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Statistical Analysis and Modeling of Growth Performance of Sesame Crop in Madhya Pradesh and India

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ABSTRACT
The present research work performed on the growth performance of sesame crop in Madhya Pradesh and India. The main objective of our study was to estimate the variability, degree of relationship and growth rate of sesame crop. Also, we focused on to determine the direct and indirect effect of most influential timeseries factors on production of sesame and lastly to find the best trend model on area, production, productivity and Minimum support price (MSP) of sesame crop of Madhya Pradesh and India as well. We found that maximum growth rate observed in MSP followed by production in Madhya Pradesh and productivity in India. The cubic and quadratic growth model are the most suitable models forarea, production, productivity and MSP in MP as well as India, except in India the linear model was found best suitable for productivity. This research work will help to make a batter decision for policy maker and researcher.
Keywords: *Growth Rate, Path analysis, MSP, Trend Model.*

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INTRODUCTION

Oilseed crops are the agricultural economy's second most important supporting factor, following only cereals. Oilseed crops make a significant contribution to agricultural GDP. The major source of vegetable oils in the country is nine oilseeds, 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). Oilseeds are ploughed across 26.67 million hectares each year, productivity 30.06 million tons (quinquennium ending 2016-17). India produces around 7-8 million tons of vegetable oils from primary sources and 3 million tons of vegetable oil from secondary sources such as cottonseed, rice bran, coconut, tree borne oilseeds, and oil palm.

Sesame is high in calories, and its popularity is expanding globally. Madhya Pradesh, Maharashtra, Rajasthan, and Gujarat accounted for more than 90% of the additional output (18.5Mt) of oilseeds from 1980-81 to 2011- 12 (Reddy, 2017). Sesame demand is steadily expanding around the world. Sesame seed exports are dominated by India, Sudan, Ethiopia, Myanmar, and Nigeria. India exports 282.21 thousand tons of sesame seed worth Rs. 3723.12 crores in 2019-20. To meet global demand, researchers must examine the crop's acreage, output, productivity, oil production, and MSP.The purpose of this study is to examine changes in sesame acreage, production, productivity, and MSP in Madhya Pradesh and India using various statistical methodologies.

Madhya Pradesh is an important contributor to oilseed in India in terms of area, production, and productivity. Madhya Pradesh represented 27.5 % of India's oilseed area and supplied 19.4 % of total Indian oilseed production. Sesame seeds contain the highest oil compared to any other oilseed to an extent of 50% and above. In Madhya Pradesh sesame is mainly grown in Chhatarpur, Tikamgarh, Sidhi, Shahdol, Morena, Shivpuri, Sagar, Damoh, Jabalpur, Mandala, East Nimar and Seoni districts of the state. The average productivity of sesame in M.P. is 387 kg/ha. [1]. India leads the nation in both acreage (16.22 lakh ha), production (6.57 lakh MT), and productivity (409 kg/ha) of sesame. After the United States, China, and Brazil, India is the fourth largest producer of oilseeds. Among the several oilseeds grown here, sesame ranks sixth in terms of production, following soybean, cotton seed, groundnut, sunflower, and mustard (National Productive Council, New Delhi). From last few years it was found that the area and production of sesame is continuously decreasing in both MP and India. So, it is necessary to statistically analyze the growth pattern of area, production, productivity and MSP of Sesame crop in Madhya Pradesh and India, so that hidden limitations in the progress of these crop may be identified in some specific terms and some suggestive solutions can be made.

Many authors studied on the importance of oil seed crop to estimate the growth performance. Non-linear stochastic models were used for describing the growth of soybean oil production in India and also in Madhya Pradesh [2]. The results indicated that the Chapman model is more useful than other non-linear models for describing the growth of soybean oil production in India, and the Weibull model was more appropriate for describing the growth of soybean oil production in Madhya Pradesh [3]. The study analyses the growth and instability in the productivity of major crops grown across the districts of Odisha and examines their sensitivity to weather conditions during different phases of technological change. The performance of growth rate and some influential time series production factors were examined in governing total barley production in Jaipur district as well as Rajasthan [4]. The author [5] investigated the trend in growth models for the average production and productivity of the sugarcane crop in Andhra Pradesh State's Coastal Andhra region from 1973-74 to 2012-13.

Based on the importance of growth rate examination on agricultural crop, our main objective is (i) to determine the statistics, variability, degree of relationship and growth rate of sesame crop in Madhya Pradesh as well as India; (ii) To determine the direct and indirect effect of most influential time series factors on production of sesame; (iii) To determine the best model for Area, Production, Productivity and MSP of sesame crop.

MATERIAL AND METHODS

The study pertains to the period of 24 years from 1996-97 to 2019-20. Secondary data for the study will be gathered from the DACNET (Department of Agriculture Cooperation), MP Krishi, and the Directorate of Economics and Statistics (DES), New Delhi, pertaining to four important factors: area, production, productivity, and price of sesame oilseeds crop in Madhya Pradesh and India over a 24-year period, *i.e.*, 1996-1997 to 2019-2020. The selected factors were as: X1 = Sesame area (‘000 ha.); X2 = Sesame production (‘000 tones); X3 = Sesame productivity (kg/ ha); X4 = Price of Sesame seed (Rs/q).

