

STATISTICAL PERSPECTIVE OF OILSEED CROP PRODUCTION IN INDIA: TREND, INSTABILITY, DECOMPOSITION AND ARIMA FORECASTING

Surabhi Jain¹, Roshni Rajak^{2**}, A. K. Vishwakarma^{1*}, Namrata Jain^{3***}, Rajani Bisen¹, Reena Nair⁴, K. N Gupta¹, Roshni Sahu¹ and V K Katara¹

¹Project Coordinating Unit (Sesame and Niger),

²Department of Mathematics and Statistics, JNKVV, Jabalpur,

³Department of Agronomy, JNKVV, Jabalpur

⁴Department of Horticulture, JNKVV, Jabalpur

*Corresponding author- A. K. Vishwakarma, akvish16@gmail.com

**Corresponding author- Roshni Rajak,

***Corresponding author- Namrata Jain, namratajain@jnkvv.org

ABSTRACT

The present study was conducted to analyse the long-term trends and variability in the area, production and productivity of total oilseed crops in India, to estimate the contribution of area, productivity, and their interaction to production growth, and to forecast future area, production, and productivity using time series analysis. The study was based on secondary time-series data for the period 1950-51 to 2024-25, collected from the IIOR, Hyderabad and Directorate of Economics and Statistics, Government of India, New Delhi. Descriptive statistics, compound growth rate, coefficient of variation, the Mann–Kendall trend test, decomposition analysis, and the Box–Jenkins ARIMA methodology were used for data analysis. Stationarity was examined using the Augmented Dickey–Fuller (ADF) test, and the analyses were carried out in R. The fitted models were evaluated using MAPE, AIC, and BIC. The results showed an increasing trend in the area, production and productivity of total oilseed crops India. Decomposition analysis revealed that productivity contributed the most to production growth, accounting for 70.3% in India, followed by the area effect (18.6%) and the interaction effect (11.0%), respectively. For forecasting ARIMA (0,1,0) with drift, ARIMA (1,1,0) with drift, and ARIMA (1,1,1) with drift model were selected for oilseed area, production and productivity for India respectively. The selected models showed satisfactory forecasting accuracy, with MAPE values ranging from 3.91 % to 10.84 %. The forecasts indicated a gradual increase in the area, production, and productivity of total oilseed crops during the forecast period. The findings suggest that ARIMA models are useful for analysing historical trends and generating reliable short-term forecasts, providing valuable support for planning and policy decisions related to oilseed development in India.

KEYWORDS: Oilseed crops, India, Time Series Analysis, ARIMA, Forecasting, Decomposition Analysis.

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1. INTRODUCTION

Oilseeds play an important role in Indian agriculture and its economy. In agriculture after cereal crops, oilseed crops are the economy's second most important supporting factor. The major source of vegetable oils in the country are nine oilseeds crops, seven of which are edible oils (soybean, groundnut, rapeseed-mustard, sunflower, sesame, safflower, and niger) and two of which are non-edible oils (castor and linseed). In India, during 2024-25, oilseed crops covered an area of about 30440 thousand hectares, out of which 29306 thousand hectares were under edible oilseeds and 1134 thousand hectares under non- edible oilseeds. Oilseed crops make a significant contribution to agricultural GDP. India is among one of the major largest oilseed product exporters in the world. The demands of oilseeds are continuously increasing for export every year. The government has started several programmes (NFSM, TRFA etc.) to increase the area and production of oilseed crops in India. In spite of these the domestic production of oilseeds has remained stagnant over the years. Despite being one of the world's largest producers of oilseeds, the country continues to depend heavily on imports of edible oils because domestic production has not kept pace with the rapidly increasing demand arising from population growth, urbanization, and changing consumption patterns. This widening demand–supply gap has intensified the

need for sustainable enhancement of domestic oilseed production through evidence-based planning and technological interventions.

Understanding the dynamics of oilseed production requires simultaneous evaluation of area, production, and productivity because these components jointly determine overall output. While expansion of cultivated area may initially increase production, sustained growth largely depends on improvements in crop productivity through technological advancement, efficient resource management, improved seed varieties, balanced nutrient application, irrigation development, and effective plant protection measures. Consequently, distinguishing the relative contributions of area expansion and productivity improvement becomes essential for designing appropriate policy interventions aimed at enhancing production efficiency and ensuring long-term sustainability. Previous studies on oilseed crops have largely focused on growth performance, instability analysis, decomposition of production, or forecasting individually. Comparatively fewer investigations have integrated descriptive statistics, trend analysis, instability assessment, decomposition techniques, and ARIMA modelling within a single analytical framework for total oilseed production in India. Moreover, changing climatic conditions, evolving production technologies, and recent policy initiatives necessitate updated empirical evidence to support strategic decision-making. In view of the strategic importance of oilseed crops for ensuring edible oil security and strengthening the agricultural economy of India, the present study undertakes a comprehensive statistical analysis of long-term changes in oilseed area, production, and productivity. The study combines descriptive statistics, growth and instability analysis, Mann–Kendall trend assessment, decomposition analysis, and ARIMA time-series modelling to evaluate historical performance and forecast future production trends. The findings are expected to assist researchers, policymakers, planners, and stakeholders in formulating effective strategies for enhancing oilseed productivity, reducing production instability, and improving the sustainability and competitiveness of the oilseed sector in India.

2. MATERIALS AND METHODS

In the present study for the trend, instability and decomposition analysis, secondary data for the period of 29 years from 1996-97 to 2024-25 were collected from the DACNET (Department of Agriculture Cooperation) and the Directorate of Economics and Statistics (DES), New Delhi, pertaining to four important factors: area, production and productivity of all the oilseeds crop in India i.e., 1996-1997 to 2024-25.

- The selected factors were as:
- X_1 = Crop area ('000ha.)
- X_2 = Crop production ('000 tones)
- X_3 = Crop productivity (kg/ha)

For the ARIMA Forecasting, secondary data for the period of 75 years from 1950-51 to 2024-25 were gathered from the Directorate of Oilseed Research, Hyderabad.

Statistical Methods Employed in Analysis

- **Coefficient of variation** :To examine the variability in the growth of area, production, and productivity, the coefficient of variation was estimated by using the formula

$$CV = (\text{Standard Deviation}/\text{Mean}) * 100$$

- **Instability Index**: The instability index suggested by Cuddy-Della Valle (1978) was used to calculate the variability of the data.

- Instability Index = $CV * \sqrt{(1 - \bar{R}^2)}$, Where $\bar{R}^2$ = Adjusted Coefficient of Multiple Correlation

Categorization of CDVI value was done as suggested by Prabakaran (2020).

0-15 Low, 15-30 Moderate and >30 High

➤ Trend Analysis

The time series data pertaining to total oilseed area, production and productivity in India were analyzed using the Mann-Kendall trend test for assessing the trend present in the data. The Mann- Kendall test and Sen's Slope estimator are commonly used together to detect and quantify trends in time series data.

It tests whether a monotonic (increasing or decreasing) trend exists.

Steps Of Mann- Kendall test

- Let the time series be: $x_1, x_2, x_3, \dots, x_n$
- The Mann-Kendall test statistics is calculated by

For all pairs $j > i$, compute sign $(x_j - x_i)$

Where:

$$\text{Sign}(x_j - x_i) = \begin{cases} +1 & \text{if } x_j - x_i > 0 \\ 0 & \text{if } x_j - x_i = 0 \\ -1 & \text{if } x_j - x_i < 0 \end{cases}$$

Then:

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^n \text{sign}(x_j - x_i)$$

- Compute Variance of S

If no tied values:

$$Var(S) = \frac{n(n-1)(2n+5)}{18}$$

If tied groups exists

$$Var(S) = \frac{n(n-1)(2n+5) - \sum t_p(t_p-1)(2t_p+5)}{18}$$

Where :

- t_p number of tied values in groups p
- Compute Standardized Test Statistic (Z)

$$Z = \begin{cases} \frac{s-1}{\sqrt{Var(s)}} & \text{if } s > 0 \\ 0 & \text{if } s = 0 \\ \frac{s+1}{\sqrt{Var(s)}} & \text{if } s < 0 \end{cases}$$

- Decision Rule

Compare |Z| with critical Z value (e.g., 1.96 at 5% significance).

