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# Dynamics of production and trend of groundnut and soybean in India

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## Abstract
India ranks as the fourth largest edible oil economy globally, following the United States, China, and Brazil. India's share in the global oilseeds area is approximately 15-20 percent, while its contribution to vegetable oil production stands at around 6-7 percent. Furthermore, India consumes about 9-10 percent of the world's total edible oils. Due to limited productivity, oilseed production in India has remained largely unchanged. CAGR analysis showed -1.91%, 0.30%, 1.49% and 4.54%, 4.95% and 0.39% growth in area, production and yield of Groundnut and Soybean respectively. Instability analysis showed more instability (58.68%) in yield of groundnut over the last three decades. To understand the trend in area, production, yield, and MSP of groundnut and soybean, Linear, Quadratic, Cubic and Logarithmic models were fitted by using the OLS. Cubic model is best fitted for area, yield and MSP, and for production, all 4 models are best fitted. To identify the factors for low production of Groundnut and Soybean, multiple regression analysis was utilized. For groundnut among all the factors, Area, Yield, and Export were found statistically significant at 5% level whereas import and MSP were found to be insignificant and for soybean, Area and Yield were found statistically significant at 5% level of significance whereas Export, import and MSP were found to be insignificant.

**Keywords:** CAGR, groundnut, instability index, multiple linear regression, soybean

## Introduction
India ranks as the fourth most significant oilseeds producer worldwide, contributing approximately 15-20% of the global oilseeds' cultivation area, 6-7% of vegetable oil production, and 9-10% of the overall consumption of edible oils. (Kumar and Tiwari, 2020) [4]. During the 2018-19 period, groundnut, rapeseed-mustard, and soybean were the dominant oilseeds, representing approximately 80% of the total cultivated area and contributing to 87% of the oilseed production in the country (Roy *et al*., 2022) [9]. In relation to the output of crops, rapeseed and mustard account for 26% and 34% of the total yield, while soybeans and peanuts make up 29% each (Singh and Singh, 2021) [10].

India, being the top purchaser of vegetable oils, relies on imports to satisfy more than 60% of its internal demand. Specifically, palm oil is sourced from Indonesia and Malaysia, while Argentina, Brazil, Ukraine, and Russia serve as the origins for imported Soya oil and Sunflower oil (Roy *et al*., 2022) [9]. The oilseed market possesses unique qualities that are evident in its significant level of product substitutability, dependence on related agricultural and food markets such as grain, meat, and animal fats, and its intricate makeup (Vinnichek *et al*., 2019) [13]. The major factors influencing the market of Oilseeds are:

a. Growth factor: Natural conditions in the United States and Latin America have a negative impact on yield. Oil prices could rise as a result of Organization of the Petroleum Exporting Countries (OPEC) likely announcement of a reduction in oil production. Reduced harvest of palm trees, ultimately leads to rise in the price of soybean oil.
b. Fall factor: Oil prices are continuing to fall due to various factors across the world *viz*. increased interest in biodiesel production, decline in population income, tariffs, etc.
c. Government interventions: The key policy changes includes privatized imports, MSP and tariff reductions

According to government data, edible oil prices in global markets have risen by up to 47 percent in the last year and by around 15-20% in the domestic market due to global factors and a local supply shortage. Due to the high risk and limited resource base of farmers in rain-fed areas, these crops are grown with minimal inputs. High seed rate and seed cost, as well as the lack of hybrids in major oilseeds such as groundnut and soybean, are other constraints to increasing crop productivity. External price shock due to the scarcity of imported oil is a major challenge in this sector.

