# A Statistical Approach for Analysis of Trend Pattern of Pigeon Pea in India


**ABSTRACT**

The present paper deals with the analysis oftrend pattern in area, production, and yield of pigeon pea in India. The analysis is carried out using secondary time series data on area, production, and yield of pigeon pea pertaining to the period 2001-2023. The trend values have been computed on fitting well-known statistical models viz., linear model, exponential model, quadratic model, and cubic model. Moreover, the accuracy of the concerned fitted models have been evaluated using various statistical measures viz., coefficient of determination ($R^2$), root mean square error (RMSE) and relative mean absolute percentage error (RMAPE). The results of the investigation reveal that the concerned models fitted well for exploring the trend in area, production, and yield of pigeon pea.Moreover, the cubic model is slightly more precise as compared to the other fitted models, and hence it could be utilized for forecasting the scenario of pigeon pea in India. The findings of the study provide useful insights towards policy formulation regarding enhancement of pigeon pea production for meeting global food demand and nutritional security.



***Keywords:****Linear model; exponential model; quadratic model; cubic model; coefficient of determination; root mean square error; relative mean absolute percentage error.*




## 1. INTRODUCTION

Pulses are essential pillars of the human diet, serving as a vital source of protein, particularly for vegetarians. In cooked form, pulses offer a rich blend of essential amino acids, dietary fibers, vitamins, and minerals.

India is the largest producer andconsumerof pulsesin the world(Source: Directorate of Pulses Development, Govt. of India [1]).In India during 2023-2024, the area under pulses was 27.51 million hectares with a production of 24.25 million tons, reporting a yield of 881 kg/hectare(Source:Directorate of Economics & Statistics, Govt. of India [2]).The most commonly grown pulses in India include chickpea, pigeon pea,urdbean, mungbean, and lentil.

Pigeon pea (*Cajanuscajan* L.), natively known as Arhar in India, belongs to Fabaceae family, and is a short-lived perennial legume. It holds a significant place in the Indian diet. Primarily grown in semi-arid and tropical regions, pigeon pea is highly valued for its adaptability to diverse climatic conditions, drought tolerance, and capacity to improve soil fertility through nitrogen fixation. As a staple in Indian cuisine, particularly in the form of split grains (*dal*), it serves as an affordable and high-quality protein source, which is essential for the predominantly vegetarian population. India is the world's leading producer of pigeon pea,making it a centrepiece for the nation’s food security and agricultural sustainability(Source: Directorate of Pulses Development, Govt. of India [1]). The major pigeon pea growing states in India include Maharashtra,Karnataka,Uttar Pradesh, Gujarat, Jharkhand and Telangana. During the year 2023-24,India reported production of 3.42 million tons of pigeon pea under 4.13 million hectares of area, witnessing a yield of 827 kg/hectare (Source: Directorate of Economics &Statistics, Govt. of India, [2]).

In recent years, several scientists and researchers have conducted studies on pulses. Kim *et al.* [3]conducted a systematic review and meta-analysis of randomized controlled trials to summarize and quantify the effects of dietary pulse consumption on body weight, waist circumference, and body fat. Gurusamy *et al.* [4] demonstrated the aspects of pulse grains for healthy foods that can tackle protein energy malnutrition and the management of diseases. Kumar *et al.* [5] investigated anti-nutritional compounds present in different pulses including their fractions, significance, and beneficial and adverse effects on human health.Yousif *et al.* [6]quantified and compared the level of mechanization across selected crops, including pulses, within the Gezira scheme, Sudan. The data about production practices, were collected from the farmers and engineers. Moreover, the level of mechanization was calculated for two scenariosviz., traditional and improved farming systems.