If |Z| > 1.96 = Significant trend

If Z > 0 = Increasing trend

If Z < 0 = Decreasing trend

Sen's Slope Estimator (Magnitude of Trend): Used to estimate the true slope of the trend. Compute all pairwise slopes

For all pairs $j > i$

$$Q_{ij} = \frac{x_j - x_i}{j - i}$$

Arrange Slopes in Ascending Order

Sort all computed slopes,

Number of slopes: $N = \frac{n(n-1)}{2}$

Calculate Media Slope

If N is odd: $Q_{med} = Q_{\frac{N+1}{2}}$

If N is even: $Q_{med} = \frac{Q_{\frac{N}{2}} + Q_{\frac{N}{2}+1}}{2}$

This median value is Sen's slope

Linear Growth Rate: The Linear growth rate is calculated by the equation: $Y = a + bt$

where, t is the time in years, independent variable,

The linear growth rate is calculated by the formula: Linear growth rate (LGR %) = $b/\bar{y} \times 100$

where $\bar{y}$ is the mean

The significance of linear growth rate (Slope b) is tested by t test using

$$t = \frac{b}{SE(b)}$$

Compound Growth Rate : is calculated by the equation: $Y = a b^t$ or $\log y = \log a + t \log b$

Where, t is the time in years, independent variable

y is the characteristic (area, production or productivity of dependent variable) a and b are parameters The 'a' and 'b' are calculated by applying the method of Least Squares.

The compound growth rate: $CGR (\%) = (b-1) \times 100$.

Once the model is fitted, the significance of growth component is determined by testing the slope coefficient $\log(b)$

Null Hypothesis: H_0 : $\log(b) = 0$ (There is no compound growth/decay; the rate is 0%).

If the p-value < 0.05, reject the null hypothesis and find that the compound growth rate is statistically significant.

Decomposition analysis: To estimate the effect of area, productivity and their interaction on the overall growth performance of production, decomposition analysis as suggested by Agrawal and Singh (2014) was applied. The equation for decomposition is given by

$$P = A_0(Y_n - Y_0) + Y_0(A_n - A_0) + \Delta A \Delta Y$$

$$1 = [(Y_0 \Delta A)/P] + [(A_0 \Delta Y)/P] + [(\Delta A \Delta Y)/P]$$

Where,

P= Change in Production, A_0 = Area in base year, A_n = Area in current year, Y_0 = Productivity in base year, Y_n = Productivity in current year, ΔA = Change in area ($A_n - A_0$), ΔY = Change in productivity ($Y_n - Y_0$).

Statistical best fitted model for Area, Production and Productivity of Oilseed crop. The most popular methodology employed in linear time series analysis is the Box-Jenkins procedure of model building using the ARIMA model. The model is written in the form ARIMA (p. d. q). Where p is the auto regressive process order, d is the data stationary process order, and q is the moving average process order for a time series y, as follows

$$(\beta) (1-\beta) d_{yt} = \theta(\beta) \varepsilon_t$$

Where, $\phi(\beta)$ is the autoregressive parameter, $\theta(\beta)$ is the moving average parameter, d is the degree of differencing parameter, B is the backshift operator and ε_t is the white noise.

Working Principles of ARIMA Model

1. Stationary: ARIMA models require the time series data to be stationary. We will use ADF test(Augmented Dickey-Fuller test) to check whether a time series is stationary or not.

Hypothesis:

The hypothesis of the ADF test are:

Null hypothesis (H_0):The series has a unit root (non- stationary). $\gamma = 0$

If the p- value is less than the chosen significance level (e. g. 5%), the null hypothesis is rejected.

After checking for stationarity we will go for selection of (p,d,q) parameters of the ARIMA model .

2. Identification: Identification of orders p and q involves analyzing the autocorrelation function (ACF) and partial autocorrelation function (PACF) plots of the time series data. ACF helps determine the MA order (q) while PACF aids in order (p) while order number of making a series

3. Parameter

parameters are

ARIMA model is

involves minimizing the error often using methods like maximum likelihood estimation to obtain the most suitable coefficients for the autoregressive and moving average terms.

4. Model selection criteria/Diagnostic Checking:

Different ARIMA (p. d. q) model will be compared using Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). The model having minimum AIC and BIC values will be selected as the best fitted model for forecasting oilseed area, production and productivity.

AIC and BIC is given by the following equation:

$AIC = (-2\log L + 2m)$, Where $m = p + q$ and L is the likelihood function.

$BIC = \log \sigma^2 + (m \log n)/n$

The Ljung –Box test statistic is used to check whether the residuals are white noise or not. The null and alternative hypothesis is

H_0 : The residuals are independently distributed.

H_A : The residuals are not independently distributed; they exhibit serial correlation.

Test statistic $Q = n(n+2) \sum_{k=1}^h (n-k)^{-1} r_k^2$

Where h is the maximum lag, n is the no. of observation, m is the number of parameters in the model. If the data are , the Ljung-Box Q statistics has a chi-square distribution with $(h-m)$ degrees of freedom.

5. Forecasting of the time series and accuracy of the model

After fitting the model it can be used to forecast future values by iterating over time. R software will be use to find the appropriate ARIMA model for forecasting.

MAPE (Mean Absolute Percentage Error) will be used as a measure of accuracy of the models.

$$MAPE = \left(\frac{\sum_{i=1}^n ((y_i - \hat{y}_i) / (y_i))}{n} \right) * 100$$

Table 1.: Descriptive statistics and Mann-Kendall trend analysis test for the time series data of total

3. RESULTS

1. Trend of Area, Production and Productivity of total oilseed in India

The historical data of total oilseed crop in India from 1996-97 to 2024-25 are presented in the fig.1.

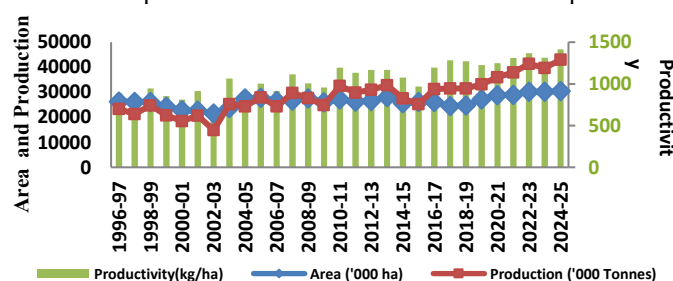


Figure-1 :Trend of total oilseed Area, Production and Productivity in India

It can be seen from the figure 1 that the total area under oilseeds in India has shown a slow but stable increase over the years. It was 26309 thousand hectares in 1996-97 and increased to 30440 th. hectares in 2024-25. The total oilseed production increased from 23328 th. tonnes in 1996-97 to 42989 th. tonnes in 2024-25. There were some ups and downs in between, but the overall trend is positive. Productivity has also improved significantly from 887 kg per hectares in 1996-97 to 1412 kg per hectare in 2024-25. The highest yield was recorded at 1412 kg/ha in the last year. Overall, total oilseed production in India increased due to improved yield, although the area under oilseeds did not increase much. This reflects significant improvement in oilseed production in the country during the study period.

crop in India (1996-97 to 2024-25).			
Parameters	Area ('000 ha)	Production ('000tonnes)	Productivity (kg./ha.)
Mean	26433.61	28701.35	1075.64
Median	26309.00	27977.80	1074.80
Stdev.	2215.60	6836.04	189.46
Kurtosis	0.03	0.21	-0.94
Skewness	-0.19	0.24	-0.07
Mann-Kendall trend	2.83	5.57	5.66
Sen's slope	157.01	706.68	19.88
TAU value	0.37	0.73	0.74

Trend of total oilseed area in India:

- The Mann–Kendall statistic (2.83) is positive, indicating an increasing trend in cultivated area over time.
- The Sen's slope estimate (157.01) shows that the cultivated area increased by approximately 157.01 thousand hectares per year.
- The Kendall's Tau value (0.37) indicates a positive association between area and time, confirming the upward trend.

Trend of total oilseed production in India:

- The Mann–Kendall statistic (5.57) reveals a strong and statistically significant increasing trend in production.
- The Sen's slope value (706.68) indicates that production increased by approximately 706.68 thousand tonnes annually.
- The Tau value (0.73) signifies a strong positive relationship between production and time, confirming a substantial upward trend.

