

## Statistical Analysis of Production and Productivity Trends in Marigold in Tumkur Districts of Karnataka

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**Abstract:** Marigold, a fragrant ornamental flower crop, holds significant economic and aesthetic value in Karnataka, particularly in Tumkur district. Known for its use in garland making, perfume extraction, and decorative arrangements, Marigold cultivation supports both livelihoods and regional floriculture markets. In this study, secondary data on Marigold production in Tumkur district from 1981 to 2023 were obtained. A comprehensive trend analysis was performed using various statistical models, including Linear, Quadratic, Cubic, Exponential, and Sinusoidal models, to examine long-term changes in production and productivity. The models were evaluated based on R-squared ( $R^2$ ) values, which indicate the proportion of variance explained, and Root Mean Square Error (RMSE), which reflects prediction accuracy. Among the models assessed, the cubic model provided the best fit for Marigold production and linear model provided the best for Marigold productivity, exhibiting the highest  $R^2$  and the lowest RMSE values, signifying its superior ability to capture the underlying pattern in the data. These results suggest that Marigold production in Tumkur has undergone non-linear changes over the years, possibly influenced by varying agro-climatic conditions, market demand, and farmer adoption of improved varieties.

**Keywords:** Linear, Quadratic, Cubic, Exponential, sinusoidal, Root Mean Sum of Squared R Squared.

### Introduction

Statistical analysis is a powerful tool for examining, interpreting, and drawing conclusions from data. In agriculture, it plays a vital role in evaluating historical trends, identifying influencing factors, and making data-driven decisions to improve productivity. By applying statistical Techniques, researchers can assess the impact of climatic, agronomic, and market variables on crop yields and develop reliable forecasts for future production.

Floriculture has witnessed remarkable growth in the Tumkur district of Karnataka, with Marigold emerging as one of the most important commercial flower crops. Marigold holds a prominent place in Karnataka's floriculture industry due to its vibrant color, long shelf life, and extensive use in religious ceremonies, festivals, and ornamental landscaping. Globally, India is recognized as a leading producer of loose flowers, with about 2.85 lakh hectares under floriculture, yielding 22.84 lakh metric tonnes of loose flowers and 9.47 lakh metric tonnes of cut flowers during 2023-24, of which Marigold contributes approximately 2.15 lakh tonnes (H'9.4% of total loose flower production) (NHB, 2024). Karnataka is among the major floriculture-producing states in India, with nearly 29,700 hectares under flower cultivation, producing 3.47 lakh metric tonnes of commercial flowers in 2022-23, where Marigold alone accounts for about 4.97% of the total flower production (Karnataka State Department of Horticulture, 2023).

Tumkur district is a significant contributor, benefiting from favourable agro-climatic conditions and proximity to Bengaluru's urban markets. The crop thrives in sandy loam soils and warm temperatures (20-35°C), and local farmers have adopted modern practices such as drip irrigation and organic cultivation. Despite these advances, production is influenced by seasonal price volatility, climate variability, and pest infestations, which can affect farmer profitability.

Knowing Marigold's economic role, analysing its production and Productivity trends is essential. Statistical analysis of historical data from 1981 to 2023 enables the identification of patterns, evaluation of growth rates, and forecasting of future production. This study focuses on Marigold production and productivity trends in Tumkur district, aiming to provide insights that can support policy formulation, enhance productivity, and promote sustainable growth in the region's floriculture sector.

## **Methodology**

Tumkur district, located in the southeastern part of Karnataka at approximately 13°20'22" N latitude and 77°06'22" E longitude, covers 10,597 sq. km. It is bordered by Chitradurga, Hassan, Chikkaballapur, Bengaluru Rural, Davanagere, and Ramanagara districts. The terrain is a mix of hills, valleys, rocky outcrops, and fertile plains, with agro-climatic zones ranging from Maidan (plains) to Semi-Malnad. Situated about 800 m above sea level, Tumkur has a tropical semi-arid climate with hot summers (30-40°C), a monsoon season (June-September), and mild winters (12-25°C). Rainfall ranges from 600 mm in drier areas to over 900 mm in parts of Sira and Madhugiri, mainly from the southwest monsoon, with some from the northeast monsoon.