In accordance with the objective delineated, the time-series data pertaining to the area, production, productivity and MSP of Sesame crop for Madhya Pradesh and India over a long span of 24 years time, *i.e.*, 1996-97 to 2019-20 had been brought under the purview of the present analysis.

Degree of relationship: To determine the degree of relationship between different variables Correlation coefficient and Decomposition analysis were applied.

Correlation coefficient: A measure of linear relationship that indicates the degree of correlation between two sets of data or between two random factors and that is equal to their covariance divided by the product of their standard deviations.

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n \sum x^2 - (\sum x)^2][n \sum y^2 - (\sum y)^2]}}$$

Decomposition analysis: To estimate the effect of area, productivity and their interaction on the overall growth performance of sesame production, decomposition analysis was applied [6]. The equation for decomposition is given by

P=A0(Yn-Y0) + Y0 (An-A0) + ΔA ΔY

1 = [(Y0ΔA)/P] + [(A0ΔY)/P] + [(ΔAΔY)/P]

Where, P= Change in Production, A0 = Area in base year, An = Area in current year, Y0 = Productivity in base year, Yn = Productivity in current year,ΔA= Change in area (An-A0), ΔY= Change in productivity (Yn-Y0).

Growth Analysis: Growth trends quantify the rate of growth over a specified period of time. A growth trend can be measured over any period of time, such as a month, year or decade. Determining the growth trend can help you predict future growth.

Linear growth rate: The linear growth rate is calculated by the equation;

Yt = a + b t; where, t is the time in years, independent variable; Y is the trend value of the dependent variable; a and b are constants.

The above equation is fitted by using the least squares method of estimation. The linear growth rate is calculated by the formula; $(LQR\%) = \frac{b}{\bar{y}} * 100$; where, $\bar{y}$ is mean of dependent variable.

Compound growth rate: Compound annual growth rate, or CAGR, is the mean annual growth rate of an investment over a specified period than one year. It represents one of the most accurate ways to calculate anddetermine returns for individual benefits, investment portfolio, and anything that can rise or fall in value over time is given by the equation Y = a*b^t or Log y = log a + t log b; where, t is the time in years; y is the characteristic (area, production, productivity and MSP of dependent variable) a and b are parameters. The 'a' and 'b' are calculated by applying the method of Least Squares.

The above growth model was linearized by using logarithmic transformation and the unknown parameters were estimated by the ordinary least squares (OLS) method. The function is computed as, (CGR %) = (Antilog b - 1) X 100.

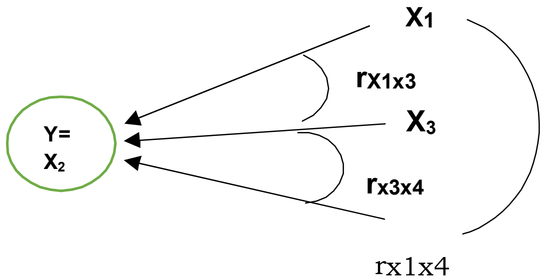

Figure 1. Path diagram showing cause and effect relationship

Path coefficient analysis: Path analysis is simply standardized partial regression coefficient partitioning the correlation coefficients into the measures of direct and indirect effects of set of independent variables on the dependent variable. It is also known as cause, and effect relationship. The author [7] developed and applied the method of path analysis for the purpose of interpretation of a system of correlation coefficients in terms of paths of causation. The theory underlying path analysis is that a variable Y is represented and completely determined by a number of intermediate factors X1, X2, ..., X4 and R, all of which except the residual R is represented as inter-correlated. Path analysis is carried out using the estimates of correlation coefficients.

In this study sesame area (X_1), sesame productivity (X_3), price of sesame (X_4), the independent variable, could be the sesame production components and are inter-correlated among themselves and also correlatedto Y=X_2

The correlation between Y(=X2) and the known variables (X1, X3, X4) may be written as a series of simultaneous linear equations equal in numberto the unknown path coefficients

$$r_{YX_1} = P_{YX_1} + r_{X_1X_3} P_{YX_3} + r_{X_1X_4} P_{YX_4} \ldots\ldots\ldots\ldots\ldots (1)$$

$$r_{YX_3} = r_{X_1X_3} P_{YX_1} + P_{YX_3} + r_{X_3X_4} P_{YX_4} \ldots\ldots\ldots\ldots\ldots (2)$$

$$r_{YX_4} = r_{X_1X_4} P_{YX_1} + r_{X_3X_4} P_{YX_3} + P_{YX_4} \ldots\ldots\ldots\ldots (3)$$

where, r_{YX_1}, r_{YX_3}, and r_{YX_4} are the simple correlation coefficientbetween each of the causal factors with the effect Y.