Trend of total oilseed productivity in India:

- The Mann–Kendall statistic (5.66) indicates a strong positive and statistically significant trend in productivity.
- The Sen's slope estimate (19.88) shows that productivity increased by about 19.88 kg/ha per year.
- The Tau value (0.74) demonstrates a strong positive association between productivity and time, confirming a consistent improvement in yield levels.

The results indicate that area, production, and productivity of total oilseed in India exhibited increasing trends during the study period and the magnitude of increase was much stronger for production and productivity than for area, as reflected by their higher Mann–Kendall statistics and Tau values.

This suggests that the growth in production was driven not only by expansion of cultivated area but also by significant improvements in productivity, likely resulting from technological advancements, improved crop management practices, and better input utilization.

2(a). Statistics, variability and growth rate of crop-wise area of oilseed crops in India

The historical crop wise data of oilseed crop in India from 1996-97 to 2024-25 is presented in the figure 2(a).

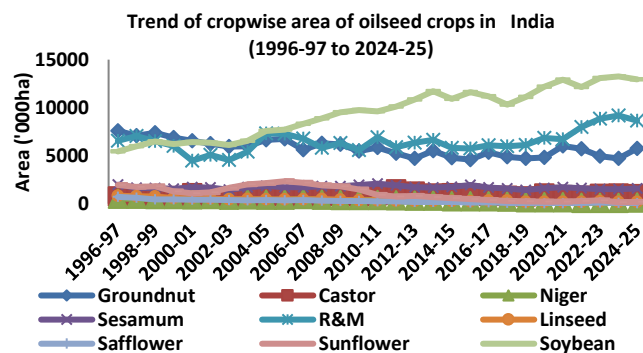


Fig.2(a): Trend of cropwise area of oilseed crops in India (1996-97 to 2024-25)

It can be revealed from the figure 2(a) that the area under oilseed crops in India has shown an overall increasing trend from 1996-97 to 2024-25. Soybean occupies the largest area and increases from 5442 thousand hectares in 1996-97 to around 12952 thousand hectares in 2024-25, showing strong growth overtime.

Rapeseed and mustard also show an increasing trend and reached 8657 thousand hectares in the last year. Groundnut area shows a declining trend in the initial years but showed some fluctuations in recent years. Sesame area remains unstable with ups and downs from 1400 to 2000 thousand hectares with little change. The area under minor oilseeds such as castor, niger, linseed, safflower and sunflower show a decreasing trend over time. Minor crops like safflower and sunflower have very low area and show a declining trend. Overall, the total

oilseed area in India is mainly influenced by soybean and rapeseed & mustard over the period. The statistical analysis of oilseed area is presented in table 2(a).

The growth and instability analysis of oilseed crops in India revealed substantial differences in area expansion and contraction during the study period. The average area under cultivation was highest in soybean (9492.01 th. hectares), followed by rapeseed and mustard (6500.13 th. hectares), and groundnut (5801.20 th. hectares), indicating their dominant contribution in total oilseed. The compound growth analysis showed a significant increase in area under soybean, which recorded the highest positive compound growth rate of 3.28 per cent per annum ($p < 0.01$). This indicates rapid expansion of soybean cultivation during the study period. Castor and rapeseed & mustard also registered significant positive growth rates of 1.29 and 1.06 per cent per annum, respectively, suggesting gradual expansion in their cultivated area. Consequently, total oilseed area in India exhibited a significant positive growth rate of 0.61 per cent per annum, indicating an overall increase in area under oilseed cultivation. In contrast, several traditional oilseed crops experienced a decline in cultivated area. Safflower recorded the highest negative compound growth rate (-8.54% per annum), followed by sunflower (-8.84%), niger (-6.23%), and linseed (-5.18%), all of which were statistically significant at the one per cent level. These results indicate a persistent reduction in area under these crops. Groundnut also showed a significant decline of 1.33 per cent per annum, suggesting a gradual shift away from its cultivation over time. Sesame exhibited a marginal negative compound growth rate (-0.28% per annum), but the growth coefficient was statistically non-significant ($p > 0.05$), indicating that the area under sesame remained relatively stagnant during the study period without any definite increasing or decreasing trend.

Table 2(a). Statistics, variability and growth rates in area of total oilseed crop in India

Crop	Average Area ('000 ha)	CV%	Instability Index (%)	Coefficient of LG equation	Linear Growth Rate	Compound Growth Rate (CGR)
Groundnut	5801.20	14.80	9.26(low)	-79.54**	-1.37	-1.33**
Castorseed	880.60	22.61	20.71(moderate)	10.63*	1.21	1.28**
Nigerseed	323.17	44.99	11.00(low)	-16.59**	-5.13	-6.23**
Sesamum	1707.33	9.36	9.41(low)	-4.73	-0.28	-0.27
Rapeseed & Mustard	6500.13	17.52	10.14(low)	71.76**	1.10	1.06**
Linseed	390.48	47.46	17.19(moderate)	-20.32**	-5.20	-5.18**
Safflower	263.52	66.37	18.03(moderate)	-19.54**	-7.42	-8.54**
Sunflower	1074.16	68.78	39.81(high)	-72.17**	-6.72	-8.84**
Soybean	9492.01	26.82	6.51(low)	291.26**	3.07	3.28**
Total Oilseed	26432.61	8.38	6.71(low)	160.75**	0.61	0.68**

Table 2(b). Statistics, variability and growth rates in production of total oilseed crop in India

Crop	Average Production ('000 t)	CV%	Instability Index (%)	Coefficient of LG equation	Linear Growth Rate	Compound Growth Rate (CGR) (%)
Groundnut	7802.69	24.93	20.34(moderate)	131.31**	1.68	1.64**
Castor seed	1304.69	38.80	23.57(moderate)	47.60**	3.65	4.06**
Niger seed	91.38	40.85	15.99(moderate)	-4.08**	-4.46	-5.26**
Sesamum	702.00	17.46	12.38(low)	10.20**	1.45	1.54**
Rapeseed & Mustard	7734.27	32.11	16.39(moderate)	246.33**	3.18	3.16**
Linseed	169.48	28.84	16.38(moderate)	-4.77**	-2.82	-2.69**
Safflower	144.75	64.33	37.93(high)	-8.92**	-6.16	-6.85**
Sunflower	666.67	60.76	39.83(high)	-35.93**	-5.39	-6.48**
Soybean	10087.34	31.23	16.29(moderate)	322.39**	3.20	3.53**
Total Oilseed	28701.35	23.82	11.33(low)	704.15**	2.45	2.50*

Table 2(c). Statistics, variability and growth rates in productivity of total oilseed crop in India.

Crop	Productivity (kg/ha)	CV%	Instability Index (%)	Coefficient of LG equation	Linear Growth Rate	Compound Growth Rate (CGR) (%)
Groundnut	1377.10	30.40	16.88	41.21**	2.99	3.02**
Castorseed	1444.95	24.67	10.50	37.45**	2.59	2.74**
Nigerseed	293.72	12.42	8.62	3.02**	1.03	1.027**
Sesamum	413.11	18.32	10.41	7.46**	1.81	1.824**
Rapeseed& Mustard	1171.54	18.71	7.49	23.35**	1.99	2.07**
Linseed	478.23	24.20	8.54	12.66**	2.65	2.64**
Safflower	595.76	22.82	17.61	9.63**	1.62	1.85**
Sunflower	715.36	27.16	13.37	19.40**	2.71	2.59**
Soybean	1057.26	14.14	14.28	2.32	0.22	0.23**

The instability analysis revealed considerable variability among crops. Crops with lower instability indices may be considered relatively stable in terms of area allocation, whereas crops with higher instability indices experienced greater fluctuations over time. The coexistence of significant positive growth in soybean, castor, and rapeseed & mustard alongside the decline of traditional oilseeds such as safflower, linseed, niger, and sunflower indicates a structural shift in the cropping pattern of Indian oilseeds. Farmers appear to have increasingly allocated land toward crops offering better productivity, profitability, and market opportunities, particularly soybean and rapeseed & mustard.

2(b). Statistics, variability and growth rate of cropwise production of oilseed crops in India

The historical data of oilseed crop production in India from 1996-97 to 2024-25 are presented in the figure 2(b).

