

Original Research Article

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A Statistical Trend Analysis on Area and Production of Jasmine in Andhra Pradesh, India

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ABSTRACT

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The present study was carried out to learn the trends in area and production of jasmine in Andhra Pradesh, India for a period of twenty years i.e., from 1998-1999 to 2017-2018. The data was tried to fit in growth models such as linear, compound, inverse, quadratic, cubic, logarithmic, s-curve, growth, power and exponential functions. Inverse curve was found to be the best fitted model based on highest and least RMSE for area and for production. Based on this trend of forecast, the area under next three years under jasmine i.e., for 2019, 2020 and 2021 was 1815.33 ha, 1705.74 ha and 1596.26 ha respectively, while the production of jasmine in the study area would be 19941 MT for 2019, 20332.34 MT for 2020 and 20722.97 MT for 2021. The compound growth rate of area of jasmine was decreasing at a rate of 2.9 per cent CGR whereas production was increasing at a rate of 2.2 per cent.

Introduction

Jasminum grandiflorum is the flowering plant belonging to the Oleaceae family. It is native to tropical and sub-tropical regions of Eurasia. It is also called as “Queen of fragrances” (Ashoka, *et al.*, 2017). This speaks the importance of jasmine. Flower is the economic part of jasmine for which it is commercially grown. It has lots of applications in the medical field. It is used as the cure for hepatitis, cirrhosis, abdominal pain due to severe diarrhoea, etc. Its use is also extended to treat cancer and sedatives to

prevent heart stroke. The extracts are used as fortified foods like jasmine tea. On inhalation of jasmine oil, it made the person feel fresh and active by working on central nervous system (Winai *et al.*, 2013).

Jasmine flourished well in high day temperature regions i.e., the temperature should be above 27°C. The ideal day temperature for jasmine is 27-32°C and night temperature is 21-27°C. The temperature drop to 15-17°C for single night would shut down the yield up to 2 weeks (Kenneth and Glenn, 2002). India along with Egypt constitutes for

95 per cent of the world jasmine production. India exported scented oil extracted from jasmine to England, United States of America, Holland, Sweden, Japan, Norway and European Union (Ashoka *et al.*, 2017). Andhra Pradesh stands third in terms of production after Tamilnadu and Karnataka (APEDA, 2016).

Pradesh for a period of 20 years was collected from the Directorate of Economics and Statistics, Government of Andhra Pradesh. The data was examined for the nature of change and degree of relationship in area and production of jasmine in Andhra Pradesh, using SPSS 22 version, various linear and non-linear statistical models were worked out.

Materials and Methods

The data regarding area (Hectare) and production (MT) of jasmine in Andhra

The linear and non-linear regression models for the crop characteristics *i.e.*, area and production of jasmine were estimated by fitting the following functions.

Parametric trend Models

Model	Functional form
Linear function	$y_t = a + bt$
Compound function	$y_t = ab^t$
Inverse function	$y_t = a + b/t$
Quadratic function	$y_t = a + bt + ct^2$
Cubic function	$y_t = a + bt + ct^2 + dt^3$
Logarithmic function	$y_t = a + b \ln(t)$
S-Curve function	$y_t = \text{Exp}(a+b/t)$ (or) $\ln(y_t) = a + b/t$
Growth function	$y_t = \text{Exp}(a + b_t)$ (or) $\ln(y_t) = a + bt$
Power function	$y_t = at^b$ (or) $\ln(y_t) = \ln(a) + b \ln(t)$
Exponential function	$y_t = ae^{bt}$ (or) $\ln(y_t) = \ln(a) + b_t$

The models fitted to the time series data of area and production were linear, compound, inverse, quadratic, cubic, logarithmic, s-curve, growth, power and exponential functions. To examine the goodness of fit of a model, R^2 and Residual Mean Square Error (RMSE) were used. This helped in measuring the accuracy in forecasting by choosing the model among the alternatives (Ramana and Hari, 2018).