In the present scenario, the time series analysis of pulses is of utmost importance for policy formulation regarding food security and meeting the global nutritional demand. Considering the given fact, several scientists and researchers conducted statistical analysis for pulses in various geographical regions. Sharma *et al.* [7] examined the growth and trend of pulse production in India using time series data on area, production, yield, and trade pertaining to the period 1980-81 to 2008-09.Sharma *et al.* [8] conducted detailed investigationof various regions of Uttar Pradesh for analysis of growth rates and instability of pulse crops for two different periods viz., before and after the launch of technological missions on pulse production in the country. The selected pulse crops were arhar, pea, gram, and lentil.Vishwajith *et al.* [9]forecasted the production scenario of pulses in major pulses growing states of India using Autoregressive Integrated Moving Average (ARIMA) and Generalised Autoregressive Conditional Heteroscedastic (GARCH) models.Vani and Mishra [10] investigated the impact of irrigation on pulses production in India using regression and linear decomposition analysis.Ray and Bhattacharyya [11]investigated the trend behavior of pulses production, productivity, and net availability of India. The time series models viz., linear, quadratic, exponential, logarithmic, power, ARIMA, and ARIMAX models were used in the analysis.Akah*et al.*[12] evaluated pulse production, consumption and utilization in Nigeria, and investigatedtrend and growth rates in area, production and yield of cowpea in Nigeria and other major regions during the period 1996-98 to 2016-2018.Mishra *et al.* [13] analyzed the trend in production of total pulses in India using autoregressive integrated moving average (ARIMA) model on the basis of time series data pertaining to the period 1961 to 2019.Biam*et al.* [14]conducted trend and decomposition analysis of pulses production in North-East Indiaacross four periods viz., Phase I (1978-79 to 1991-92); Phase II (1992-93 to 2005-06), Phase III (2006-07 to 2019-20) and Pool (1978- 79 to 2019-2020).Balai *et al.* [15] reported the growth, decomposition and instability in area, production and productivity of rabi pulse crops viz., gram and lentil in Madhya Pradesh.Kumar *et al.* [16]carried out the comparative assessment of instability and growth rate in area, production, and yield of major pulses(viz., chickpea, pigeon pea, urdbean, and mungbean) in India using secondary time series data pertaining to the period 2000-2021.Prioty*et al.* [17] examined growth and instability in area, production, and yield of minor pulses in Bangladesh using secondary time series data pertaining to the period1981-2020.Some other noteworthy contributions towards statistical modeling and time series analysis of crops, other than pulses, have been made byKumar and Menon [18], Rana and Kumar [19], Kumar *et al.* [20], and Prakash *et al*. [21].

The objective of the present paper is to analyzethetrend patternin area, production, and yield of pigeon peain India.The analysis is carried outby fitting well-known statistical models (viz., linear, exponential, quadratic, and cubic models) to the time series data on pigeon peapertaining to the period 2001-2023, and estimating the trend values. The accuracy of the concerned fitted models have been evaluated using coefficient of determination ($R^2$), root mean square error (RMSE) and relative mean absolute percentage error (RMAPE).

## 2. MATERIALS AND METHODS

In the present paper, the secondary time series data on pigeon pea pertaining to the period 2001-2023is utilized for the analysis of trend pattern in area, production, and yield of pigeon pea in India. The time series data have been obtained from the records of Directorate of Economics & Statistics, DAC&FW, Govt. of India.

In order to analyze the trend pattern in area, production, and yield of pigeon pea, the trend values are obtained by fitting linear, exponential, quadratic, and cubic models to the time series data as follows:

**(a) Linear Model:**

$$y_t = a + bt \ldots (1)$$

where $y_t$ denotes the observed time series value of area, production, or yield (as the case may be) of pigeon pea at time $t$.

The values of constants '$a$' and '$b$' are obtained by using the principle of least squares on solving the following normal equations:

$$\sum y_t = na + b\sum t \ldots (2)$$

$$\sum ty_t = a\sum t + b\sum t^2 \ldots (3)$$

where '$n$' represents the number of observed values.

**(b) Exponential Model:**

$$y_t = ae^{bt} \ldots (4)$$

Taking natural log on both sides of above equation, we have

$$log_e y_t = log_e\, a + bt\, log_e\, e$$

i.e., $Y_t = A + bt$... (5)

where $Y_t = log_e y_t$ , $A = log_e\, a$ , and $log_e\, e = 1$

The normal equations for estimating the values of '$A$' and '$b$' are as follows:

$$\sum Y_t = nA + b\sum t \text{... (6)}$$

$$\sum tY_t = A\sum t + b\sum t^2 \text{...(7)}$$

Finally, the value of '$a$' is obtained on using

$$a = antilog\,(A)$$

**(c) Quadratic Model:**

$$y_t = a + bt + ct^2 \text{... (8)}$$

The values of constants '$a$', '$b$', and '$c$'are obtained on using the principles of least squares as follows:

$$\sum y_t = na + b\sum t + c\sum t^2 \text{... (9)}$$

$$\sum ty_t = a\sum t + b\sum t^2 + c\sum t^3 \text{... (10)}$$

$$\sum t^2y_t = a\sum t^2 + b\sum t^3 + c\sum t^4 \text{...(11)}$$

**(d) Cubic Model:**

$$y_t = a + bt + ct^2 + dt^3 \text{... (12)}$$

The values of constants '$a$', '$b$','$c$' and '$d$' are obtained on solving the following normal equations.