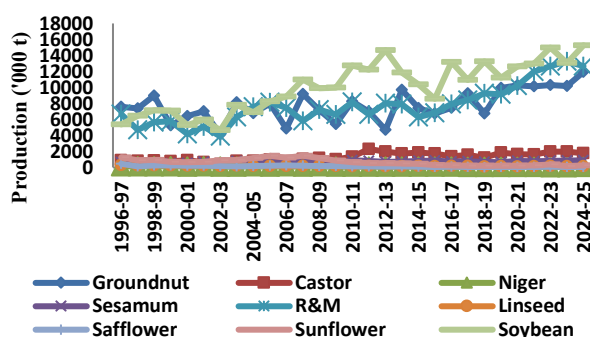


Fig.2(b): Trend of cropwise production of oilseed crops in India (1996-97 to 2024-25)

It can be seen from the fig. 2(b) that the production of oilseed crops in India shows an overall increasing trend with fluctuations during the study period. Soybean is the major crop and its production increases from 5380 thousand tonnes in 1996-97 to about 15268 thousand tonnes in 2024-25. Groundnut production also increased overall and reached 11942 thousand tonnes in the year 2024-25. Rapeseed & Mustard showed significant growth and reached 12667 thousand tonnes in 2024-25. Sesame and castor production exhibited slight growth with minor fluctuations over the period. The production of minor oilseeds like niger, linseed, safflower and sunflower was showed a low and declining trend in recent years.

The analysis of oilseed production in table 2(b) revealed considerable differences in growth performance, variability, and instability among the major oilseed crops. The mean production was highest for soybean (10087.34 th. tonnes), followed by groundnut (7802.69 th. tonnes) and rapeseed & mustard (7734.27 th. tonnes), indicating their dominant contribution to total oilseed production. Niger, linseed, and safflower recorded relatively low average production levels. The coefficient of variation (CV) indicated substantial variation in production among crops. Safflower exhibited the highest variability (64.33%), followed by sunflower (60.76%), suggesting large fluctuations in production over time. Conversely, sesame recorded the lowest variability (17.46%), indicating comparatively stable production levels.

The Cuddy–Della Valle instability index, which accounts for trend effects, showed that sunflower (39.83%) and safflower (37.25%) experienced the highest instability, reflecting greater uncertainty and fluctuations in production. On the other hand, total oilseeds (11.44%) and sesame (12.31%) showed relatively lower instability, indicating more stable production performance during the study period.

The linear growth rate (LGR) analysis revealed significant positive growth in groundnut, castor, sesamum, rapeseed & mustard, soybean, and also for total oilseeds production. Soybean registered the highest annual increase (322.39 th. tonnes per year), followed by rapeseed & mustard (246.33 th. tonnes per year) and groundnut (131.31 th. tonnes per year). When expressed as a percentage of mean production, soybean (3.20%) and rapeseed & mustard (3.18%) exhibited the highest growth rates, indicating rapid expansion in production. Niger, linseed, safflower, and sunflower recorded significant negative linear growth rates, indicating a persistent decline in production over the study period. Safflower showed the sharpest decline (-6.16% of mean production per year), followed by sunflower (-5.39%) and niger (-4.46%). These declining trends may be attributed to reduced area under cultivation, shifting farmer preferences toward more profitable crops, and technological constraints.

The compound growth rate (CGR) analysis further confirmed the linear growth findings. Castor recorded the highest positive compound growth rate (4.06% per annum), followed by soybean (3.53%), rapeseed & mustard (3.16%), groundnut (1.64%), and sesamum (1.54%). All these growth rates were statistically significant at the 1 percent level, indicating sustained long-term growth. Niger (-5.26%), safflower (-6.85%), sunflower (-6.48%), and linseed (-2.69%) showed significant negative compound growth rates, reflecting a continuous decline in production throughout the study period.

The overall oilseed sector demonstrated a positive and significant growth trend, with total oilseed production increasing at a compound growth rate of 2.50 percent per annum and a linear growth rate equivalent to 2.45 percent of mean production. The relatively low instability index for total oilseeds suggests that aggregate production growth was achieved with moderate stability despite fluctuations in individual crops.

Overall, the results indicate that soybean, rapeseed & mustard, castor, and groundnut were the major drivers of growth in the oilseed sector, while safflower, sunflower, niger, and linseed experienced significant production declines. These findings highlight the need for crop-specific strategies aimed at improving productivity, reducing instability, and revitalizing declining oilseed crops to ensure balanced and sustainable growth in the oilseed sector.

2(c). Statistics, variability and growth rate of cropwise productivity of oilseed crops in India

The historical data of productivity of oilseed crop in India from 1996-97 to 2024-25 are presented in the fig. 2(c).

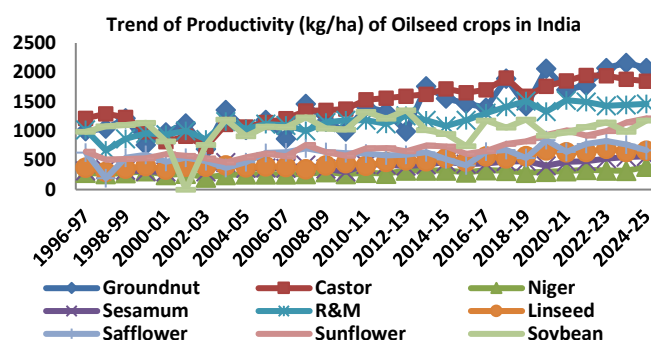


Fig. 2(c): Trend of cropwise productivity of oilseed crops in India (1996-97 to 2024-25)

It can be seen from the fig.2(c) that the productivity of oilseed crops in India show a increasing trend with fluctuations from 1996-97 to 2024-25. Groundnut yield increased from 999 kg/ha in 1996-97 to 2073 kg/ha in 2024-25. Castor also showed significant improvement in productivity, increasing from 1216 kg/ha to 1852 kg/ha over the period. Rapeseed and mustard productivity also show a increasing trend, from 1017 kg/ha to 1463 kg/ha. Soybean yield fluctuated between 738 and 1353 kg/ha and does not show a increasing trend in recent years. Sesamum productivity improves slowly from 321 kg/ha to 567 kg/ha.

The yield of minor crops like niger, linseed, safflower and sunflower show moderate improvement in productivity over the time. Overall, the yield of major oilseed crops like groundnut, castor and rapeseed & mustard have shown better improvement in yield.

The results of statistical analysis in table 2(c) indicate considerable variation in productivity levels among different oilseed crops. Castorseed recorded the highest average productivity (1444.95 kg/ha), followed by groundnut (1377.10 kg/ha) and rapeseed & mustard (1171.54 kg/ha). Soybean also exhibited relatively high productivity (1057.26 kg/ha), whereas nigerseed recorded the lowest productivity (293.72 kg/ha), indicating substantial differences in yield potential among crops. The coefficient of variation (CV) shows that the groundnut has the highest variability in productivity (30.40%), followed by sunflower (27.16%), castorseed (24.67%), and linseed (24.20%). Nigerseed recorded the lowest CV (12.42%), suggesting relatively stable productivity over the study period.

The instability index further highlights fluctuations in productivity. Safflower showed the highest instability (17.61%), followed by groundnut (16.88%), soybean (14.28%), and sunflower (13.37%). Rapeseed & mustard recorded the lowest instability index (7.49%), indicating comparatively stable productivity. The total oilseed group also exhibited low instability (8.15%), reflecting overall stability in productivity across the oilseed sector. The coefficients of the linear growth (LG) equation were positive for all crops. The coefficients were statistically significant at the 1 per cent level for groundnut (41.21), castorseed (37.45), nigerseed (3.02), sesamum (7.46),

rapeseed & mustard (23.35), linseed (12.66), safflower (9.63), and sunflower (19.40), indicating a significant upward trend in productivity over time. However, soybean (2.32) and total oilseeds (19.83) did not exhibit statistically significant growth.

The linear growth rate (LGR) and compound growth rate (CGR) showed positive trends for all crops, showing improvement in productivity throughout the study period. Groundnut recorded the highest LGR (2.99% of the mean) and CGR (3.02%), followed by castorseed (2.59% and 2.74%), sunflower (2.71% and 2.59%), and linseed (2.65% and 2.64%). Rapeseed & mustard also showed a healthy growth rate with an LGR of 1.99% and a CGR of 2.07%. Sesamum, safflower, and nigerseed exhibited moderate annual productivity growth ranging from about 1.0 to 1.9 per cent. Soybean registered the lowest growth, with an LGR of only 0.22% and a CGR of 0.23%, indicating nearly stagnant productivity. Overall, total oilseed productivity increased at an annual compound rate of 1.88%, reflecting moderate but positive growth during the study period.