The area, production, and yield scenarios have shown a mixed trend from the first (1951-56) to the eleventh Five Year Plan (2007-2012). The eleventh five-year plan documented the best average output, with figures of 267.48 lakh hectares, 286.27 lakh tons, and 1082 kg/hectare. Oilseeds cover 13% of the total cultivated land, contribute to 3% of the gross national product (GNP), and make up 10% of the overall value of agricultural commodities. The majority, approximately 72%, of the oilseeds area is dedicated to rainfed farming with limited inputs, where issues such as biotic and abiotic stresses significantly hinder oilseed productivity. The yield, which remained steady at 1,168 kg per hectare between 2012 and 2014, experienced a decline in the following two years. It reached 1,075 kg per hectare in 2014-2015 and further decreased to 968 kg per hectare in 2015-2016. However, there has been a shift in this trend, and the yield rebounded to 1,225 kg per hectare in 2015-2016 (Singh and Singh, 2021) [10]. Major contributors to annual oilseeds production comes from three annual crops; soybean, groundnut and rapeseed-mustard. Yellow revolution, started in the year 1986, was also associated with the oilseed production to achieve self-sufficiency in oilseeds cultivation and production. However, the ability to meet the demand for oilseeds that was attained during the Yellow Revolution in the early 1990s has not been sustained in the current era (Teja *et al*., 2022) [11]. It should be emphasized that the yield demonstrated a 1.2% annual compound growth rate over the span of five years, from 2012-13 to 2016-17. Moving forward, there are projections indicating that the yield will experience a compound annual growth rate of 3.6% for the next five-year period, from 2017-18 to 2021-2022. The lack of significant progress in the field of grain cultivation is primarily attributed to the increased focus on this particular area. Typically, these crops are grown in regions with poor soil fertility, such as marginal and sub-marginal areas. In order to prevent the land from being left uncultivated, farmers opt to cultivate these crops (Thapa *et al*., 2019) [12].

## Objectives

- To analyse the compound annual growth rate (CAGR) and instability of Area, Production and Yield of Groundnut and Soybean in India.
- To examine the dynamics of production, export and import of groundnut and soybean in India.
- To identify the factors for low production of groundnut and soybean in India.

## Materials and Methods

To analyse the oilseed trend, data from the Directorate of Economics and Statistics was collected. This secondary data covered a 30-year period from 1991 to 2021 and included information on the area, production, yield, and minimum support price (MSP) of oilseed crops. The compiled data was then analysed to examine the trends in oilseed area, production, yield, and MSP in India.

**Compound Annual Growth Rate:** The simple growth rate showing the absolute change in growth per unit of time can be written, mathematically as: $dY_t/dt$.

Compound Annual Growth Rate can be mathematically written as

$$CAGR = [(1/Y_t).\ (dY_t/dt)] = [(Y_{t+1} - Y_t)\ /Y_t].$$

It is rate of change of $Y_t$ per unit of change in time 't' expressed as a fraction of the magnitude of $Y_t$ itself. The CAGR has been estimated using the exponential function of the following form: $Y_t = Ae^{bt}$

The log transformation of this function is as follows:

$$\text{Loge } Y_t = \text{Log}_e A + bt$$

The formula for calculating CAGR from the log liner can be derived as follows: Let '$Y_O$' be the value of the variables under study in the base period '$Y_t$' be the value of the variable in the time 't' and 'r' be the value of CGR (compound growth rate). Using compounding formula we get, $Y_t = Y_O (1+r)^t$ Log transformation of the above is Log $Y_t$ = log $Y_o$ + t log (1+r) Assuming log $Y_O$ = log A and log (1+ r) = b, the same expression can be put as

Log $Y_t$ = log A+bt (Kalra and Srivasatava, 2022) [3]

**Instability analysis:** Instability represents the uncertainty, with the help of indicators like Coefficient of variation, Standard deviation and instability index, etc. The instability in area, production and productivity of groundnut was analyzed using the following method suggested by Nayak *et al*. (2021) [6].

Instability index = Standard deviation of natural logarithm (Yt+1/Yt)

Where, Yt is the area/production /yield in the current year and Yt + 1 is for the next year.

**Model fitting:** In order to analyse the patterns in area, production, yield, and minimum support price (MSP), polynomial models were employed through the ordinary least squares method. The study utilized linear, quadratic, cubic, and logarithmic models to examine these variables (Dash *et al*., 2017) [1].

Linear model: $Y_t=a+bt+e_t$
Quadratic model: $Y_t=a+bt+ct^2+e_t$
Cubic model: $Y_t=a+bt+ct^2+dt^3+e_t$
Logarithmic function: Y=a+b log X

Model adequacy checking: The diagnostic tests that examine the randomness and normality of residuals help verify the independence and distribution assumptions of the data (Qian and Li, 2021) [8].