$$\sum y_t = na + b\sum t + c\sum t^2 + d\sum t^3 \text{... (13)}$$

$$\sum ty_t = a\sum t + b\sum t^2 + c\sum t^3 + d\sum t^4 \text{... (14)}$$

$$\sum t^2y_t = a\sum t^2 + b\sum t^3 + c\sum t^4 + d\sum t^5 \text{... (15)}$$

$$\sum t^3y_t = a\sum t^3 + b\sum t^4 + c\sum t^5 + d\sum t^6 \text{... (16)}$$

## 3. RESULTS AND DISCUSSION

The secondary time series data on area, production, and yield of pigeon pea in India is presented in Table 1. The trend values are obtained on fitting linear, exponential, quadratic and cubic models to the data on area, production, and yield, and the findings are depicted in Tables 2, 3 and 4, respectively. Moreover, the fitted model equations for area, production, and yield of pigeon pea are presented in Table 5.

**Table 1.** Time series data on area, production, and yield of pigeon pea in India

| Year | **Area** (in Million Hectares) | **Production** (in Million Tons) | **Yield** (in Tons / Hectare) |
|---|---|---|---|
| 2001 | 3.33 | 2.26 | 0.68 |
| 2002 | 3.36 | 2.19 | 0.65 |
| 2003 | 3.52 | 2.36 | 0.67 |
| 2004 | 3.52 | 2.35 | 0.67 |
| 2005 | 3.58 | 2.74 | 0.77 |
| 2006 | 3.56 | 2.31 | 0.65 |
| 2007 | 3.73 | 3.08 | 0.83 |
| 2008 | 3.38 | 2.27 | 0.67 |
| 2009 | 3.47 | 2.46 | 0.71 |
| 2010 | 4.37 | 2.86 | 0.65 |
| 2011 | 4.01 | 2.65 | 0.66 |
| 2012 | 3.89 | 3.02 | 0.78 |
| 2013 | 3.90 | 3.17 | 0.81 |
| 2014 | 3.85 | 2.81 | 0.73 |
| 2015 | 3.96 | 2.56 | 0.65 |
| 2016 | 5.34 | 4.87 | 0.91 |
| 2017 | 4.44 | 4.29 | 0.97 |
| 2018 | 4.55 | 3.32 | 0.73 |
| 2019 | 4.53 | 3.89 | 0.86 |
| 2020 | 4.72 | 4.32 | 0.92 |
| 2021 | 4.90 | 4.22 | 0.86 |
| 2022 | 4.07 | 3.31 | 0.81 |
| 2023 | 4.13 | 3.42 | 0.83 |

(**Source:** Directorate of Economics & Statistics, DAC&FW, Govt. of India)

**Table 2.** Trends values for area of pigeon pea

| **Year ($t$)** | $y_t$ | **Trend Values** | | | |
|---|---|---|---|---|---|
| | | **Linear** | **Exponential** | **Quadratic** | **Cubic** |

| | | Model $(L_t)$ | Model $(E_t)$ | Model $(Q_t)$ | Model $(C_t)$ |
|---|---|---|---|---|---|
| 2001 | 3.33 | 3.33 | 3.35 | 3.21 | 3.45 |
| 2002 | 3.36 | 3.39 | 3.40 | 3.30 | 3.40 |
| 2003 | 3.52 | 3.45 | 3.46 | 3.39 | 3.38 |
| 2004 | 3.52 | 3.51 | 3.51 | 3.48 | 3.38 |
| 2005 | 3.58 | 3.57 | 3.57 | 3.57 | 3.42 |
| 2006 | 3.56 | 3.64 | 3.62 | 3.65 | 3.48 |
| 2007 | 3.73 | 3.70 | 3.68 | 3.73 | 3.55 |
| 2008 | 3.38 | 3.76 | 3.73 | 3.80 | 3.64 |
| 2009 | 3.47 | 3.82 | 3.79 | 3.88 | 3.74 |
| 2010 | 4.37 | 3.88 | 3.85 | 3.95 | 3.85 |
| 2011 | 4.01 | 3.94 | 3.91 | 4.01 | 3.96 |
| 2012 | 3.89 | 4.00 | 3.97 | 4.08 | 4.08 |
| 2013 | 3.90 | 4.07 | 4.03 | 4.14 | 4.19 |
| 2014 | 3.85 | 4.13 | 4.10 | 4.19 | 4.29 |
| 2015 | 3.96 | 4.19 | 4.16 | 4.25 | 4.38 |
| 2016 | 5.34 | 4.25 | 4.22 | 4.30 | 4.46 |
| 2017 | 4.44 | 4.31 | 4.29 | 4.34 | 4.52 |
| 2018 | 4.55 | 4.37 | 4.36 | 4.39 | 4.56 |
| 2019 | 4.53 | 4.44 | 4.42 | 4.43 | 4.58 |
| 2020 | 4.72 | 4.50 | 4.49 | 4.47 | 4.56 |
| 2021 | 4.90 | 4.56 | 4.56 | 4.50 | 4.52 |
| 2022 | 4.07 | 4.62 | 4.63 | 4.53 | 4.44 |
| 2023 | 4.13 | 4.68 | 4.70 | 4.56 | 4.32 |