Overall, the analysis suggests that while most oilseed crops experienced significant improvements in productivity over time, the magnitude of growth differed considerably across crops. Groundnut and castorseed demonstrated the highest productivity growth despite relatively high variability, whereas rapeseed & mustard combined moderate growth with low instability, indicating a more consistent performance. Soybean exhibited comparatively stagnant productivity growth, highlighting the need for technological interventions and improved production practices to enhance its productivity.

3. Decomposition analysis of Area, Production and Productivity of total oilseed production India

The decomposition analysis was performed to determine the effect of area, productivity, and their interaction effect on the production for all the crops during the study period (1996-97 to 2024-25) in India. The result of the analysis was presented in table 3.

Table 3: Effect of area and productivity and their interaction on production in India

Production	Area Effect (%)	Productivity Effect (%)	Interaction Effect (%)
Groundnut	-42.1	187.3	-45.2
Castorseed	30.8	53.1	16.1
Nigerseed	109.4	-48.9	39.4
Sesamum	-52.7	192.9	-40.3
Rapeseed & Mustard	35.8	48.6	15.7
Linseed	124.9	-122.1	97.1
Safflower	100.6	-7.1	6.4
Sunflower	103.1	-93.6	90.5
Soybean	75.1	10.5	14.5
Total Oilseed	18.6	70.3	11.0

The table 3 shows that the productivity effect had a significant effect on the growth of oilseed production in India. Productivity effect was contributed the largest portion (70.3%) of the increase in production followed by area effect (18.6%) and the interaction effect was only 11.0%. From the cropwise decomposition analysis we found that the productivity was the primary responsible factor in case of total oilseed production of groundnut, castor seed, sesame, rapeseed and mustard, while area was primary responsible factor in case of nigerseed, linseed, safflower, sunflower and soybean in India.

Overall, the findings indicate that productivity enhancement (70.3%) was the key driver of total oilseed production growth, highlighting the importance of technological progress alongside efficient land use for sustained growth in the oilseed production.

4. Forecasting and validation of the total oilseed area, production and productivity using ARIMA models for India

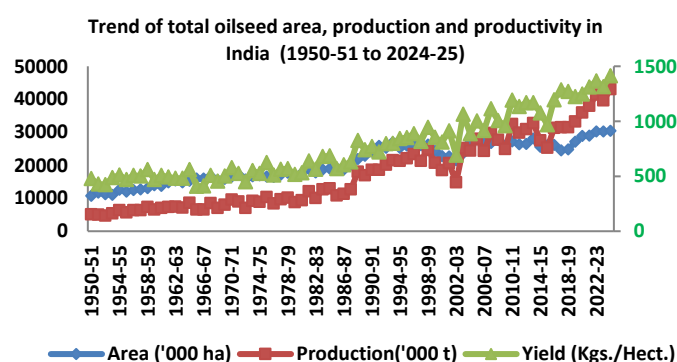


Fig. 4: Trend of total oilseed area, production and productivity in India (1950-51 to 2024-25)

From the fig. 4, we can see that from 1950-51 (10727 th. ha.) to 2024-25 (30440 th. ha.) there is a linear increase in the area of oilseed crops in India. The data on total oilseeds production and productivity in India from 1950–

51 to 2024–25 shows considerable fluctuations with an overall increasing trend. Fig. 4 indicate a steady upward trend from 1950-51 (478 kg/ha.) to 2024-25 (1412 kg/ha) in the productivity of oilseed crops in India along with considerable year-to-year fluctuations. This represents nearly a threefold increase in productivity of total oilseed in India. To fit the ARIMA model first we check the stationarity of the collected data by ADF test.

Table 4(a) ADF test Statistic for oilseed area, production and productivity in India

All India oilseed area (in '000 ha)	Original series	First difference series
ADF Statistic	-2.8705	-4.4155
P value	0.2204	0.01
Stationary or Non-stationary	Non-stationary	Stationary
All India Oilseed Production (in '000 t)	Original series	First difference series
ADF Statistic	-1.5767	-4.7623
P value	0.7481	0.01
Stationary or Non-stationary	Non-stationary	Stationary
All India oilseed Productivity (in kg/ha)	Original series	First difference series
ADF Statistic	-1.3942	-6.7269
P value	0.8226	0.01
Stationary or Non-stationary	Non-stationary	Stationary

After applying the ADF test on actual data of Area, Production and Productivity (table 4(a)) the p value is greater than .05, hence we fail to reject the null hypothesis and found that the series is non stationary. To make the series stationary we apply differencing. After applying the differencing, we can see in the table 4(a) that the p value is less than .05, hence the series is stationary.

Identification of the model: Once the time series become stationary the candidate ARIMA models are identified. After obtaining the autocorrelation function (ACF) and the partial autocorrelation function (PACF), multiple ARIMA models that closely fits the data can be identified from fig. 4(a), 4(b) and 4(c).

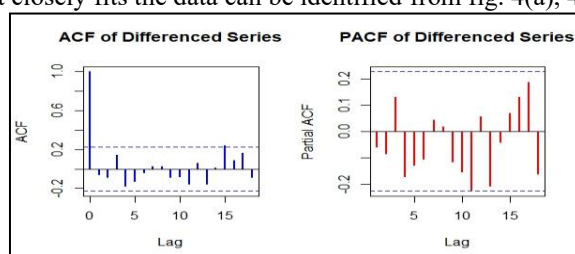


Fig. 4(a): ACF and PACF plot of Differenced series of oilseed area in India

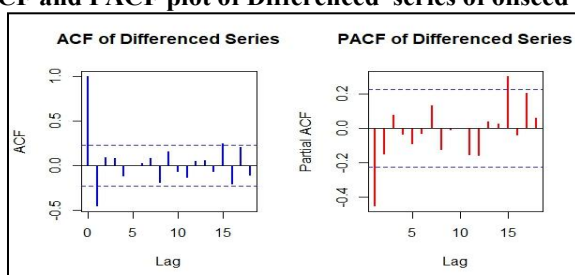


Fig. 4 (b): ACF and PACF plot of differenced series of oilseed production in India

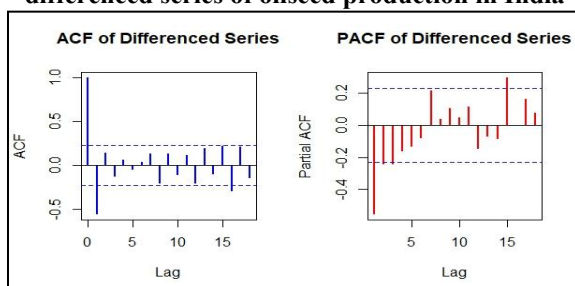


Fig. 4(c): ACF and PACF plot of differenced series of oilseed productivity in India

Using data from 1950-51 to 2009-10 for estimation and 2010-11 to 2024-25 for validation, we select best model on the basis of lower AIC and BIC value.

Selection of the model

From the ACF and PACF plot given above the selected models and their comparison based on AIC and BIC values are given below in table 4(b), 4(c) and 4(d).