Trend Model: The five models, *viz*., linear, quadratic, compound, cubic and exponential, were fitted on the last 24 years data. The functional forms of these models are given as (i)

Linear trend, (ii) Quadratic trend, (iii) Cubic trend, (iv) Compound trend and (v) Exponential trend.

RESULT

Data Performance: From *per se performance*, It can be revealed from the figure 2 that the area of sesame in 1996-97 was 178 thousand ha and increased to 315 thousand ha in 2019-20 similarly the production of sesame in 1996-97 was 46.7 thousand tones and increased to 126 thousand tones in 2019-20. The productivity of sesame in 1996-97 was 262.4 kg per hectare and increased to 400 kg per hectare in 2019-20. Minimum support price of sesame in 1996-97 was 870 Rs/q and increased to 6485 Rs/q in 2019-20 in Madhya Pradesh.

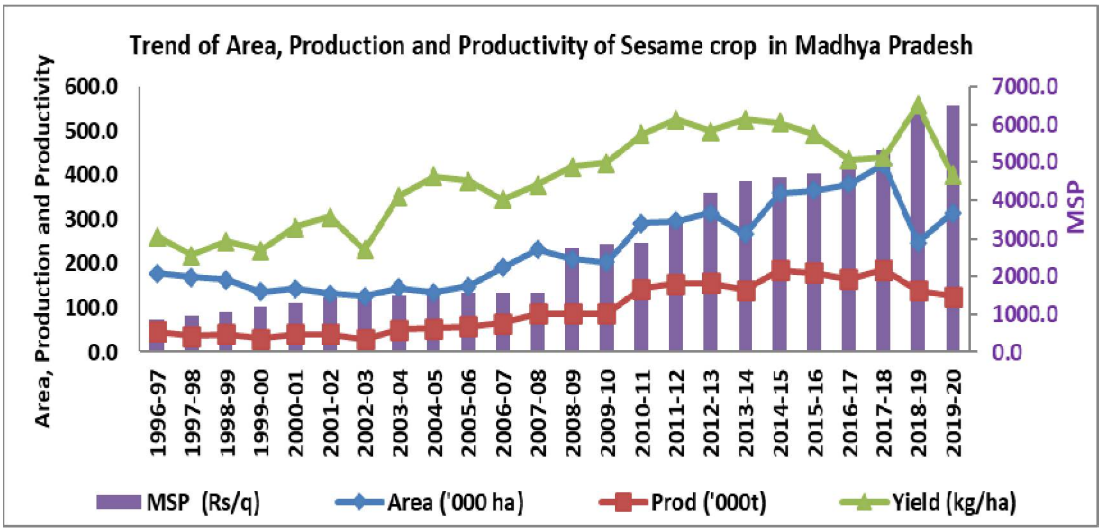

Figure 2: Trend of Area, Production and Productivity of sesame crop in MP

It can be revealed from the figure 3 that the area of sesame in 1996- 97 was 1991.7 thousand ha and decreased to 1622.6 thousand ha in 2019-20. The production of sesame in 1996-97 was 640 thousand tones and fluctuated increase to 657.5 thousand tones in 2019-20. The productivity of sesame in 1996-97 was 321.3 kg per hectare and increased to 405.2 kg per hectare in 2019-20. Minimum support price of sesame in 1996-97 was 870 Rs/q and increased to 6485 Rs/q in 2019-20 in India.