This study is based on secondary data regarding the production (in Metric Tons) and productivity (in Metric Tons/hectare) of Marigold in Tumkur from 1981-82 to 2022-23. The data was sourced from the District Statistical Office, Tumkur and the Directorate of Economics and Statistics, Bangalore.

### ***Descriptive Analysis***

(a) **Mean:** The arithmetic mean is defined as the sum of all the observations divided by the total number of observations.

$$\text{Arithmetic mean } (\bar{x}) = \frac{\sum_{i=1}^n x_i}{n},$$

where,

$x_i$  =  $i^{\text{th}}$  observation and  $n$  = Number of observations.

(b) **Coefficient of Variation (%)**

Coefficient of Variation:

$$CV = \frac{\sigma}{x} \times 100, ,$$

where,

$x$  = mean and  $\sigma$  = standard deviation.

Standard deviation:

$$\sqrt{\frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})^2}, ,$$

where,

$x_i$  =  $i^{\text{th}}$  observation,

$x$  = mean,

$n$  = Number of observations.

### ***Trend analysis***

(a) **Linear model:** The simple linear regression model for  $n$  observations can be written as

$$Y_t = \beta_0 + \beta_1 X_t + \varepsilon, t = 1, 2, 3, \dots, n$$

where,

$Y_t$  = dependent variable (Production/Productivity),

$X_t$  = independent variable (Time),

$\beta_0$  = intercept,

$\beta_1$  = coefficient to be estimated,

$\varepsilon$  = error term at time  $t$ .

(b) **Quadratic model:** Here the model is

$$Y_t = \beta_0 + \beta_1 X + \beta_2 X^2 + \varepsilon, t = 1, 2, 3, \dots, n$$

where,

$Y_t$  = dependent variable (Production/Productivity),

$X$  = independent variable (Time),

$\beta_0$  = intercept,

$\beta_1, \beta_2$  = coefficients to be estimated,

$\varepsilon$  = error term at time  $t$ .

**(c) Cubic model:** Here model is

$$Y_t = \beta_0 + \beta_1 X + \beta_2 X^2 + \beta_3 X^3 + \varepsilon, \quad t = 1, 2, 3, \dots, n$$

where,

$Y_t$  = dependent variable (Production/Productivity),

$X$  = independent variable (Time),

$\beta_0$  = intercept,

$\beta_1, \beta_2, \beta_3$  = coefficients to be estimated,

$\varepsilon$  = error term at time  $t$ .

**(d) Exponential Model**

The exponential model represents

$$Y_t = \beta_0 e^{\beta_1 X_t + \varepsilon_t}, \quad t = 1, 2, 3, \dots, n$$

where,

$Y_t$  = dependent variable (Production/Productivity),

$X_t$  = dependent variable (Time),

$\beta_0$  = intercept,

$\beta_1$  = coefficient to be estimated,

$\varepsilon_t$  = error term at time  $t$ .

**(e) Sinusoidal Model**

The sinusoidal regression model is given by

$$Y_t = \beta_0 \cdot \sin(\beta_1 \cdot X_t + \beta_2) + \beta_3 + \varepsilon_t, \quad t = 1, 2, 3, \dots, n$$

where:

$Y_t$  - dependent variable (Production/Productivity),

$X_t$  - dependent variable (Time),

$\beta_0$  = amplitude of the wave (controls the height of oscillations),

$\beta_1$  = frequency (controls how frequently the oscillations occur),

$\beta_2$  = phase shift (controls the horizontal shift of the wave),

$\beta_3$  = vertical shift or baseline level,

$\varepsilon_t$  = error term at time t.

## Results and Discussion

A statistical model used to find the trends or patterns in data over time, which helps the variables in making predictions is trend analysis. In this study, an effort was made to apply various models and determine the best-fitting one for the production of Marigold in Tumkur district of Karnataka. The selection of the best model was based on its significance,  $R^2$  value, and RMSE values. Simplicity was also a key factor; if a linear model proved to be highly significant, it was chosen as the best fit. This approach helps avoid overfitting, which could compromise the accuracy of future data projections.