Model (p,d,q), All India Area		AIC	BIC	
ARIMA(2,1,2) with drift		Inf	-	
ARIMA(0,1,0) with drift		992.32	996.48	
ARIMA(1,1,0) with drift		994.31	1000.54	
ARIMA(0,1,1) with drift		994.31	1000.55	
ARIMA(0,1,0)		993.78	995.86	
ARIMA(1,1,1) with drift		996.05	1004.36	
Best model: ARIMA(0,1,0) with drift				
MAPE with train data: 4.05%				
Model Parameter	Estimate	Standard Error	Z value	P -value
drift	258.17	136.72	1.89	0.0589

Table 4(b) Tested ARIMA models for oilseed area in India

Table 4(c) Tested ARIMA models for oilseed production in India

Model (p,d,q), All India Production		AIC	BIC	
ARIMA(2,1,2) with drift		Inf	-	
ARIMA(0,1,0) with drift		1091.453	1081.92	
ARIMA(1,1,0) with drift		1075.691	1081.92	
ARIMA(0,1,1) with drift		1077.246	1083.47	
ARIMA(0,1,0)		1090.559	1092.63	
ARIMA(1,1,1) with drift		1077.455	1085.76	
ARIMA(2,1,0) with drift		1077.471	1085.78	
ARIMA(2,1,1) with drift		Inf		
ARIMA(1,1,0)		1077.35	1081.50	
Best model: ARIMA(1,1,0) with drift				
MAPE with train data: 11.02%				
Model Parameter	Estimate	Standard Error	Z value	P -value
ar1	-0.5125	0.1118	-4.58	4.570930e-06
drift	355.73	180.72	1.968	4.902774e-02

Table 4(d) Tested ARIMA models for oilseed productivity in India

Model (p,d,q), All India Productivity	AIC	BIC
ARIMA(2,1,2) with drift	679.21	691.68
ARIMA(0,1,0) with drift	711.68	715.84
ARIMA(1,1,0) with drift	681.70	687.93
ARIMA(0,1,1) with drift	677.83	684.07
ARIMA(0,1,0)	710.09	712.17
ARIMA(1,1,1) with drift	675.53	683.85
ARIMA(2,1,1) with drift	677.39	687.78
ARIMA(1,1,2) with drift	677.24	687.63
ARIMA(0,1,2) with drift	676.12	684.43
ARIMA(2,1,0) with drift	679.70	688.01
ARIMA(1,1,1)	680.72	686.96
Best model: ARIMA(1,1,1) with drift		

MAPE with train data: 8.29%				
Model Parameter	Estimate	Standard Error	Z value	P-value
ar1	-0.3399	0.1551	-2.19	2.838086e-02
ma1	-0.5984	0.1301	-4.59	4.229682e-06
drift	9.5691	2.7656	3.46	5.399494e-04

Diagnostic Checking: From the table given above we can see that the ARIMA(0,1,0) with drift was found the most suitable model for oilseed area, ARIMA(1,1,0) with drift was found the most suitable model for oilseed production and ARIMA(1,1,1) with drift was found the most suitable model for oilseed productivity on the basis of lower AIC and BIC value. The coefficients of parameters were estimated and also check for the significance level at 5 %. Once the model was selected, next step is to check whether the assumptions about the errors or residuals are satisfied or not. The result of Ljung-Box test statistics for residual test is given below in table 4(h).

Table 4(h):Ljung-Box test statistics (best_model)				
Best Model	Q*	df	p-value	
Area ARIMA(0,1,0) with drift	8.9802	10	0.534	
Production ARIMA(1,1,0) with drift	4.2166	10	0.896	
Productivity ARIMA(1,1,1) with drift	2.0544	10	0.995	

As the p-value of the test statistics be greater than 0.05, this means the residuals for our time series model are independent or residuals are white noise. The graphical representations of the residuals are given below in figure 4(d), 4(e) and 4(f).

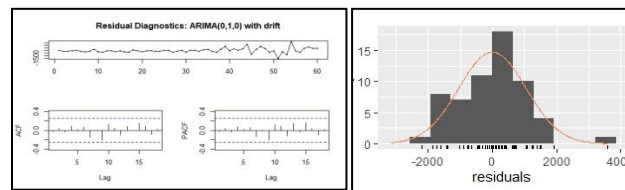


Figure 4(d): ACF and PACF plot of residuals for the best fitted models for oilseed area in India

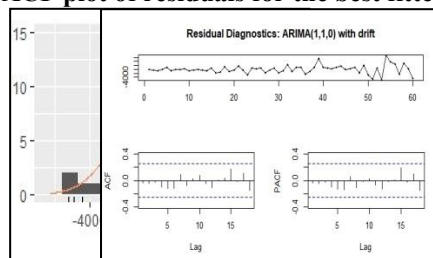


Figure 4(e):ACF and PACF plot of residuals for the best fitted models for oilseed production in India

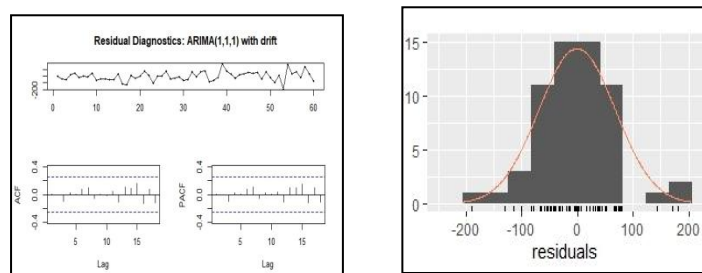


Figure 4(f): ACF and PACF plot of residuals for the best fitted models for oilseed productivity in India

Validation and accuracy check of the selected model

After selection of the best model on the basis of 60 years (1950-51 to 2009-10) data, next 15 years (2010-11 to 2024-25) data were used for the validation of the model. The result of the validation of the model is presented in the table 4(e),4(f) and 4(g) below along with mean absolute percentage error of the model.

Table 4(e). Model validation of oilseed area in India

Year of prediction	Actual value	Forecasted value	% error prediction
2010-11	27224	26217	3.70
2011-12	26308	26475	0.64
2012-13	26484	26734	0.94
2013-14	28050	26992	3.77
2014-15	25596	27250	6.46
2015-16	26087	27508	5.45
2016-17	26177	27766	6.07
2017-18	24508	28024	14.35
2018-19	24794	28283	14.07
2019-20	27139	28541	5.16
2020-21	28834	28799	0.12
2021-22	28945	29057	0.39
2022-23	30239	29315	3.06
2023-24	30192	29573	2.05
2024-25	30440	29832	2.00
MAPE in Prediction (%)			4.54 %

Table 4(f).Model Validation of oilseed production in India

Year of prediction	Actual value	Forecasted value	% error prediction
2010-11	32479	26874	17.26
2011-12	29799	26391	11.44
2012-13	30941	27177	12.17
2013-14	32749	27312	16.60
2014-15	27511	27781	0.98
2015-16	25251	28079	11.20
2016-17	31276	28464	8.99
2017-18	31459	28805	8.44
2018-19	31522	29168	7.47
2019-20	33219	29520	11.14
2020-21	35946	29878	16.88
2021-22	37963	30232	20.36
2022-23	41355	30589	26.03
2023-24	39669	30944	22.00
2024-25	42989	31300	27.19
MAPE in Prediction (%)			14.54 %

Table4(g). Model Validation of oilseed productivity in India

Year of prediction	Actual value	Forecasted value	% error prediction
2010-11	1193	1034	13.31
2011-12	1133	1021	9.85
2012-13	1168	1038	11.12
2013-14	1168	1045	10.47
2014-15	1075	1056	1.77
2015-16	968	1065	10.03
2016-17	1195	1075	10.05
2017-18	1284	1084	15.53
2018-19	1271	1094	13.96
2019-20	1224	1103	9.85
2020-21	1247	1113	10.72
2021-22	1312	1123	14.41
2022-23	1368	1132	17.22
2023-24	1314	1142	13.11
2024-25	1412	1151	18.47
MAPE in Prediction (%)			11.99 %

As the mean absolute percentage error was 4.54 %, 14.54% and 11.99% only. Hence these models may be used for future forecasting of total oilseed in India.

Forecasting of the total oilseed area, production and productivity in India and accuracy check of the model

After the selection of the best model, the selected model were refitted on the whole dataset (1950-51 to 2024-25) and used to generate forecast upto next five years (2029-30). After refitting the model parameters and MAPE are

Table 4(i). Model parameters and MAPE of fitted model on oilseed area in India

Model Parameter	Estimate	Standard Error	Z value	P - value
drift	266.39	126.71	2.10	0.0355
MAPE	3.91			

Table 4(j). Model parameters and MAPE of fitted model on oilseed production in India

Model Parameter	Estimate	Standard Error	Z value	P - value
drift	502.1976	187.8025	2.6741	0.0000
Ar1	-0.4564	0.1031	-4.426	0.0075
MAPE	10.84299			

Table 4(k). Model parameters and MAPE of fitted model on oilseed productivity in India

Model Parameter	Estimate	Standard Error	Z value	P-value
drift	12.4639	2.8271	4.4088	0.000
Ar1	-0.1780	0.1461	-1.218	0.223
Ma1	-0.6315	0.1068	-5.912	0.000
MAPE	8.19			

The forecasted value of the oilseed **area, production and productivity** calculated on basis of selected model from 2025-26 to 2029-30 are presented below in the table 4(l), 4(m) and 4(n).