$$RMSE = \sqrt{\frac{\sum_{t=1}^n (A_t - F_t)^2}{n}}$$

Where

A_t is the actual value at time t
 F_t is the forecasted value at time t

The compound growth rate is calculated using compound function.

$$R^2 = SS_{Reg}/TSS$$

$$CGR (\%) = (b-1)*100$$

Where

Results and Discussion

SS_{Reg} = Sum of Square due to regression
 TSS = Total Sum of Square

The data presented in Table 1 gave the area and production details over the study period. The compound growth rate of area and

production was calculated using the compound function. The compound growth rate of area was decreasing at a rate of 2.9 per

cent and that of production was increasing at a rate of 2.2 per cent.

Table.1 Area and Production of jasmine in Andhra Pradesh

Year	Area (Ha)	Production (Tonnes)
1999	5213	2775
2000	5653	10755
2001	3878	9441
2002	2837	15090
2003	5266	15499
2004	1698	19796
2005	2290	21972
2006	2657	23386
2007	2634	24928
2008	2528	26725
2009	2525	7962
2010	2141	2956
2011	2375	2678
2012	2515	11987
2013	2307	10854
2014	2270	11741
2015	2744	49861
2016	2363	14537
2017	2718	8950
2018	2877	24220
CGR	-2.9 %	2.2 %

Table.2 The parametric values of fitted linear and non-linear models for area of jasmine in Andhra Pradesh

Model	Coefficients				Goodness of fit	
	a	b	c	d	R ²	RMSE
Linear	224974.11	-110.53			0.34**	882.52
Logarithmic	1693333.51	-222265.36			0.34**	881.88
Inverse	-219556.76	446950246.57			0.35**	880.27
Quadratic	224974.11	-110.53	0.00		0.34**	882.52
Cubic	224974.11	-110.53	0.00	0.00	0.34**	882.52
Compound	61278422137521 95000000000000 0.00	0.97			0.29*	880.94
Power	2.509E+196	-58.42			0.29*	881.33
S-Curve	-50.55	117489.098			0.29*	880.77
Growth	66.29	-0.03			0.29*	880.94
Exponential	61278422137521 95000000000000 0.00	-0.03			0.29*	880.94

***, indicates significant at 1% and 5% level of probability respectively

Table.3 Estimated value of area of jasmine in Andhra Pradesh

Year	Estimated value (ha)
2019	1815.33
2020	1705.74
2012	1596.26

Table.4 The parametric values of fitted linear and non-linear models for production of jasmine in Andhra Pradesh

Model	Coefficients				Goodness of fit	
	a	b	c	d	R ²	RMSE
Linear	-777480.873	394.97			0.04	10441.05
Logarithmic	-6019876.90	793632.08			0.04	10440.84
Inverse	809786.08	-1594696541.98			0.05	10440.67
Quadratic	-777480.87	394.97	0.00		0.04	10441.05
Cubic	-777480.87	394.97	0.00	0.00	0.04	10441.05
Compound	1.361E-15	1.02			0.03	10998.69
Power	6.787E-141	43.68			0.03	10998.74
S-Curve	53.12	-87776.13			0.03	10998.41
Growth	-34.23	0.02			0.03	10998.74
Exponential	1.361E-15	0.02			0.03	10998.74