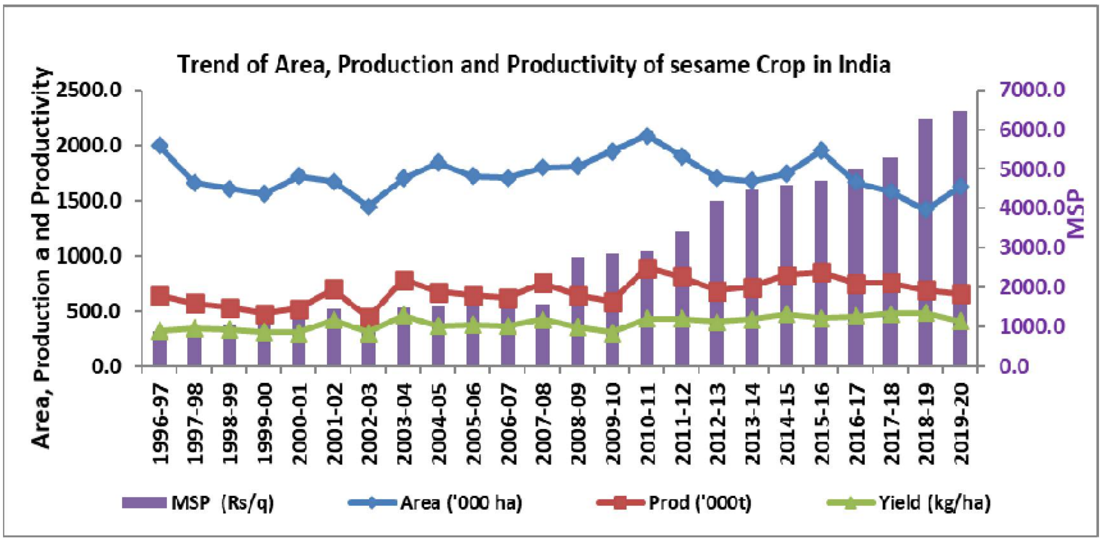

Figure 3: Trend of Area, Production and Productivity of sesame crop in India

Tables 1 and 2 show the statistics, variability, and growth rate ofthe sesame crop's area, production, productivity and MSP in Madhya Pradeshand India from 1996-97 to 2019-20.

According to the table on average, Madhya Pradesh contributed 13.41% of the area and 14.40 % of the sesame production in India.

Table 1: Statistics, variability and growth rate of Area, Production andProductivity of Sesame in MP

	AREA	PRODUCTION	PRODUCTIVITY	MSP
Mean	232.20	97.28	390.64	2870.38
Standard Deviation	97.26	60.58	107.60	1940.77
CV (%)	39.28	57.61	27.16	62.98
Instability Index	28.03	34.92	18.83	26.80
LGR (%)	4.69	7.30	3.29	8.49
CGR (%)	4.80	8.60	3.60	9.50

*Area (‘000 ha), Production (‘000 t), Productivity (kg/ha), MSP (Rs/q).

Table 2: Statistics, variability and growth rate of Area, Production andProductivity of Sesame in India

	AREA	PRODUCTION	PRODUCTIVITY	MSP
MEAN	1730.52	675.43	390.60	2870.38
Standard Deviation	161.23	117.87	62.79	1940.77
CV%	9.44	17.34	15.39	62.98
Instability Index	9.43	16.43	13.34	26.80
LGR	-0.06	1.45	1.57	8.49
CGR	-0.10	1.50	1.60	9.50

*Area (‘000 ha), Production (‘000 t), Productivity (kg/ha), MSP (Rs/q).

The values of the coefficients of variation revealed the existence of greater inconsistency (fluctuation) in the data. From the table, it was noted that the maximum coefficient of variation was observed for minimum support price both in India (62.98%) as well as in Madhya Pradesh (62.98%). The minimum coefficient of variation was observed for productivity in Madhya Pradesh (27.16%) and for area in India (9.44%). Hence, it concluded that the most stable factors were area and productivity in India and Madhya Pradesh, respectively.

The linear and compound growth rates for India and Madhya Pradesh are shown in Tables 1 and 2, respectively. It is seen from the table that the maximum linear and compound growth rates have been observed with respect to the price of sesame both in India and Madhya Pradesh followed by production in Madhya Pradesh and productivity in India respectively. The minimum linear growth rate (-0.06%) and compound growth rate (-0.10%) have been observed with respect to area in India, and in Madhya Pradesh,the minimum linear growth rate (3.29%) and compound growth rate (3.60%) have been observed with respect to productivity.

The decomposition analysis was performed during the study period with the contribution of area, productivity, and the interaction effect on the increase of sesame production in Madhya Pradesh and India (1996-97 to 2019-20).

Table 3: Decomposition analysis of Area, Production and Productivityof Sesame in Madhya Pradesh

Sesame Production	Area Effect (%)	Productivity effect (%)	Interaction Effect (%)
1996-97 to 2007-08	34.19	50.64	15.17
2008-09 to 2019-20	114.72	-9.79	-4.92
Overall	45.33	30.90	23.78

According to table 3, in the instance of sesame production in MadhyaPradesh, area was the primary factor responsible for the increase in sesame crop production in Madhya Pradesh, while productivity and interaction impact were secondary. For the 1996-1997 to 2007-08, 2008-09 to 2019-20, and overall research periods, the area effect was calculated to be 34.19 %, 114.72 %, and 45.33 %, respectively. In the case of sesame production in India, productivity was the primary responsible element for a growth in sesame crop production, while area and interaction impact were secondary and have negative impact. The productivityeffect was calculated to be 169.31%, 539.33%, and 954.75% for the 1996-1997 to 2007-08, 2008-09 to 2019-20, and overall period of the study, respectively (Table 4).

Table 4: Decomposition analysis of Area, Production and Productivity of Sesame in India

Sesame Production	Area Effect (%)	Productivity effect (%)	Interaction Effect (%)
1996-97 to 2007-08	-52.94	169.31	-16.37
2008-09 to 2019-20	-383.74	539.33	-55.59
Overall	-677.82	954.75	-176.93

Correlation Metrix: The correlation coefficients for the different pairs of variables were assessed for Madhya Pradesh as well as India. The interrelationship among the total sesame production X2(Y dependent) variable and other production factors independent variables (sesame area, productivity, and minimum support price) are represented in table 5 for Madhya Pradesh.

Table 5: Correlation matrix of sesame production factors on the sesame production in Madhya Pradesh.