Table 4(i). Future forecasting of total oilseed area in India using selected ARIMA model

Year of prediction	Forecast value	Lower Confidence limit (95%)	Higher Confidence limit (95%)
2025-26	30706.39	28555.33	32857.45
2026-27	30972.78	27930.73	34014.84
2027-28	31239.18	27513.43	34964.92
2028-29	31505.57	27203.45	35807.68
2029-30	31771.96	26962.05	36581.87

The ARIMA (0,1,0) with Drift model forecasts that the area under oilseed cultivation is expected to show a gradual and consistent increase over the five-year forecast period from 2025-26 to 2029-30.

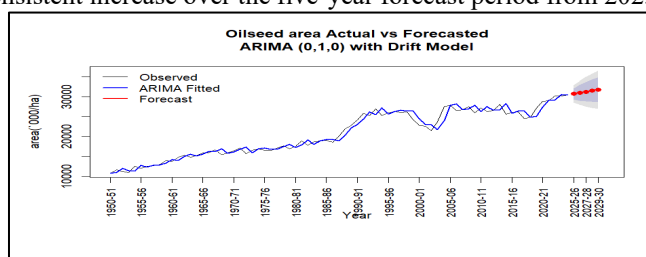


Fig. 4(g): Actual, predicted and forecasted value of oilseed area in India

The forecast values continue the long-term upward trend observed in recent years, reflecting the positive drift component incorporated in the model. The 95% confidence intervals widen progressively with the forecast horizon, indicating that uncertainty increases as predictions extend further into the future. The lower and upper confidence limits suggest that the cultivated area is likely to remain within a plausible range, even under varying future conditions.

Table 4(m). Future forecasting of total oilseed production in India using selected ARIMA model

Year of prediction	Forecast value	Lower Confidence limit (95%)	Higher Confidence limit (95%)
2025-26	42205.10	37549.88	46860.32
2026-27	43294.30	37995.76	48592.83

2027-28	43528.58	37178.29	49878.87
2028-29	44153.06	37104.98	51201.13
2029-30	44599.44	36834.09	52364.80

From the forecasted value in table 4(m) we found an increasing trend in oilseed production in India in upcoming years from 42205 th. tonnes to 44599 th. tonnes .

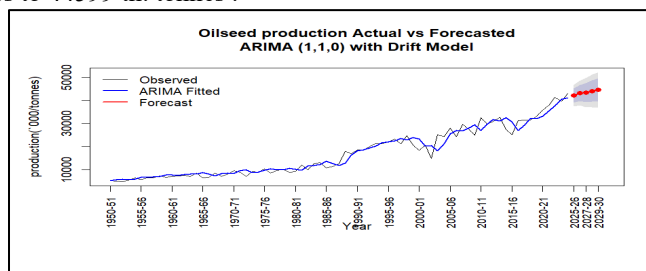


Fig.4(h) :Actual, predicted and forecasted value of oilseed production in India

Table 4(n): Future forecasting of total oilseed productivity in India using selected ARIMA model

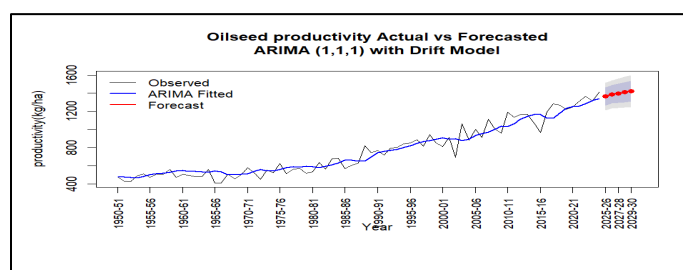


Fig. 4(i): Actual, predicted and forecasted value of oilseed productivity in India

Year of prediction	Forecast value	Lower Confidence limit (95%)	Higher Confidence limit (95%)
2025-26	1364.66	1213.13	1516.19
2026-27	1387.77	1233.52	1542.03
2027-28	1398.34	1235.97	1560.72
2028-29	1411.14	1242.15	1580.13
2029-30	1423.55	1248.01	1599.09

In table 4(n), the ARIMA (1,1,1) with Drift model forecasts that oilseed productivity will continue to exhibit an upward trend during the five-year forecast period from 2025-26 to 2029-30 with an average annual increase of approximately 15 kg/ha over the forecast period. The forecasted productivity is expected to increase from 1364.66 kg/ha in 2025-26 to 1423.55 kg/ha in 2029-30, indicating sustained improvements in oilseed yield over time.

5. DISCUSSION:

The statistical analysis of area of total oilseed shows that at all India level, oilseed area increased only marginally, whereas production and productivity showed substantial improvement. The Mann–Kendall analysis indicated significant increasing trends for Area ($Z = 2.83$), Production ($Z = 5.57$) and Productivity ($Z = 5.66$). The higher trend values for productivity compared with area indicate that production growth in India has mainly been driven by yield improvement. These findings are consistent with Reddy (2017), Gandhimathy (2022) and Vinod Kumar et al. (2025), who reported that technological advancement has played an increasingly important role in improving oilseed production in India.

The crop wise analysis of total oilseed area in India shows that soybean has the highest positive compound growth rate (3.28%), followed by castor and rapeseed & mustard. Groundnut, linseed, safflower, sunflower and niger showed decline in area. These findings indicate a structural shift in India's oilseed economy from traditional oilseed crops toward soybean and rapeseed & mustard. Similar observations were reported by Bharti et al. (2012), Goyal et al. (2022) and Gandhimathy (2022).

Statistical analysis of total oilseed production of India shows that, soybean, rapeseed & mustard and groundnut are the major contributor in total oilseed production. The positive compound growth was recorded for Castor (4.06%), Soybean (3.53%), Rapeseed& mustard (3.16%) and Groundnut (1.64%) whereas negative growth was found for Niger, Linseed, Sunflower and Safflower. The decline in these crops is mainly associated with

reduction in cultivated area, poor profitability and competition from soybean. These findings support the observations of Singh and Bansal (2020) and Vinod Kumar *et al.* (2025).

At all India oilseed data, groundnut shows the highest productivity growth followed by castor, sunflower and linseed. Soybean productivity remained almost stagnant despite occupying the largest cultivated area. This finding agrees with Patidar (2021) and Kumar *et al.* (2023), who emphasized that soybean productivity has reached a plateau in many regions of Madhya Pradesh and India.

In India, production growth was influenced more by productivity enhancement than by expansion of cultivated area, reflecting wider adoption of improved technologies, better crop management and policy interventions. Purbia (2002), Kumar and Gupta (2004), Swain (2007), Bharti *et al.* (2012), Reddy (2017), Kolar *et al.* (2020), Baghel *et al.* (2023) and Kumar *et al.* (2023) similarly concluded that growth in oilseed production has resulted from a combination of area expansion and productivity improvement, although the relative contribution of these factors varies across crops and regions. Overall, the results suggest that future policy should focus on improving productivity of stagnating crops, reducing production instability through climate-resilient technologies, and revitalizing declining traditional oilseed crops to achieve sustainable growth and reduce dependence on edible oil imports.

The analysis of all-India area, production and productivity of total oilseed shows the long-term increasing trends with periodic fluctuations during 1950-51 to 2024-25. The ADF test showed non-stationarity in area, production and productivity, then first-order differencing was done to make series stationary suitable for ARIMA modelling. The best forecasting model for total oilseed area in India was ARIMA (0,1,0) with drift. The validation MAPE of only 4.54 per cent indicates excellent predictive performance. Forecasts indicated that the oilseed area would increase steadily from 30.71 million hectares in 2025-26 to 31.77 million hectares by 2029-30. These results support the projections reported by Smitha and Sumathy (2024), Chandra *et al.* (2024) and Sharma and Singh (2024), who also reported continued expansion of oilseed area in India.