**Table 3.** Trends values for production of pigeon pea

| Year $(t)$ | $y_t$ | Trend Values |
|---|---|---|

| | | **Linear Model** $(L_t)$ | **Exponential Model** $(E_t)$ | **Quadratic Model** $(Q_t)$ | **Cubic Model** $(C_t)$ |
|---|---|---|---|---|---|
| 2001 | 2.26 | 2.12 | 2.19 | 2.09 | 2.45 |
| 2002 | 2.19 | 2.21 | 2.26 | 2.19 | 2.34 |
| 2003 | 2.36 | 2.29 | 2.32 | 2.28 | 2.28 |
| 2004 | 2.35 | 2.38 | 2.39 | 2.38 | 2.27 |
| 2005 | 2.74 | 2.47 | 2.46 | 2.47 | 2.29 |
| 2006 | 2.31 | 2.56 | 2.53 | 2.56 | 2.34 |
| 2007 | 3.08 | 2.64 | 2.60 | 2.65 | 2.43 |
| 2008 | 2.27 | 2.73 | 2.67 | 2.74 | 2.53 |
| 2009 | 2.46 | 2.82 | 2.75 | 2.83 | 2.66 |
| 2010 | 2.86 | 2.90 | 2.83 | 2.92 | 2.80 |
| 2011 | 2.65 | 2.99 | 2.91 | 3.01 | 2.94 |
| 2012 | 3.02 | 3.08 | 2.99 | 3.09 | 3.09 |
| 2013 | 3.17 | 3.16 | 3.07 | 3.18 | 3.24 |
| 2014 | 2.81 | 3.25 | 3.16 | 3.27 | 3.39 |
| 2015 | 2.56 | 3.34 | 3.25 | 3.35 | 3.52 |
| 2016 | 4.87 | 3.42 | 3.35 | 3.43 | 3.64 |
| 2017 | 4.29 | 3.51 | 3.44 | 3.52 | 3.74 |
| 2018 | 3.32 | 3.60 | 3.54 | 3.60 | 3.82 |
| 2019 | 3.89 | 3.68 | 3.64 | 3.68 | 3.86 |
| 2020 | 4.32 | 3.77 | 3.74 | 3.76 | 3.87 |
| 2021 | 4.22 | 3.86 | 3.85 | 3.84 | 3.84 |
| 2022 | 3.31 | 3.94 | 3.96 | 3.92 | 3.77 |
| 2023 | 3.42 | 4.03 | 4.07 | 4.00 | 3.65 |