$R^2$=RSS/TSS=1-ESS/TSS

$$\text{RMSE} = \sqrt{\frac{\sum_{i=1}^{n}(Yt - \hat{Y}t)^2}{n}}$$

**Multiple linear regression function:** A multiple linear regression function was fitted to analyse the influencing factor for low production of oilseed in India.

$$Y=a+b_1x_1+b_2x_2+b_3x_3+b_4x_4+b_5x_5+b_6x_6$$

Where,
Y= Dependent variable (production); X1= Area; X2= Production; X3= Yield; X4=MSP; X5=Export; X6= Import

## Results and Discussion

### To analyse the compound annual growth rate (CAGR) and instability of Area, Production and Yield of Groundnut and Soybean in India

The results in Table 1 indicates that Groundnut showed a negative growth rate of 1.91% in terms of area whereas production and yield showed considerable positive growth rate of 0.30% and 1.49% respectively. Similar findings were found in the study of Nayak *et al*. (2021) [6]. In case of Soybean, although area and production had a significantly high growth rate of 4.54% and 4.95%, the yield witnessed a very low growth rate of 0.39%. This indicated that the increase in production was just linked to increase in area and significant research work needs to be done for varietal intervention for increasing the yield. Similar trend was reported in the study of Parmar and Devi (2021) [7]. However, Instability analysis revealed high instability of 58.68% in yield of Groundnut which can be attributed to several reasons beyond the study of this paper.

**Table 1:** CAGR and Instability Index of area, production and yield of Groundnut and Soybean over 30 years

| | | Area | Production | Yield |
|---|---|---|---|---|
| Groundnut | CAGR | -1.91% | 0.30% | 1.49% |
| | Instability | 9.25% | 33.74% | 58.68% |
| Soybean | CAGR | 4.54% | 4.95% | 0.39% |
| | Instability | 7.17% | 21.26% | 20.76% |

### To examine the dynamics of area, production, yield & MSP of Groundnut and Soybean in India

**Groundnut:** The perusal of Table 2 depicts the regression coefficient estimates, Root Mean Square Error and p-value of the model for groundnut area, yield, production and MSP in India.

**Table 2:** Regression coefficient estimates, RMSE, and p-value of the models for Groundnut area, production, yield, and MSP in India

| | Model | a | B | c | d | $R^2$ | RMSE | P Value |
|---|---|---|---|---|---|---|---|---|
| Area | Linear | 6.739 | -.100 | | | 0.714 | 0.364 | <0.001 |
| | Logarithmic | 7.474 | -.821 | | | 0.615 | 0.442 | <0.001 |
| | Quadratic | 6.697 | .085 | -.001 | | 0.715 | 0.363 | <0.001 |
| | Cubic | 5.890 | .240 | -.034 | 0.001 | 0.759 | 0.334 | <0.001 |
| Production | Linear | 5.998 | 0.106 | | | 0.146 | 1.479 | 0.096 |
| | Logarithmic | 5.291 | 0.850 | | | 0.119 | 1.509 | 0.136 |
| | Quadratic | 6.643 | -0.044 | .007 | | 0.161 | 1.466 | 0.225 |
| | Cubic | 5.0840 | 0.586 | -.058 | 0.002 | 0.191 | 1.440 | 0.322 |
| Yield | Linear | 811.4 | 43.04 | | | 0.537 | 230.6 | <0.001 |
| | Logarithmic | 531.8 | 341.4 | | | 0.430 | 262.7 | 0.002 |
| | Quadratic | 1015.6 | -4.4 | 2.1 | | 0.569 | 222.4 | 0.001 |
| | Cubic | 897.02 | 43.5 | -2.84 | 0.142 | 0.573 | 221.4 | 0.003 |
| MSP | Linear | 179.26 | 223.48 | | | 0.924 | 230.6 | <0.001 |
| | Logarithmic | -1260.8 | 1767.35 | | | 0.721 | 255.9 | <0.001 |
| | Quadratic | 1006.6 | 31.27 | 8.357 | | 0.958 | 222.4 | <0.001 |
| | Cubic | 1947.89 | -348.79 | 47.25 | -1.13 | 0.974 | 221.4 | <0.001 |

It was noted that when various polynomial models were applied to analyse the data on groundnut crop's area, production, yield, and minimum support price (MSP), the cubic model demonstrated the most accurate fit for the variables of area, yield, and MSP with R2 value of 0.759, 0.573, 0.974 and RMSE value of 0.334, 221.4, 221.4 respectively, whereas no model was found significant for production (Figure 1 a, b, c, d).