Correlation matrix	Production ('000 t)	Area ('000 ha)	Productivity (kg/ha)	MSP (Rs/q)
Production (,000t)	1.0000			
Area ('000 ha)	0.9610**	1.0000		
Productivity (kg/ha)	0.8666**	0.7089**	1.0000	
MSP (Rs/q)	0.8652**	0.8335**	0.7716**	1.0000

** Correlation is significant at the 0.01 level

According to the results, sesame production was positively and significantly connected with sesame area (0.9610), productivity (0.8666), and minimum support price (0.8652). The table 5 also shown that the area and minimum support price had a strong association. These factors were interconnected with each other. This reveals the importance of these components as production influencing factors. The correlation coefficients between X2(Y) and other factors (area, productivity and minimum support price) for India are presented in table 6. The results indicated that the productivity (0.8345) of sesame had a highly positive and significant correlation with sesame production in India followed by area and MSP. The table 6 also shown that the productivity and minimum support price had a strong association

Table 6: Correlation matrix of sesame production factors on the totalsesame production in India.

Correlation matrix	Production ('000t)	Area ('000 ha)	Productivity (kg/ha)	MSP (Rs/q)
Production ('000t)	1.0000			
Area ('000 ha)	0.4973*	1.0000		
Productivity (kg/ha)	0.8345**	-0.0539	1.0000	
MSP (Rs/q)	0.4821*	-0.1581	0.6768**	1.0000

* Correlation is significant at the 0.05 level, ** Correlation is significant at the 0.01 level

Path Analysis: Path analysis results aimed to diagnose the direct and indirect effect of important factors on the total sesame production which are summarized in table 7 to table 8 with respect to Madhya Pradesh and India as a whole respectively. Direct effects are represented by diagonal elements, while indirect effects are represented by off-diagonal elements (Table 7). This reveals thatarea had the highest positive effect (0.7047), followed by productivity (0.3772) (Figure 4). Table 8 represents the path coefficient analysis between selected factors and sesame production in India. This indicates that productivity had a highly positive effect (0.8848) on sesame production followed by area (0.5399) (Figure 5).

Table 7: Path coefficient between sesame production and selectedfactors in Madhya Pradesh

Production	Area	Productivity	MSP	r
Area	**0.7047**	0.2674	-0.0110	=0.9611
Productivity	0.4995	**0.3772**	-0.0102	=0.8665
MSP	0.5874	0.2910	**-0.0132**	=0.8652

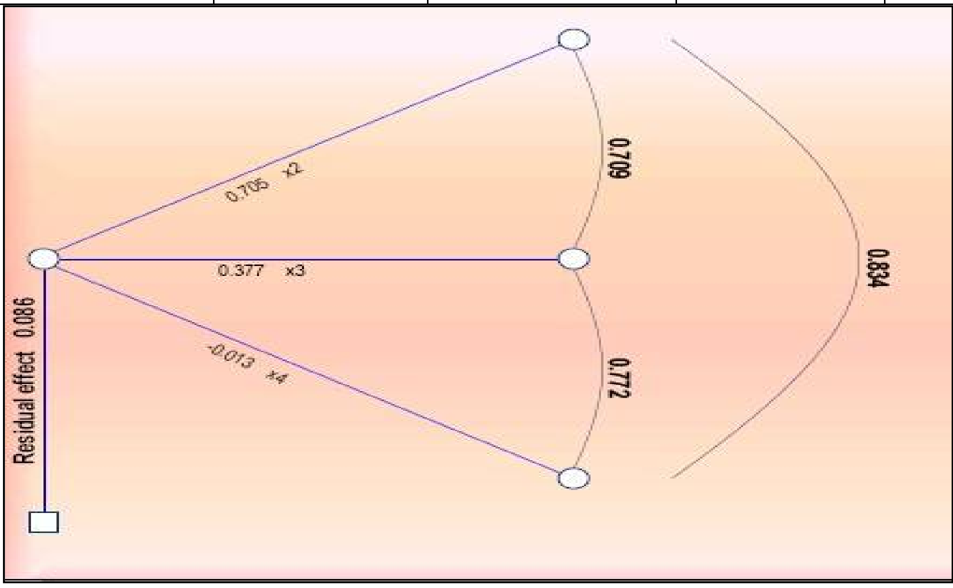

Figure 4: Path diagram includes the variables X1, X3, and X4, towardthe determination of sesame production in Madhya Pradesh.