**Table 4.** Trends values for yield of pigeon pea

| Year ($t$) | $y_t$ | Trend Values | | | |
|---|---|---|---|---|---|
| | | Linear Model ($L_t$) | Exponential Model ($E_t$) | Quadratic Model ($Q_t$) | Cubic Model ($C_t$) |
| 2001 | 0.68 | 0.65 | 0.65 | 0.66 | 0.68 |
| 2002 | 0.65 | 0.66 | 0.66 | 0.67 | 0.68 |
| 2003 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 |
| 2004 | 0.67 | 0.68 | 0.68 | 0.68 | 0.67 |
| 2005 | 0.77 | 0.69 | 0.69 | 0.69 | 0.68 |
| 2006 | 0.65 | 0.70 | 0.70 | 0.70 | 0.68 |
| 2007 | 0.83 | 0.71 | 0.71 | 0.71 | 0.69 |
| 2008 | 0.67 | 0.72 | 0.72 | 0.72 | 0.70 |
| 2009 | 0.71 | 0.73 | 0.72 | 0.72 | 0.71 |
| 2010 | 0.65 | 0.74 | 0.73 | 0.73 | 0.72 |
| 2011 | 0.66 | 0.75 | 0.74 | 0.74 | 0.74 |
| 2012 | 0.78 | 0.76 | 0.75 | 0.75 | 0.75 |
| 2013 | 0.81 | 0.77 | 0.76 | 0.76 | 0.77 |
| 2014 | 0.73 | 0.78 | 0.77 | 0.77 | 0.78 |
| 2015 | 0.65 | 0.79 | 0.78 | 0.78 | 0.80 |
| 2016 | 0.91 | 0.80 | 0.79 | 0.79 | 0.81 |
| 2017 | 0.97 | 0.81 | 0.80 | 0.80 | 0.82 |
| 2018 | 0.73 | 0.82 | 0.81 | 0.81 | 0.83 |
| 2019 | 0.86 | 0.83 | 0.82 | 0.83 | 0.84 |
| 2020 | 0.92 | 0.84 | 0.83 | 0.84 | 0.85 |
| 2021 | 0.86 | 0.85 | 0.84 | 0.85 | 0.85 |
| 2022 | 0.81 | 0.86 | 0.85 | 0.86 | 0.85 |
| 2023 | 0.83 | 0.87 | 0.87 | 0.87 | 0.85 |

In Tables 2, 3 and 4, the term ‘$y_t$’ denotes the observed value of area (in million hectares), production (in million tons), and yield (in tons / hectare)of pigeon pea for the year ‘$t$’ ($t$ = 2001, 2002, ... ,2023). Moreover, ‘$L_t$’denotes the linear trend value of area, production, and yield of pigeon pea for the year ‘$t$’. In a similar manner, ‘$E_t$’denotes the exponential trend value, ‘$Q_t$’ denotes the quadratic trend value, and ‘$C_t$’ denotes the cubic trend value.

The relative influence of the trend values on the observed values of area, production, and yield of pigeon pea are graphically demonstrated in Figs. 1 to 12.

**Table 5.** Models equations for area, production, and yield of pigeon pea in India

| | Linear Model | Exponential Model | Quadratic Model | Cubic Model |
|---|---|---|---|---|
| **Area** | $y_{t'} = 4 + 0.06t'$ | $y_{t'} = 3.97e^{0.015\,t'}$ | $y_{t'} = 4.08 + 0.06t' - 0.0016t'^2$ | $y_{t'} = 4.08 + 0.11t' - 0.0016t'^2 - 0.0006t'^3$ |
| **Production** | $y_{t'} = 3.08 + 0.09\,t'$ | $y_{t'} = 2.99e^{0.028\,t'}$ | $y_{t'} = 3.09 + 0.09\,t' - 0.0004t'^2$ | $y_{t'} = 3.09 + 0.15\,t' - 0.0004t'^2 - 0.0008t'^3$ |
| **Yield** | $y_{t'} = 0.76 + 0.01\,t'$ | $y_{t'} = 0.75e^{0.013t'}$ | $y_{t'} = 0.75 + 0.01\,t' + 0.0001t'^2$ | $y_{t'} = 0.75 + 0.01\,t' + 0.0001t'^2 - (6 \times 10^{-5})t'^3$ |

(**Note:** $t' = t - 2012$)