As presented in Table 1, in the Tumkur district, the average production of Marigold was 1639.37 MT with a standard deviation of 640.85 MT, indicating considerable fluctuations across the study period. The coefficient of variation (CV = 39.09%) reflects a moderate level of variability in production, suggesting that Marigold production has experienced noticeable but manageable fluctuations over time. The skewness value (-0.87) indicates a slight negative skewness, implying that years with higher-than-average production were relatively fewer. The kurtosis value (-0.52) signifies a platykurtic distribution, suggesting a flatter curve with data more evenly spread and less concentration around the mean.

For productivity, the average was 12.05 MT/ha with a standard deviation of 3.19, and a CV of 26.46%, which is lower than that of production, indicating relatively greater stability in yield levels across years. The skewness value (0.27) shows a mild positive skew, meaning that slightly more years recorded above-average productivity. The kurtosis value (-1.11) again reflects a platykurtic distribution, suggesting a broad and less peaked spread of productivity data. These results indicate that while Marigold production showed moderate instability, its productivity remained fairly consistent, highlighting resilience in yield performance over time. These results are on par with Dwivedi et al. (2024).

Trend analysis was carried out using various linear and nonlinear models such as Linear, Quadratic, Cubic, Exponential, and Sinusoidal to identify the best-fitting model for Marigold production and productivity in Tumkur district (Table 2).

For production, the Linear model recorded an  $R^2$  of 0.23 and RMSE of 554.30, with both coefficients ( $\beta_0 = 1639.37$ ,  $\beta_1 = -24.69$ ) being statistically significant. The Quadratic model provided a slight improvement ( $R^2 = 0.24$ , RMSE = 551.71) with  $\beta_0$  and  $\beta_1$  significant, while  $\beta_2$ , was not. The Cubic model offered the best statistical fit with the highest  $R^2$  (0.55) and lowest RMSE (424.69); coefficients  $\beta_0$ ,  $\beta_1$  and  $\beta_3$  were statistically significant, while  $\hat{\alpha}$ ,

was not. The Exponential model achieved an  $R^2$  of 0.22 and RMSE of 557.97, with significant coefficients. The Sinusoidal model performed poorly ( $R^2 = 0.04$ ,  $RMSE = 77430.51$ ), despite significance in most coefficients. Hence, the Cubic model was identified as the best-fitted model for Marigold production in Tumkur district.

For productivity, the Linear model exhibited strong performance with an  $R^2$  of 0.64 and RMSE of 1.90, with both  $\beta_0$  (12.05) and  $\beta_1$  (-0.20) statistically significant. The Quadratic model slightly improved the fit ( $R^2 = 0.65$ ,  $RMSE = 1.87$ ) with significant  $\beta_0$  and  $\beta_1$  while  $\beta_2$ , was not significant. The Cubic model provided the best overall performance ( $R^2 = 0.69$ ,  $RMSE = 1.76$ ), where  $\beta_0$ ,  $\beta_1$ , and  $\beta_3$  were significant. The Exponential model showed an  $R^2$  of 0.61 and RMSE of 1.96, with significant coefficients. The Sinusoidal model achieved the highest  $R^2$  (0.74) and the lowest RMSE (0.18); however, inconsistencies in coefficient significance suggest overfitting. Thus, considering both model performance and coefficient stability, the Linear model was deemed the most suitable for modeling Marigold productivity in Tumkur district.

In Figure 1, in actual Marigold production between 2006 and 2010, fluctuations in the production due to a shift toward high-value crops and urbanization pressures near Tumkur town, which reduced farmland (Anon., 2011, NABARD). Again in 2021 decrease in production due to post-COVID reasons. Despite this the cubic model provided the best fit ( $R^2 = 0.55$ ), which captures more complex, non-linear trends in the data compared to simpler models, and gradual upward movement possibly supported by market access to Bengaluru and the crop's demand during festive seasons.