Table 8: Path coefficient between sesame production and selectedfactors in India

Production	Area	Productivity	MSP	r
Area	**0.5399**	-0.0476	0.0049	=0.4972
Productivity	-0.0291	**0.8848**	-0.0212	=0.8345
MSP	-0.0854	0.5987	**-0.0313**	=0.4820

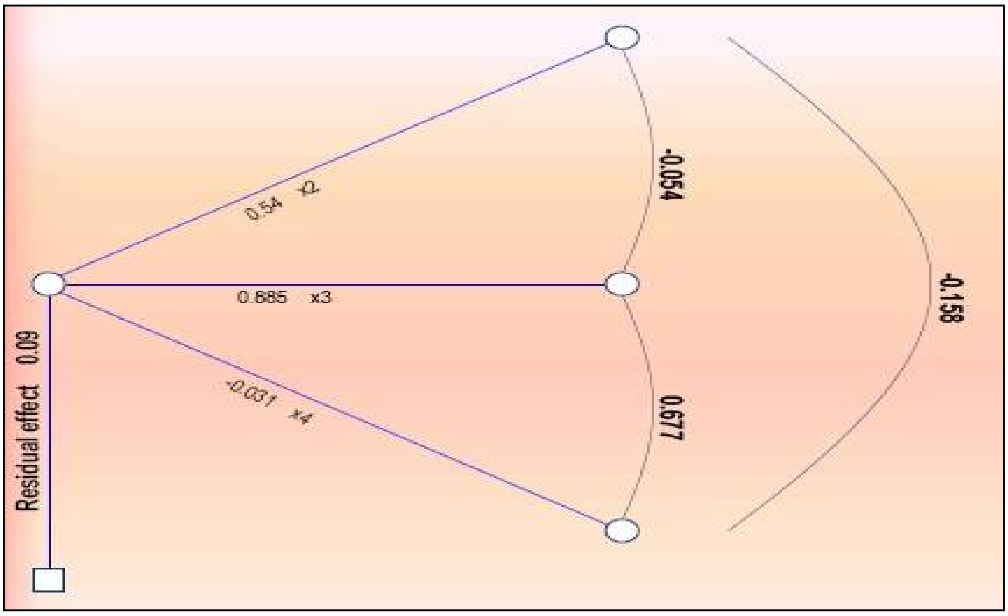

Figure 5: Path diagram includes the variables X1, X3, and X4, towardsthe determination of sesame production in India.

Direct & Indirect Influence: The table 9 and 10 are showing the direct and indirect influence of Sesame factors on the total Sesame production in Madhya Pradesh and India. The table 9 reveals that the most direct influencing factor for sesame production was area, which ranked first, followed by productivity, which ranked second, and minimum support price, which ranked third. The total indirect effect of the other factors was ranked first in case of MSP followed by productivity and area. Except for the minimum support price, all of the factors had a direct positive impact on sesame production in India (Table 10). Sesame productivity ranked first, followed by sesame area. India had the greatest total indirect effect of the other factors in case of minimum support price considered for direct effect.

Table 9: Direct and indirect influence of Sesame factors on the totalSesame production in MP

Factors	Direct influence	Rank of direct influence	Total indirect influence	Rank of indirect influence
Sesame area	0.7047	1	0.2564	3
Sesame productivity	0.3772	2	0.493	2
Minimum support price	-0.0132	3	0.8784	1

Table 10: Direct and indirect influence of Sesame factors on the totalSesame production in India

Factors	Direct influence	Rank of direct influence	Total indirect influence	Rank of indirect influence
Sesame area	0.5399	2	-0.0427	2
Sesame productivity	0.8848	1	-0.0503	3
Minimum support price	-0.0313	3	0.5133	1

Statistical Model Trend: Five statistical models linear, quadratic, cubic, compound, and exponential were tested to determine the changing pattern of area, production,productivity and MSP of sesame crop in Madhya Pradesh and India. The statistical coefficients of the parameters of each model were determined and expected frequencies were calculated on the basis of model equations. Abest model was selected on the basis of R^2, Adjusted R^2, standard error of estimation, and RMSS value. In a set of competing best fitted appropriate models, a best-fit parsimonious model has the highest adjusted R^2 with the greater number of parameters. The result obtained after fitting of these models on the 24 years data of area, production, productivity, and minimum support price of sesame crop in Madhya Pradesh and India are described below in tables 11 to 17 with figure 6 to 12.

Table 11: Value of different criterion (model wise) on Sesame Area in Madhya Pradesh

Models	t=24				
	Equation	R^2	Adj R^2	Std. Err. Of est.	RMSS
Linear	$Y=95.99+10.89t$	0.714	0.701	49.903	2490.263
Quadratic	$Y=130.80+2.86t+0.32t^2$	0.737	0.712	48.920	2393.185
Cubic	$Y=241.89-45.58t+5.06t^2-0.01t^3$	0.871	0.852	35.099	1231.960
Compound	$Y=120.32*1.04^t$	0.730	0.717	0.206	.042
Exponential	$Y=120.32e^{0.04t}$	0.730	0.717	0.206	.042