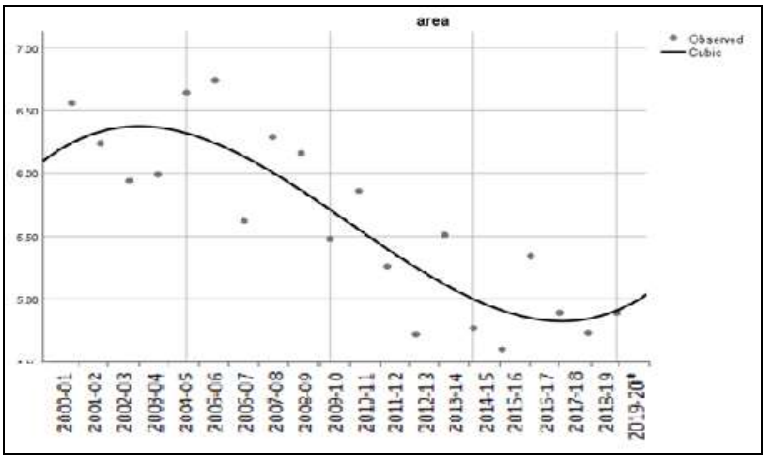


**Fig 1a:** Best fitted Cubic model for area under groundnut cultivation

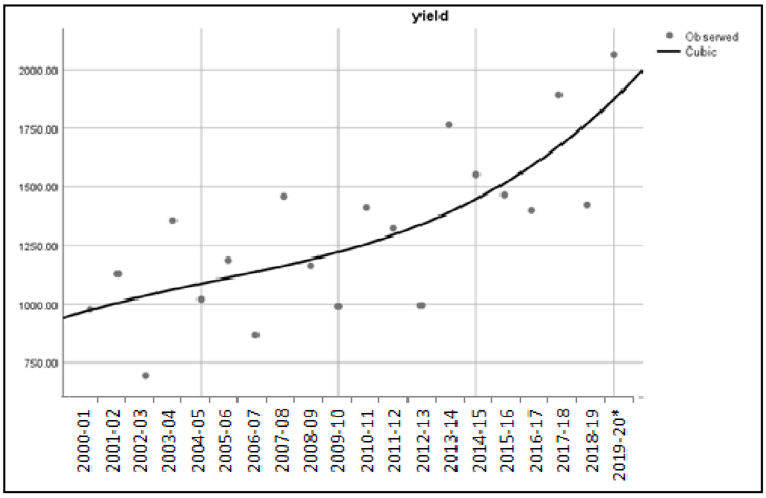


**Fig 1b:** Best fitted Cubic model for yield of groundnut

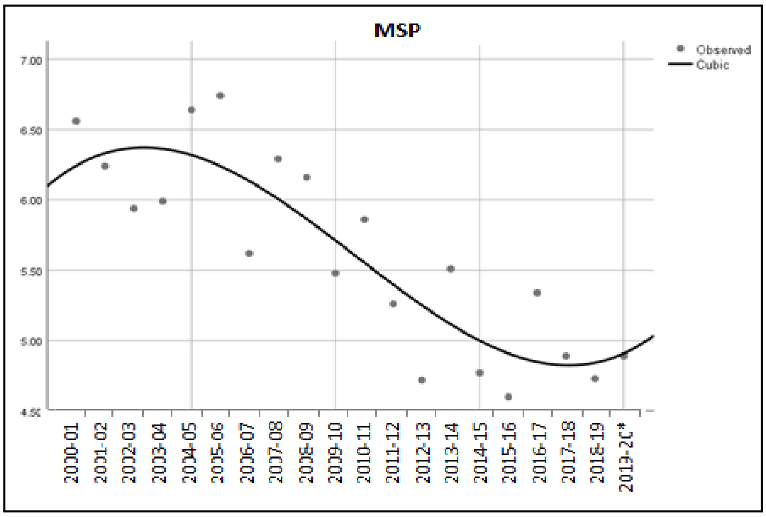


**Fig 1c:** Best fitted Cubic model for MSP of groundnut

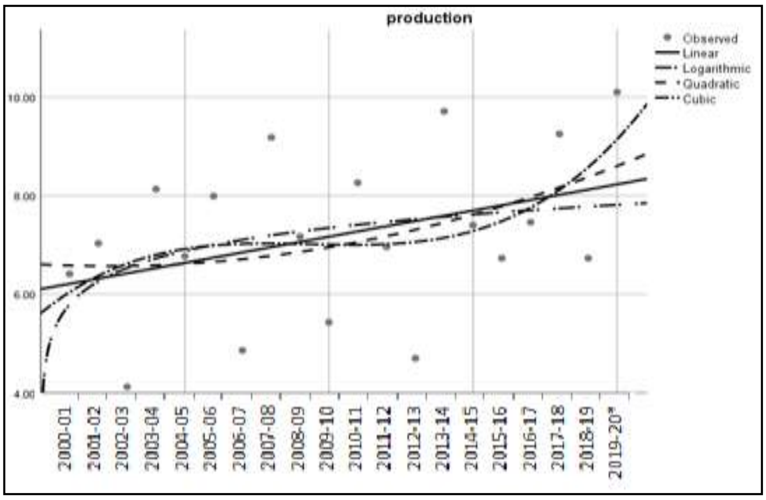


**Fig 1d:** Represents all 4 models fitted for production of groundnut

**Soybean:** Table 3 shows regression coefficients, Root Mean Square Error and p-value of the model for soybean area, yield, production and MSP in India.

**Table 2:** Regression coefficient estimates, RMSE, and p-value of the models for Soybean area, production, yield, and MSP in India

| | Model | a | b | c | d | $R^2$ | RMSE | P Value |
|---|---|---|---|---|---|---|---|---|
| Area | Linear | 6.01 | 0.317 | | | 0.898 | 0.36 | <0.001 |
| | Logarithmic | 4.59 | 2.243 | | | 0.851 | 0.44 | <0.001 |
| | Quadratic | 5.02 | 0.586 | -0.013 | | 0.936 | 0.36 | <0.001 |
| | Cubic | 5.69 | 0.241 | 0.027 | -0.001 | 0.946 | 0.33 | <0.001 |
| Production | Linear | 6.03 | 0.367 | | | 0.597 | 1.48 | <0.001 |