In Figure 2, Marigold productivity is displayed. In 1988 even though increased production productivity decreased, it was due to a decrease in the area in particular area in 1994, again a sharp increase in productivity due to improved varieties and better management practices. Again in 2006 sharp rise due to higher production in that particular year. The linear model provided the most balanced and reliable fit ( $R^2 = 0.64$ ;  $RMSE = 1.89$ ), which captures a complex trend with both coefficients statistically significant.

**Table 1: Descriptive Statistics of Marigold Production and Productivity in Tumkur District of Karnataka**

<i>Parameter</i>	<i>Descriptives</i>	<i>Marigold</i>
<b>Production</b>	Mean	1639.37
	SD	640.85
	CV (%)	39.09
	Skewness	-0.87
	Kurtosis	-0.52
<b>Productivity</b>	Mean	12.05
	SD	3.19
	CV (%)	26.46
	Skewness	0.27
	Kurtosis	-1.11

**Table 2: Comparison of models for predicting the production and productivity of Marigold in the Tumkur district of Karnataka**

Models	Production			Productivity		
	$\beta$	$R^2$	RMSE	$\beta$	$R^2$	RMSE
<b>Linear (<math>\beta_0</math>)</b>	1639.37**	0.23	554.30	<b>12.05**</b>	<b>0.64</b>	<b>1.90</b>
( $\beta_1$ )	-24.69**			<b>-0.20**</b>		
<b>Quadratic (<math>\beta_0</math>)</b>	1699.32**	0.24	551.71	12.43**	0.65	1.87
( $\beta_1$ )	-24.69**			-0.20**		
( $\beta_2$ )	-0.39			-0.002		
<b>Cubic (<math>\beta_0</math>)</b>	<b>1699.32**</b>	<b>0.55</b>	<b>424.69</b>	12.43**	0.69	1.76
( $\beta_1$ )	<b>-89.86**</b>			-0.32**		
( $\beta_2$ )	<b>-0.39</b>			-0.002		
( $\beta_3$ )	<b>0.24**</b>			0.0004*		
<b>Exponential (<math>\beta_0</math>)</b>	1615.29**	0.22	557.97	11.82**	0.61	1.96
( $\beta_1$ )	-0.01**			-0.02**		
<b>Sinusoidal (<math>\beta_0</math>)</b>	-23645.05	0.04	77430.51	-0.40**	0.74	0.18
( $\beta_1$ )	-1.78**			0.10**		
( $\beta_2$ )	-3794.35**			-3.88		
( $\beta_3$ )	151417.80**			2.83**		

Note: \*\* Significant at 1 per cent

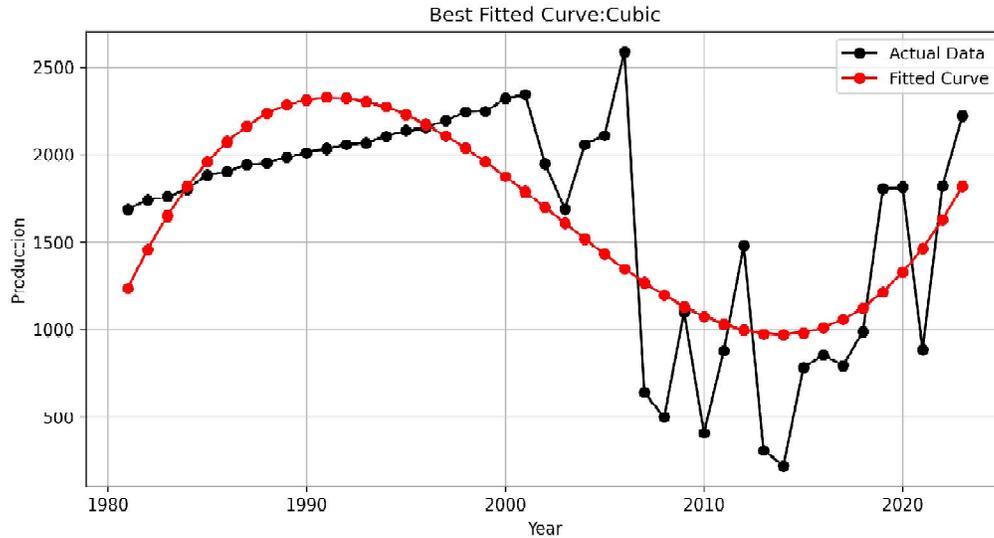
**Table 3: Suitable models for the production of Marigold in Tumkur districts of Karnataka**