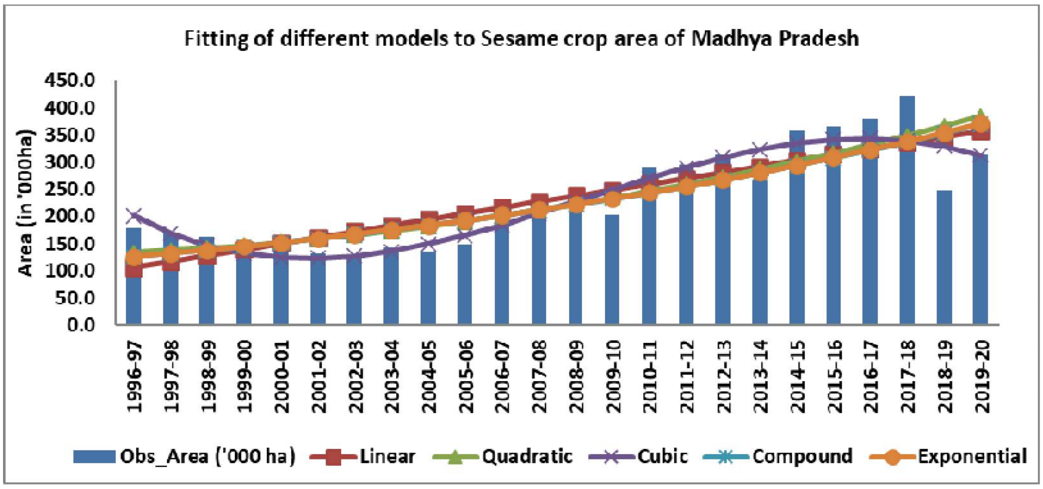

Figure 6. fitting of different model to sesame crop area of Madhya Pradesh

Table 12: Value of different criterion (model wise) on SesameProduction in Madhya Pradesh

Models	t=24				
	Equation	R^2(%)	Adj R^2	Std. Err. Ofest.	RMSS
Linear	Y=8.44+7.10t	.804	.795	25.359	643.087
Quadratic	$Y=9.90+6.77t+0.01t^2$	.804	.786	25.949	673.331
Cubic	$Y=78.78-23.27t+2.95t^2-0.07t^3$	.941	.932	14.648	214.557
Compound	$Y=28.92*1.08^t$	.840	.833	.260	.068
Exponential	$Y=28.92*e^{0.08t}$	.840	.833	.260	.068

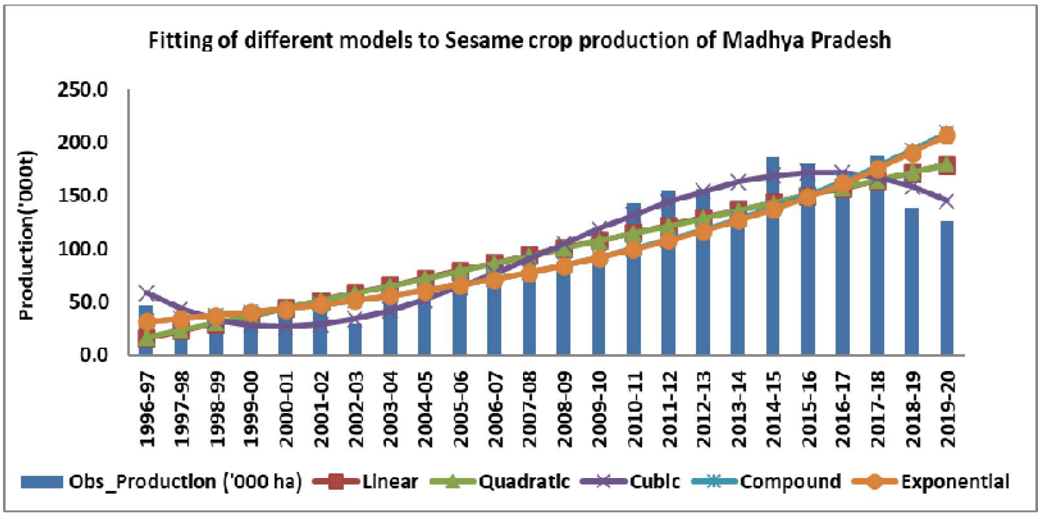

Figure 7. fitting of different model to sesame crop production of Madhya Pradesh

Table 13: Value of different criterion (model wise) on Sesame Productivity in Madhya Pradesh

Models	t=24				
	Equation	R^2(%)	Adj R^2	Std. Err. Of est.	RMSS
Linear	Y=230.03+12.84t	.733	.721	56.068	3143.658
Quadratic	$Y=160.43+28.91t-0.64t^2$	.803	.784	49.309	2431.352
Cubic	$Y=250.34-10.30t+3.20t^2-0.10t^3$	.868	.848	41.398	1713.820
Compound	$Y=240.42*1.03^t$	.738	.726	.154	.024
Exponential	$Y=240.42*e^{0.03t}$	.738	.726	.154	.024

