jammu and Kashmir based on the secondary data for the period of 1974-75 to 1999-2000. This study revealed that area, production and productivity of major fruit crops had a positive and statistically significant growth during the study period. Sanjeev Panwaret al., (2009) undertaken the study of different non-linear models, viz logistic, gompertz, quadratic were applied for onion export of India and conducted comparative study for these models.

The present study is based on 65 years of data i.e., from 1950 to 2015 of Turmeric in India. The linear growth rate (LGR) and compound growth rate (CGR) for the crop characteristics i.e., area, production and productivity of Turmeric

Crop in three regions of India are estimated by fitting the following functions, the analysis of the data has been carried out by using data on area production and productivity obtained from web site: www.indian stat.com

MATERIALS AND METHODS

Linear growth rate (LGR) and compound growth rate (CGR) for the crop characteristics and the trend equations were fitted by using different growth models. Growth models are nothing but the models that describe the behavior of a variable overtime. The growth models taken under consideration here are as follows.

Methodology for fitting the trend equations

The trend equations were fitted by using different growth models. Growth models are nothing but the models that describe the behavior of a variable overtime. The growth models taken under consideration here are as follows.

Linear function

A linear model is one in which all the parameters appear linearly.

The mathematical equation is given by

$Yt = a + bt$

Where

Yt is the dependent variable i.e., area, production and productivity

t is the independent variable, time in years

a and b are the constants

The constants ‘a’ and ‘b’ are estimated by applying the Ordinary Leasts Square approach.

Logarithmic function

This model shows very rapid growth, followed by slower growth

The mathematical equation is given by

$Yt = a + b \ln(t)$

Where,

Yt is the dependent variable i.e., area, production and productivity

t is the time in years, independent variable 'a' and 'b' are constants

The constants 'a' and 'b' are estimated by applying the Ordinary Least Squares approach.

Inverse function

Inverse curve shows a decreasing growth.

Inverse fit is given by the equation

$Yt = a + b/t$

Where,

Yt is the dependent variable i.e., area, production and productivity

t is the independent variable, time

'a' and 'b' are parameters

The parameters can be estimated by the method of Ordinary Least Squares (OLS).

Quadratic function

This function is useful when there is a peak or a trough in the data of past periods.

Quadratic fit is given by the equation

$Yt = a + bt + ct2$

Where,

Yt is the dependent variable i.e., area, production and productivity

t is the independent variable, time in years

a, b and c are constants

The constants can be calculated by applying the method of ordinary least squares approach.

Cubic function

This function is useful when there is or has been, two peaks or two troughs in the data of past periods.

Cubic fit or third degree curve is given by the equation

$Yt = a + bt + ct2 + dt3$

Where,

Yt is the dependent variable i.e., area, production and productivity

t is the independent variable, time in years

a, b, c and d are parameters

The parameters are calculated by ordinary least squares technique.

Compound function

This function is useful when it is known that there is or has been, increasing growth or decline in past periods

Compound fit is given by

Yt = abt

Or lnYt = ln a + t ln b

Where,

Yt is the dependent variable, area, production and productivity

t is the independent variable, time in years

a and b are parameters or constants

The constants can be obtained by using ordinary least squares technique.

S-curve

S-curve fit is given by

Yt = Exp (a+b/t)

Or lnYt = a + b/t

Where,

Yt is the dependent variable, area, production and productivity

t is the independent variable, time in years

a and b are parameters or constants

Ordinary Least Squares (OLS) method can be applied to estimate the parameters of the model.

Growth function

The fit is given by

Yt = Exp (a + bt)

Or lnYt = a + bt

Where,

Yt is the dependent variable, area, production and productivity

t is the independent variable, time in years

a and b are parameters or constants

The constants are obtained by ordinary least squares technique.

Power Function

The fit is given by the equation

Yt = atb

Or lnYt = ln a + b ln(t)

Where,

Yt is the dependent variable, area, production and productivity

t is the independent variable, time in years

a and b are parameters or constants

The constants are calculated by ordinary least squares technique.

The fit is similar to exponential fit, but produces a forecast curve that increases or decreases at different rate.

Exponential fit

If, when the values of t are arranged in an arithmetic series, the corresponding values of y form a geometric series, the relation is of the exponential type.

The function of this type can be given by

Yt = a Exp (bt)

Or lnYt = ln a + (bt)

Where,

Yt is dependent variable i.e., area, production and productivity

t is independent variable, time in years

a and b are constants

The constants are calculated by ordinary least squares technique.

Methodology for the estimation of future projections

The future projections of area, production and productivity of Turmeric crop India up to 2018 AD were estimated upon the best fitted growth model used for fitting the trend equations.

Methodology for the best fitted model

The choice of the trend equation amongst the available alternatives is very crucial. Many researchers use coefficient of multiple determination, R2 or adjusted R2 ( ) as the criterion of model selection.

Where,

K is the number of constants in the equation

N is the total number of observations

It was observed that R2 is not enough to examine goodness of fit of a model (Reddy, 1978). So in addition to adj R2, the residual mean square (RMS) which will also measure the accuracy in forecasting is the best criterion to choose a model from among the alternatives.

In the present study, the model with least residual mean square (RMS) and significant adj R2 was considered to be the best fitted model.

Before choosing a model, one should be certain that the disturbance term satisfies all the conditions of randomness, non-autocorrelation, homoscedasticity and normality. In the present study, an attempt has been made to verify the most important assumption of randomness of residuals.