Table.5 Estimated value of production of jasmine in Andhra Pradesh

Year	Estimated value (MT)
2019	19941.33
2020	20332.34
2012	20722.97

Fig.1 Depiction of observed area and predicted area

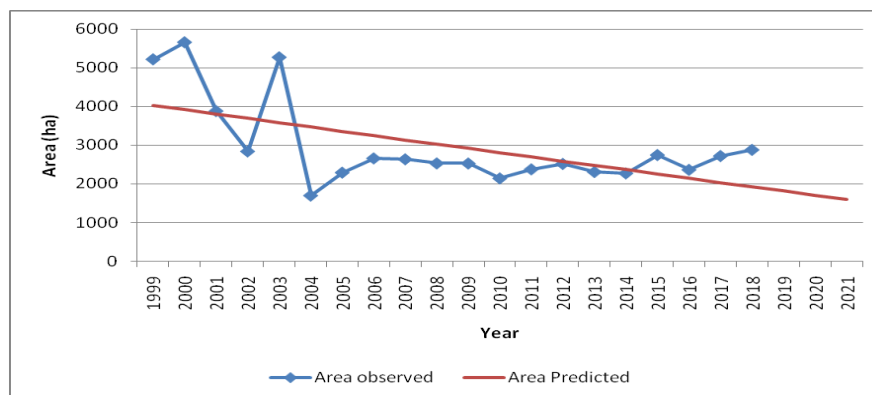
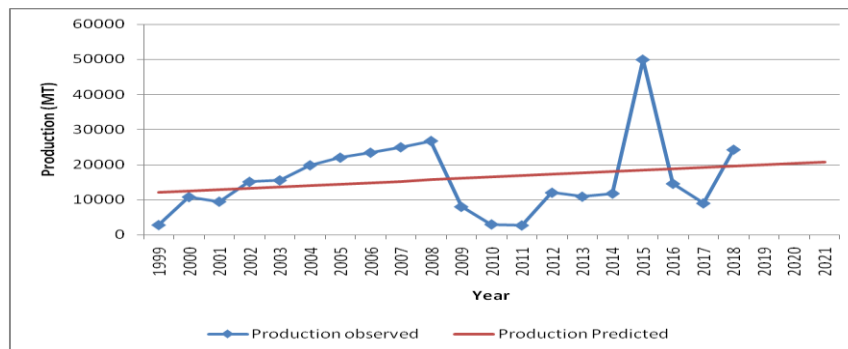


Fig.2 Depiction of observed production and predicted production



Different linear and non-linear models were employed to study the trend in area and production of jasmine in Andhra Pradesh for the study period. Based on maximum R^2 and minimum RMSE values, inverse curve was suitable model for the data and projection of future values of area and production of jasmine in Andhra Pradesh. The results were in conformity with Satheyandrakumar and Chandrashekar (2015) and Pramod (2020).

Trends in area

Table 2 gave the details of all the models examined to fit the data of area of jasmine in Andhra Pradesh. From the table, it can be observed that inverse model is best fit for the data with maximum R^2 (35 %) and minimum RMSE (880.27). Inverse model was found to be best fit trend for the future projection of area of jasmine. The fitted model was given by

$$y_t = a+b/t$$

Table 3 presented the projected values of jasmine over the next three years i.e., for 2019, 2020 and 2021. The projected value for 2019 was 1815.33 ha, for 2020 was 1705.74 ha and for 2021 it was 1596.26 ha. Figure 1 was the depiction of predicted values for area against observed values for area of jasmine in Andhra Pradesh.

Trends in production

Maximum R^2 value was 5 % and minimum RMSE was 10440.67. These values occurred when the data was fitted with inverse model in Table 4. This has shown that inverse model was the best fit model for the data. The fitted model was given by

$$y_t = a+b/t$$

The future projections were displayed in Table 5 which were calculated based on the inverse model. The projected value for the year 2019 was 19941.33 MT, for 2020, it was 20332.34 MT and for 2021, it was 20722.97 MT. Figure 2 was the depiction of predicted values for production against observed values for production of jasmine in Andhra Pradesh.

In conclusion the compound growth rate for area and production were calculated using compound function. The CGR for area was decreasing at a rate of 2.9 per cent and for production, it was increasing at a rate 2.2 per cent. Inverse model was the best fit model for both area and production of jasmine in Andhra Pradesh. The future values of area and production were projected based on the inverse model. There was decrease in projected values of area from 2019 (1815.33 ha) to 2021 (1705.74 ha) with 2020 (1596.26 ha) being constant. There was an increase in the projected production values with

19941.33 MT in 2019, 20332.34 MT in 2020 and 20722.97 MT in 2021

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