For total oilseed production in India, ARIMA (1,1,0) with drift provided the best fit. The autoregressive parameter and drift component were statistically significant. The model produced a validation MAPE of 14.54 per cent and projected production to increase from 42.21 million tonnes in 2025-26 to 44.60 million tonnes by 2029-30. These projections are consistent with the studies of Ravichandran *et al.* (2018), Smitha and Sumathy (2024), Saidulu and Sharma (2025), and Sharma (2025), they also forecast continue increase in India's oilseed production. However, the widening confidence intervals indicate increasing uncertainty over longer forecast horizons, largely because agricultural production remains strongly influenced by monsoon variability, climate change and market fluctuations.

The ARIMA (1,1,1) with drift model was selected for forecasting total oilseed productivity in India. The model produced a validation MAPE of 11.99 per cent and projected productivity to increase from 1364.66 kg/ha in 2025-26 to 1423.55 kg/ha by 2029-30. The forecasts showed a continued increase in productivity during the forecast period, indicating that technological improvements and enhanced crop management practices are likely to sustain future productivity gains. Similar results have been reported by Kumar *et al.* (2017), Revathi *et al.* (2023), Smitha and Sumathy (2024), and Chandra *et al.* (2024), also find that ARIMA models effectively capture long-term productivity trends in Indian agriculture.

The forecasting indicates a positive trend for India's oilseed production. The projected increase in area, production and productivity reflects the combined effects of technological enhancement, new varieties and government support programmes. The comparatively low MAPE values for area and moderate values for production and productivity demonstrate that the selected ARIMA models provide reliable tools for short-term agricultural forecasting and can support policy formulation, production planning and resource allocation.

6. CONCLUSION

The trend analysis of total oilseed crops indicated an overall increasing trend in area, production and productivity India during the study period. Soybean remained the dominant oilseed crop, while rapeseed & mustard and groundnut also contributed significantly to total oilseed production. The results further indicated that production growth in India was influenced more by productivity improvement. The Cuddy–Della Valle instability index, which accounts for trend effects, showed that sunflower and safflower shows the highest instability, reflecting greater uncertainty and fluctuations in production.

The decomposition analysis showed that productivity effect was the major contributor to the growth of total oilseed production in India. In India productivity effect accounted for 70.3 per cent of the increase in total oilseed production, followed by area effect (18.6%) and interaction effect (11.0%). These results indicate that improving crop productivity along with maintaining the existing cultivated area is important for sustaining oilseed production.

The forecasting analysis showed that ARIMA (0,1,0) with drift was the most suitable model for forecasting total oilseed area ARIMA (1,1,0) with drift and ARIMA (1,1,1) with drift were found to be the best models for forecasting production and productivity, respectively, in India. The forecast results indicated that total oilseed area, production and productivity are expected to increase gradually during the period 2025-26 to 2029-30 in India.

Overall, the findings of the study indicate that improvement in productivity, adoption of improved technologies and better crop management practices, along with maintaining the existing area under oilseed cultivation, will be important for increasing oilseed production in India.

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REFERENCES:

1. Agrawal P K and Singh O P (2014). Growth and Instability of soybean production in Madhya Pradesh, India: A decomposition Approach, *Annals of Agri Bio Research*, **19**(3), 554-560.
2. Baghel, B., Balai, H. K., & Malviya, P. K. (2023). Kharif oilseed crops cultivation in Madhya Pradesh (India): Growth and decomposition analysis. *Economic Affairs*, **68**(01), 423-428.
3. Bharti, A. K., Sharma, M. K., Sharma, H. L., Sisodia, B. V. S., & Dube, L. K. (2012). Pattern of growth and technological impact on oilseeds production in Uttar Pradesh.1-5
4. Chandra, R. P., Krishnan, P., & Brahme, R. (2024). Forecasting and simulation of rapeseed and mustard (RM) oilseed production and productivity in India. *The Indian Economic Journal*.187-207.
5. Cuddy, J.D.A. and Valle, P.A.D. (1978), Measuring the instability of time series data. *Oxford Bulletin of Economics and Statistics*, **40**: 79-85.
6. Gandhimathy, B. (2022). Growth and instability of oilseeds in India. *The Indian Society Of Oilseeds Research*. **39**(3 - 4)
7. Goyal, M., Kaur, A., & Chopra, S. (2022). Forecasting and growth trends of oilseed crops in Punjab. *Indian J Econ Dev*, **18**(1), 31-43.
8. Kolar, P., Awasthi, P. K., & Sahu, A. (2020). Growth performance of oilseeds among leading states in India. *Economic Affairs*, **65**(2), 219-224.
9. Kumar KS, and Gupta MK. (2004). "Growth rate and income stability of Soybean in different agroclimatic zones of Madhya Pradesh", *Journal of oilseeds Research*, **21**: 379-380
10. Kumar, M., Raman, R. K., & Kumar, S. (2017). Forecasting of soybean yield in India through ARIMA model. *International Journal of Pure and Applied Bioscience*, **5**(5), 1538-1546.
11. Kumar, P. P., Rao, S. V. R., Choudhary, V. K., & Koshta, A. K. (2023). Growth and decomposition of major oilseeds in Madhya Pradesh (2000–01 to 2017–18). *Journal of Oilseeds Research*, **37**, 260.
12. Kumar, V., Sharma, A. K., Yogi, R. K., & Singh, V. V. (2025). Rapeseed-Mustard Cultivation in India: National Overview and Regional Insights with Reference to Madhya Pradesh. *Journal of Oilseed Brassica*, **16**, 2. 149–157.
13. N Revathi, Dixita Gourshetty, V Haritha, Noorbina Razak, Arsha Sugathan, Sankar M, Ashitha Thomas, Aveen Ragh, Humbare Mrunalini Dinkar and Vaisakh Venu (2023). From historical data to future predictions: Analyzing and forecasting oilseed yield trends in India using time series methods. *The Pharma Innovation Journal*, **12**(12S), 1145–1157
14. Patidar, r. K. (2021). Growth and instability, price behaviour of soybean in madhyapradesh. [Master's thesis, Jawaharlal Nehru Krishi Vishwa Vidyalaya]. Krishikosh.
15. Prabakaran K. (2020) Statistical Analysis of foodgrains production in Madurai district of Tamilnadu. *International Journal of Chemical Studies* 2020; **8**(3): 2514-2516.
16. Purbia B. (2002). "Analysis of trend, growth and instability in Production of major crops in Rajasthan". M.Sc. Thesis. Department of Agricultural Economics and Management, Rajasthan College of Agriculture, MPUAT, Udaipur.
17. Ravichandran, S., Yashavanth, B. S., & Kareemulla, K. (2018). Oilseeds production and yield forecasting using ARIMA-ANN modelling. *Journal of Oilseeds Research*, **35**(1), 57–62.
18. Reddy, K. V. (2017). Area, production, yield trends and pattern of oilseeds growth in India. *Economic Affairs*, **62**(2), 327–334.
19. Sarada, C., Alivelu, K., Sambasiva Rao, V., Sudhakara Babu, S. N., & Varaprasad, K. S. (2015). *Oilseeds statistics: A compendium – 2015*. ICAR–Indian Institute of Oilseeds Research.
20. Saidulu, B., & Sharma, M. R. (2025). Forecasting soybean crop production using ARIMA model. *International Journal of Innovative Science and Research Technology*, **10**(3), 3016–3023.
21. Sharma, L., & Singh, U. (2024). Forecasting of area, production and productivity of mustard using time series analysis in India. *International Journal of Agricultural Invention*, **9**(2), 108–114.
22. Sharma, L., Singh, U., Rajpoot, K. and Choudhary, L. (2024). Time series analysis for mustard production, productivity and area forecasting in Madhya Pradesh, India. *Plant Archives*, Vol. 24, Special Issue (GABELS), pp.225-231.
23. Sharma, S. (2025). A time series analysis of oilseeds production in India. *Researchgate Publication*.
24. Singh, L., & Bansal, S. (2020). Status of rapeseed and mustard crop in India: Trend and decomposition analysis. *Journal of Krishi Vigyan*, **8**(2), 279.
25. Smitha, P., & Sumathy, M. (2024). ARIMA model for forecasting of area, production and productivity of oilseeds in India. *The Journal of Research ANGRAU*, **52**(3), 106–113.
26. Swain, H. (2007). Trends and variability in oilseeds production in Rajasthan. *Agricultural Situation in India*, **62**, 367–375.