Test for randomness of residuals

Non-parametric one sample run test can be used to test the randomness of residuals. A run is defined as a succession of identical symbols in which the individual scores or observations originally were obtained.

Let ‘n1’, be the number of elements of one kind and ‘n2’ be the number of elements of the other kind in a sequence of N = n1 + n2 binary events. For small samples i.e., both n1 and n2 are equal to or less than 20 if the number of runs r fall between the critical values, we accept the H0 (null hypothesis) that the sequence of binary events is random otherwise, we reject the H0.

For large samples i.e., if either n1 or n2 is larger than 20, a good approximation to the sampling distribution of r (runs) is the normal distribution, with

Then, H0 may be tested by

The significance of any observed value of Z computed from the above formula may be determined by reference to the Standard Normal Distribution table.

RESULTS AND DISCUSSIONS

In India the average area under Turmeric during the study period (1950-2015) was 110.2 thousand hectares. The coefficient of variation recorded for the study period was 16.8 per cent and the linear and compound growth rates recorded during the study period were 2.4 and 2.6 per cent per annum respectively.The area of Turmeric in India exhibited a positive trend and it was found significant at 1% level of significance in case of compound growth rate and linear growth rate.The average production of Turmeric during the study period (1950 to 2015) was 390.7 thousand tones with a coefficient of variation of 26.1 per cent. The linear growth rate and compound growth rate recorded for the study period were 3.8 and 4.1 per cent per annum respectively. The production of Turmeric in India exhibited a positive trend it was found significant at 1% level of significance in case of compound growth rate and linear growth rate. The average productivity of Turmeric during the study period (1950 to 2015) was 3.0 tones/ha with a coefficient of variation of 34.7 per cent. The linear growth rate and compound growth rate recorded for the study period were 1.5 and 1.4 per cent per annum respectively. The production of Turmeric in India exhibited a positive trend and has been increasing significantly during the study period and it was found significant at 1% level of significance in case of compound growth rate and linear growth rate

Table.1: Growth Rates in Area, Production and Productivity of Turmeric Crop in India

	AREA	PRODUCTION	PRODUCTIVITY
LGR (%)	2.4**	3.8**	1.5**
CGR (%)	2.6**	4.1**	1.4**
CV (%)	16.8	26.1	34.7
** Significance at 1% level LGR = Linear growth rate			
* Significance at 5% level CGR = Compound growth rate			
CV = Coefficient of variation			

Area under Turmeric in India is projected by using Cubic function which is found to be best for this purpose as it has the least RMS and significant Adj R2 and also fulfilled the assumption of randomness of residuals. The area under Turmeric projected by Logarithmic function by 2018 AD would be 215.97 thousand hectares which is in increasing trend. Regarding the production of Turmeric, Quadraticlinear function is found to be the best model for future projections; the projected production would be increasing to1247.05 thousand tonnes by 2018 AD. Regarding the productivity of Turmeric, Cubic function was found to be the best model for future projections, the projected production would be increasing to 5.3 tonnes/ha by 2018 AD.

Table.2: Growth models of Area of Turmeric in India

Model	a	b	c	d	AdjR2	RMS	Runs
Linear	19.803	2.701			0.92**	223.48	25
Logarithmic	-42.454	47.211			0.63**	1080.60	21
Inverse	121.377	153.276			0.16	2447.76	25
Quadratic	41.057	.826	.028		0.95**	139.72	25
Cubic	52.236	-1.104	.099	-.001	0.96**	124.61	25
Compound	40.732	1.026			0.95**	160.69	25
Power	20.491	.482			0.72**	2448.33	19
S	4.697	-1.635			0.20	160.69	25
Growth	3.707	.026			0.95**	729.32	31
Exponential	40.732	.026			0.95**	160.69	25
**Significant at 1% level							
*Significant at 5% level							

Table.3: Growth models of Production of Turmeric in India

Model	a	b	c	d	AdjR2	RMS	Runs
Linear	113.558	15.054			.80**	20718.57	28
Logarithmic	-390.899	241.597			.46	56267.56	27
Inverse	441.770	-705.310			.09	94397.57	31
Quadratic	158.827	-8.980	.359		.93**	6261.17	18
Cubic	185.574	-13.598	.530	-.002	.93**	6874.66	30
Compound	71.098	1.042			.88**	10012.09	14
Power	30.185	.687			.55	104746.72	24
S	5.776	-2.022			.11	10012.09	22
Growth	4.264	.041			.88**	51242.69	26
Exponential	71.098	.041			.88**	10012.09	22
**Significant at 1% level							
*Significant at 5% level							

Table.4: Growth models of Productivity of Turmeric in India

Model	a	b	c	d	AdjR2	RMS	Runs
Linear	1.454	.048			.65**	0.45	25
Logarithmic	.838	.686			.29	0.91	21
Inverse	3.164	-1.487			.03	1.25	25
Quadratic	2.648	-.058	.002		.85**	0.19	25
Cubic	3.249	-.161	.005	0.003	.88**	0.14	25
Compound	1.747	1.015			.61**	0.37	25
Power	1.477	.205			.26	1.29	19
S	1.079	-.379			.02	0.37	25
Growth	.558	.015			.61**	0.87	31
Exponential	1.747	.015			.61**	0.37	25
**Significant at 1% level							
*Significant at 5% level							

Table.5: Forecasting Area, Production and Productivity of Turmeric in India

Year	Area(, 000 ha)	Production (,000 tonnes)	Productivity(tonnes /ha)
2016-17	210.85	1167.44	5.25
2017-18	213.45	1206.89	5.30
2018-19	215.97	1247.05	5.34

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