| | Logarithmic | 3.84 | 2.85 | | | 0.681 | 1.51 | <0.001 |
| | Quadratic | 3.34 | 1.1 | -0.35 | | 0.741 | 1.47 | <0.001 |
| | Cubic | 3.55 | 0.992 | -0.022 | 0.00 | 0.741 | 1.44 | <0.001 |
| Yield | Linear | 982.56 | 6.451 | | | 0.048 | 230.65 | 0.353 |
| | Logarithmic | 886.34 | 77.459 | | | 0.131 | 262.79 | 0.117 |
| | Quadratic | 781.43 | 61.305 | -2.612 | | 0.256 | 222.41 | 0.081 |
| | Cubic | 696.88 | 104.447 | -7.625 | 0.159 | 0.275 | 221.40 | 0.151 |
| MSP | Linear | 223.90 | 152.243 | | | 0.911 | 274.04 | <0.001 |
| | Logarithmic | -143.93 | 928.95 | | | 0.640 | 551.61 | <0.001 |
| | Quadratic | 845.001 | -17.148 | 8.066 | | 0.976 | 134.10 | <0.001 |
| | Cubic | 1016.92 | -104.87 | 18.259 | -0.324 | 0.981 | 125.19 | <0.001 |

The researchers noted that when various polynomial models were applied to analyse the data on soybean crop's area, production, yield, and minimum support price (MSP), the cubic model demonstrated the most accurate fit for the variables of area, yield, and MSP with R2 value of 0.946, 0.275, 0.981 and RMSE value of 0.33, 0.151, 125.19 respectively, whereas no model was found significant for production (Figure 2 a, b, c, d).