Crop	Best Model	Equation	$R^2$
Marigold	Cubic	Production	0.55
		$y = 0.24x^3 - 89.86x + 1699.32$	
Marigold	Linear	Productivity	0.64
		$y = 12.05x - 0.20$	

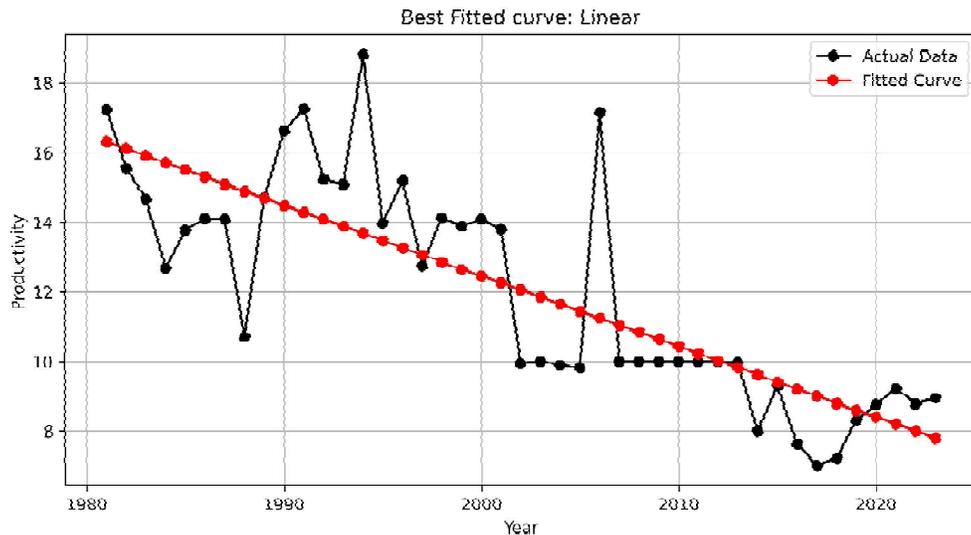
This study is consistent with the findings of Sudha *et al.* (2013), Manasa *et al.* (2024), and Nikhil *et al.* (2023), who also identified the cubic model as the best fit for analyzing trends in area, production, and productivity of crops such as maize and cotton in Karnataka. Similarly, the results are in agreement with Rao and Srinivasulu (2006) and Rashmi *et al.* (2024), who reported that the linear model provided the best fit for capturing production and productivity trends in turmeric and potato, respectively.

**Conclusion**

The trend analysis of Marigold in the Tumkur district over a period of 43 years (1981-82 to 2022-23) revealed significant insights into the crop’s production and productivity dynamics. Among the models evaluated, the Cubic model was identified as the best fit for production, while the Linear model emerged as the most suitable for productivity, based on their higher



**Fig. 1:** Plot of the best-fitted models for the production of Marigold in Tumkur



**Fig. 2:** Plot of the best-fitted models for the productivity of Marigold in Tumkur

$R^2$  values and lower RMSE, indicating strong model performance and reliability. These results confirm that the selected models effectively capture the historical variability in Marigold cultivation and provide dependable projections for future trends. The findings contribute to a deeper understanding of long-term shifts in Marigold production behavior in Tumkur and emphasize the importance of data-driven modeling in agricultural planning. Moreover, the results serve as a valuable tool for policy formulation, resource allocation, and strategic

planning, aiding both farmers and policymakers in promoting sustainable growth and market resilience of Marigold cultivation in the district.

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