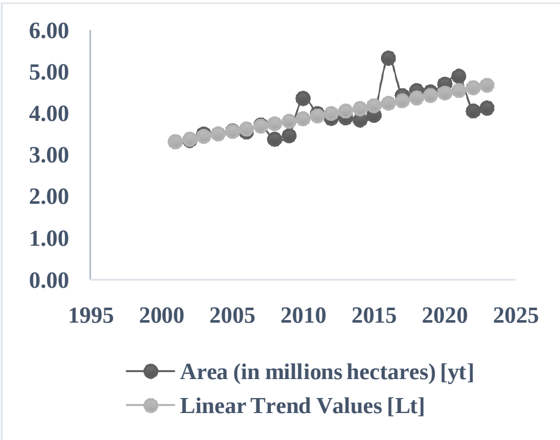


**Fig. 1 Linear trend values for area of pigeon pea**

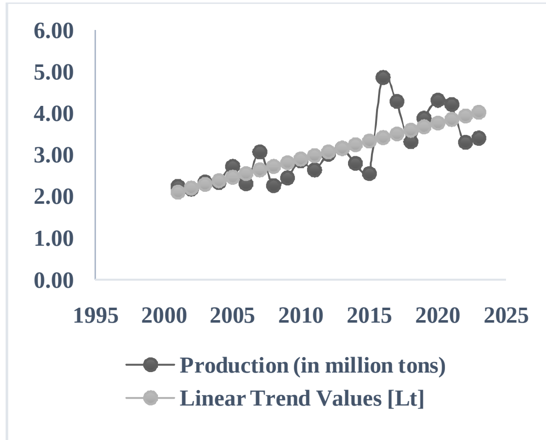


**Fig. 2 Linear trend values for production of pigeon pea**

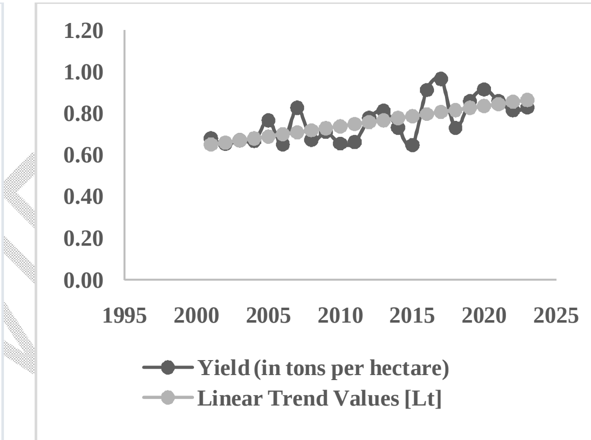


**Fig. 3 Linear trend values for yield of pigeon pea**

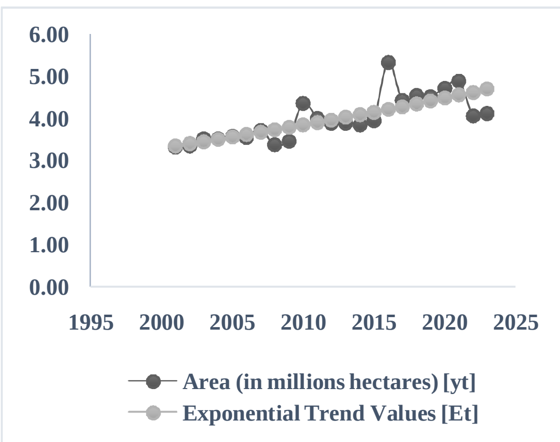


**Fig. 4 Exponential trend values for area of pigeon pea**

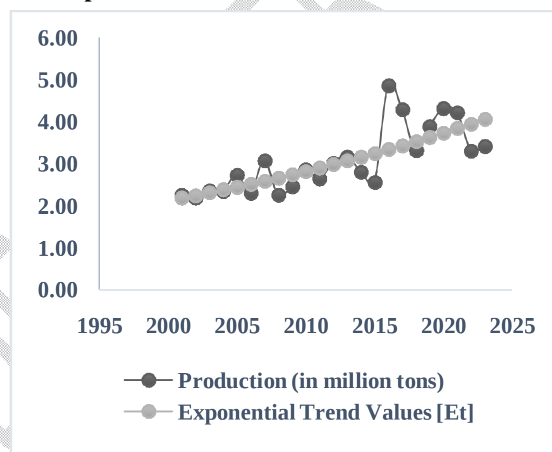


**Fig. 5Exponential trend values for production of pigeon pea**

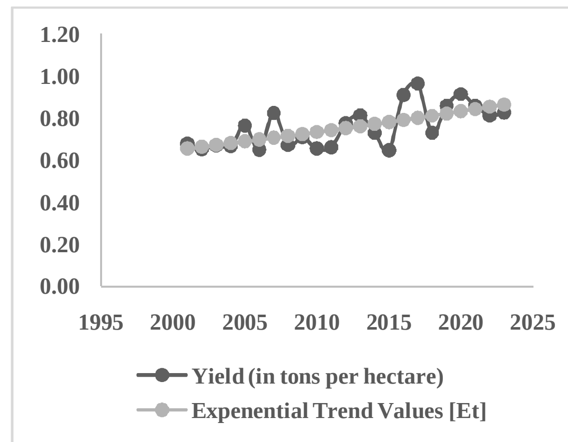


**Fig. 6Exponential trend values for yield of pigeon pea**

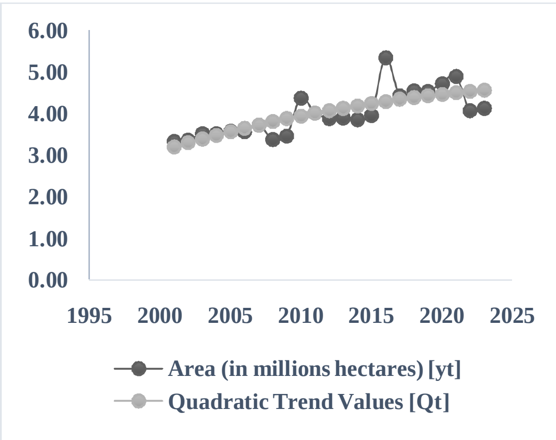


**Fig. 7 Quadratic trend values for area of pigeon pea**

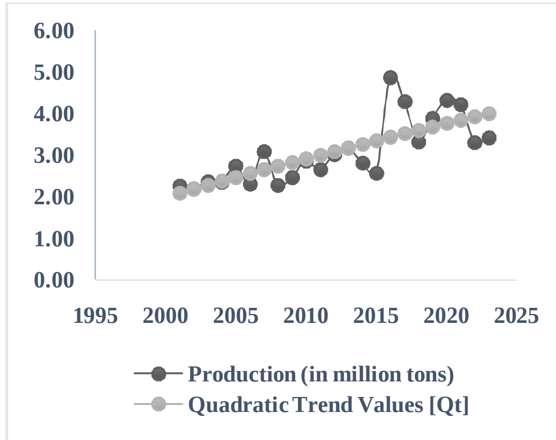


**Fig. 8Quadratic trend values for production of pigeon pea**

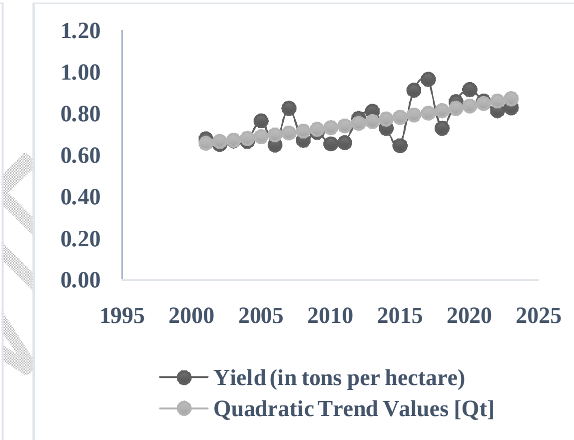


**Fig. 9Quadratic trend values for yield of pigeon pea**

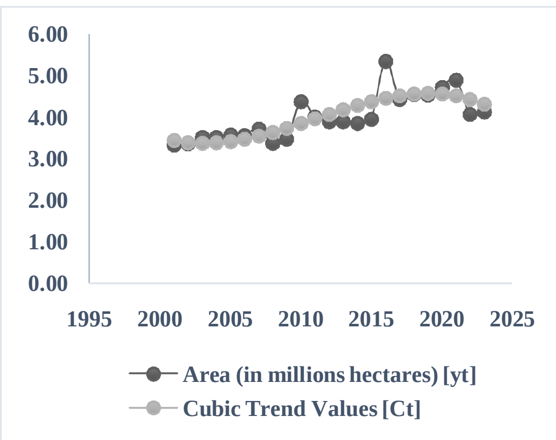


**Fig. 10 Cubic trend values for area of pigeon pea**

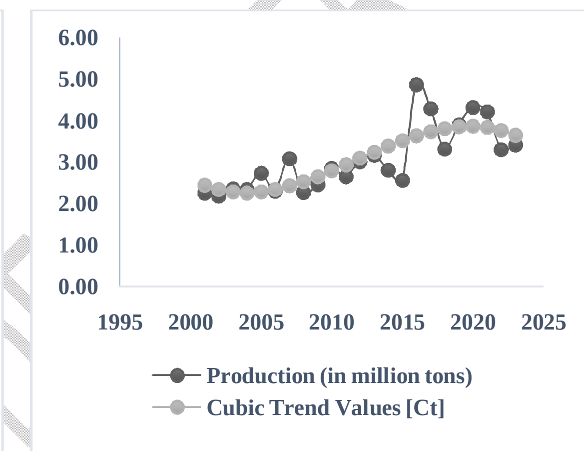


**Fig. 11Cubic trend values for production of pigeon pea**

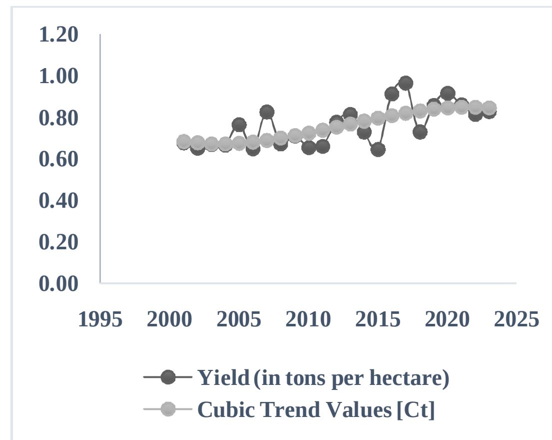


**Fig.12 Cubic trend values for yield of pigeon pea**

The accuracy of the concerned fitted modelshave been evaluated using various statistical measures viz., coefficient of determination ($R^2$), root mean square error (RMSE) and relative mean absolute percentage error (RMAPE) using the following formulae:

$$R^2 = 1 - \frac{\sum_{t=1}^{n}(y_t - \hat{y}_t)^2}{\sum_{t=1}^{n}(y_t - \bar{y})^2}$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{t=1}^{n}(y_t - \hat{y}_t)^2}$$

and

$$RMAPE = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{y_t - \hat{y}_t}{y_t}\right| \times 100$$