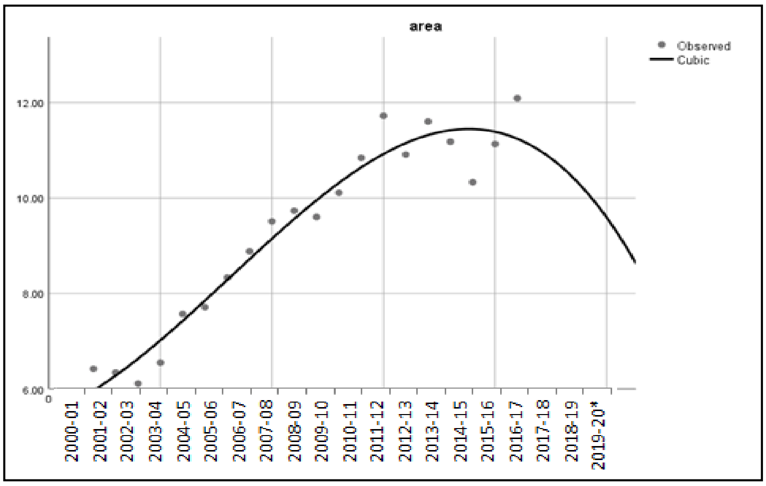


**Fig 2a:** Best fitted Cubic model for area under soybean cultivation

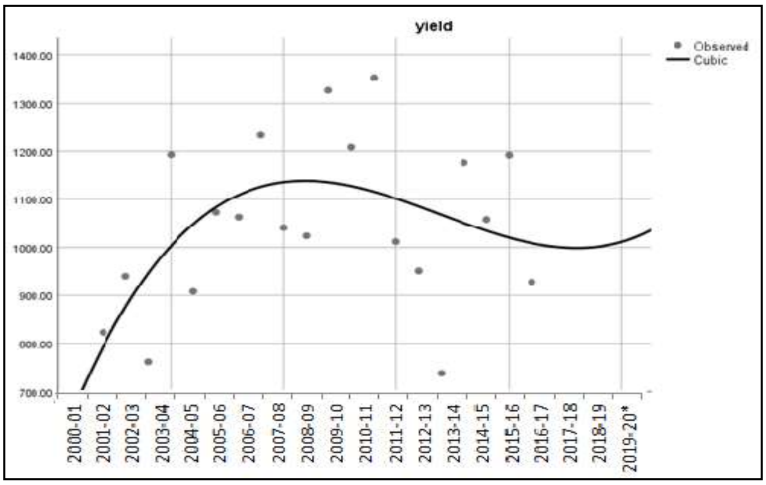


**Fig 2b:** Best fitted Cubic model for yield of soybean

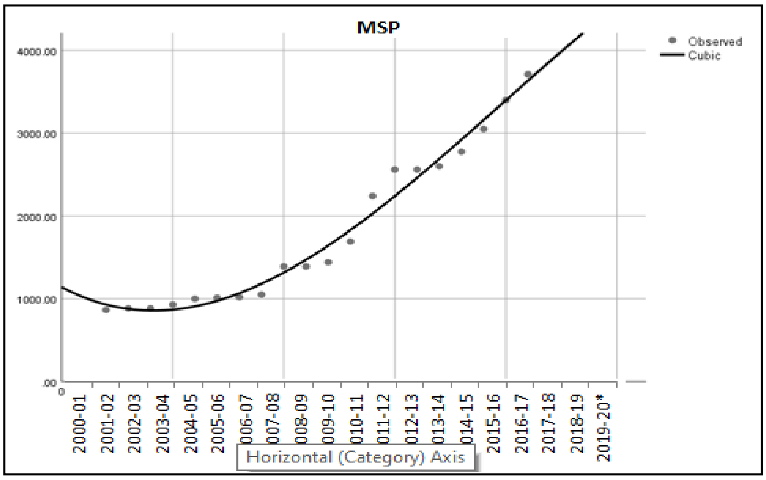


**Fig 2c:** Best fitted Cubic model for MSP of soybean

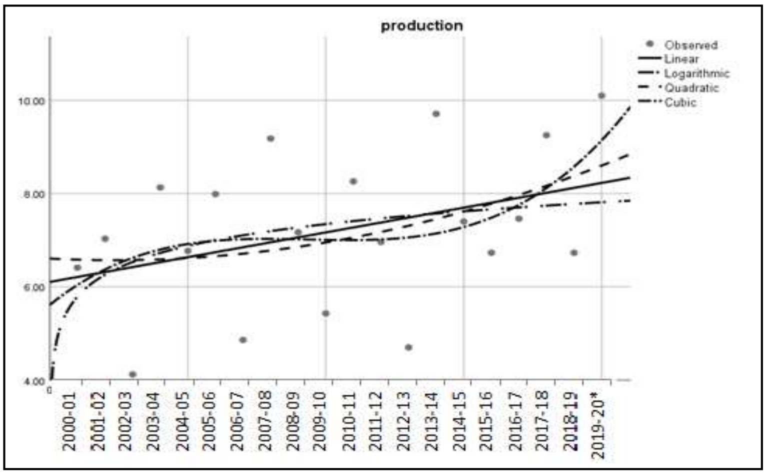


**Fig 2d:** Represents all 4 models fitted for production of soybean

## To identify the factors for low production of Groundnut & Soybean in India

Table 4 represents the result of regression of factors affecting low production of groundnut. Among all the factors, Area (X1), Yield (X2), and Export (X3) were found statistically significant at 5% level whereas import (X4) and MSP (X5) were found to be insignificant. The negative values of import (X4) and MSP (X5) indicates decrease in the production, while all other factors have a positive value meaning that an increase in area, yield and export leads to increase in production. The coefficient of multiple determination (R2) of the model was 0.993 indicating high explanatory power of the model. Apart from this, Teja *et al*. (2022) [11] found in their study, some other challenges faced at the farm level including the limited distribution of appropriate high-yielding varieties or hybrids, inadequate moisture leading to stress, expensive production costs, delayed access to necessary inputs & the problem of low and unstable prices.

**Table 4:** Regression analysis of factors affecting low production of groundnut

| | Coefficients | Significance |
|---|---|---|
| Intercept | -7.579* | 0.000 |
| Area ($X_1$) | 1.329* | 0.000 |
| Yield ($X_2$) | .005* | 0.000 |
| Export ($X_3$) | .001* | 0.020 |
| Import ($X_4$) | -2.617E-5 | 0.820 |
| MSP ($X_5$) | -4.109E-5 | 0.587 |
| $R^2$ | 0.993 | |

*Significance at 5 percent level

Table 5 represents the result of regression of factors affecting low production of soybean. Among all factors, Area (X1) and Yield (X2) were found statistically significant at 5% level of significance whereas other factors Export (X3), import (X4) and MSP (X5) were found to be insignificant. The coefficient of multiple determination (R2) of the model was 0.988 indicating high explanatory power of the model.

Apart from this, other reasons found in the study by Pathak (2018) [14] were the limited acceptance of technology and farmers' lackadaisical attitude towards soybean cultivation, along with the inadequate accessibility of high-quality inputs, specifically seeds, at the appropriate timing and reasonable cost, insufficient implementation of effective soil and nutrient management practices, and inadequate agricultural extension services contribute to the suboptimal adoption of technology in soybean farming.

**Table 5:** Regression analysis of factors affecting low production of Soybean

| | Coefficients | Significance |
|---|---|---|
| Intercept | -8.902* | .000 |
| Area ($X_1$) | .871* | .000 |
| Yield ($X_2$) | .010* | .000 |
| Export ($X_3$) | .000 | .688 |
| Import ($X_4$) | -7.764 E-7 | .505 |
| MSP ($X_5$) | .000 | .321 |
| $R^2$ | 0.988 | |

*Significance at 5 percent level

## Conclusions
It is important to encourage minor oilseed-producing states to identify the specific limitations in their regions. Efforts should then be focused on creating the necessary infrastructure and efficiently implementing oilseed development programs which will help in creating favourable conditions for increased oilseed production in those regions.

As part of the Make in India initiative, incentivizing the establishment of large-scale processing plants that will create strong backward linkages with the suppliers in order to increase domestic oilseed production. These processing plants can collaborate with farmer producer organizations (FPOs) to enhance the output of oilseeds, which serve as the raw material. FPOs play a crucial role in endeavours to promote and enhance domestic oilseed production.

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