where$\bar{y}$ denotes the mean value of variable $Y$, i.e., area, production, or yield (as the case may be) of pigeon pea. Also, $\hat{y}_t$represents the trend value of variable$Y$, which is obtained on fitting the concerned models (such as linear model, exponential model, quadratic model, or cubic model) to the variable $Y$.

The values of $R^2$, RMSE and RMAPE for the concerned fitted models on area, production, and yield of pigeon pea are computed and the findings are summarized inTable 6.

**Table 6.** Model evaluation for area, production, and yield of pigeon pea in India

| | **Model** | **$R^2$** | **RMSE** | **RMAPE** |
|---|---|---|---|---|
| Area | Linear | 0.586 | 0.343 | 5.583 |
| | Exponential | 0.625 | 0.347 | 5.608 |
| | Quadratic | 0.600 | 0.337 | 5.953 |
| | Cubic | 0.674 | 0.305 | 5.702 |
| Production | Linear | 0.574 | 0.495 | 11.415 |
| | Exponential | 0.633 | 0.501 | 11.017 |
| | Quadratic | 0.575 | 0.495 | 11.584 |
| | Cubic | 0.635 | 0.458 | 10.893 |
| Yield | Linear | 0.441 | 0.073 | 7.678 |
| | Exponential | 0.449 | 0.073 | 7.594 |
| | Quadratic | 0.444 | 0.072 | 7.627 |
| | Cubic | 0.465 | 0.071 | 7.088 |

The following results are obtained from Table 6:

(i) The values of $R^2$ for the fitted models are greater than $0.5$ for area and production of pigeon pea, whereas for the yield $R^2 < 0.5$ for the concerned fitted model.

(ii) The cubic model reported highest $R^2$in area, production, and yield of pigeon pea,as compared to the other models.

(iii)The cubic model reported leastRMSEin area, production, and yield of pigeon pea, as compared to the other models.

(iv)In terms of production and yield, the cubic model exhibited least RMAPE as compared to the other fitted models. However, in terms of area, all the fitted models have nearly the same RMAPE values.

Hence, on considering the above mentioned points, it can be revealed that the concerned fitted models are appropriate for analysis of trend pattern in area, production, and yield of pigeon pea in India. Moreover, the cubic model seems to be more precise, as compared to the other models, for exploring the scenario of trend pattern in pigeon pea.

## 4. CONCLUSION

In the present paper, trend pattern analysis is carried out for area, production, and yield of pigeon pea in India using time series data pertaining to the period 2001-2023. The trend values have been estimated by fitting linear, exponential, quadratic, and cubic models to the concerned time series data on pigeon pea. Moreover, the accuracy of the fitted models have been measured using coefficient of determination ($R^2$), root mean square error (RMSE) and relative mean absolute percentage error (RMAPE).

The results of the analysis reveal that the concerned fitted models are appropriate for estimating the trend in area, production, and yield of pigeon pea. Moreover, on the basis of values of $R^2$, RMSE, and RMAPE, it can be concluded that the cubic model is slightly more reliable as compared to the other fitted models for forecasting the scenario of pigeon pea in India.

The findings of the investigation provide useful insights towards policy formulation regarding enhancement of pigeon pea production for meeting global food demand and nutritional security. In order to boost the pigeon pea production, the potential farmers could be encouraged for its cultivation.

### Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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