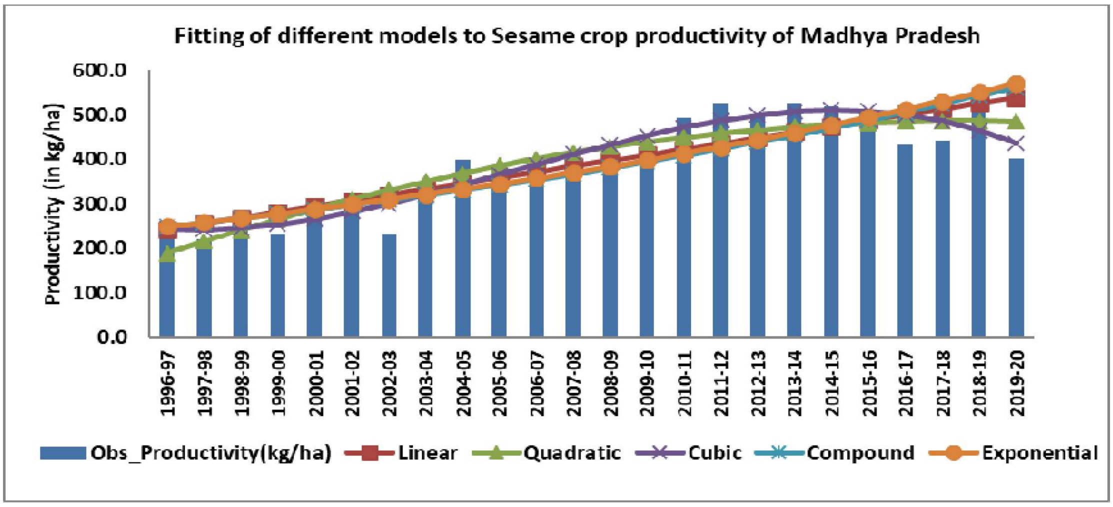

Figure 8. fitting of different model to sesame crop productivity of Madhya Pradesh

Table 14: Value of different criterion (model wise) on Sesame Area in India

Models	**t=24**				
	Equation	**R^2 (%)**	**Adj R^2**	**Std. Err. Of est.**	**RMSS**
Linear	Y=1742.84-0.98t	.002	-.044	166.813	27826.553
Quadratic	Y=1598.27+32.37t-1.33t^2	.129	.046	159.476	25432.711
Cubic	Y=1891.75-95.61t+11.20t^2-0.33t^2	.421	.334	133.284	17764.667
Compound	Y=1737.34*0.99^t	.002	-.043	.096	.009
Exponential	Y=1737.34*$e^{0.00t}$	.002	-.043	.096	.009

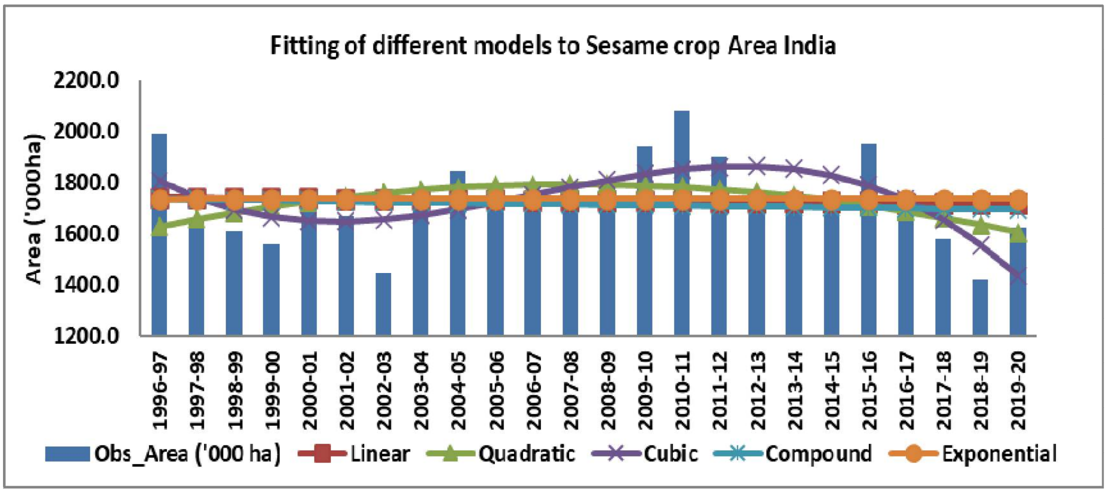

Figure 9. fitting of different model to sesame crop area in India

Table 15: Value of different criterion (model wise) on SesameProduction in India

Models	**t=24**				
	Equation	**R^2(%)**	**AdjR^2**	**Std. Err. Of est.**	**RMSS**
Linear	Y=553.08+9.78t	.349	.320	96.585	9328.657
Quadratic	Y=492.25+23.82t-0.56t^2	.393	.335	95.470	9114.451
Cubic	Y=615.93-30.11t+4.72t^2-0.14t^3	.494	.418	89.344	7982.391
Compound	Y=549.45*1.01^t	.358	.329	.148	.022
Exponential	Y=549.45*$e^{0.01t}$	.358	.329	.148	.022

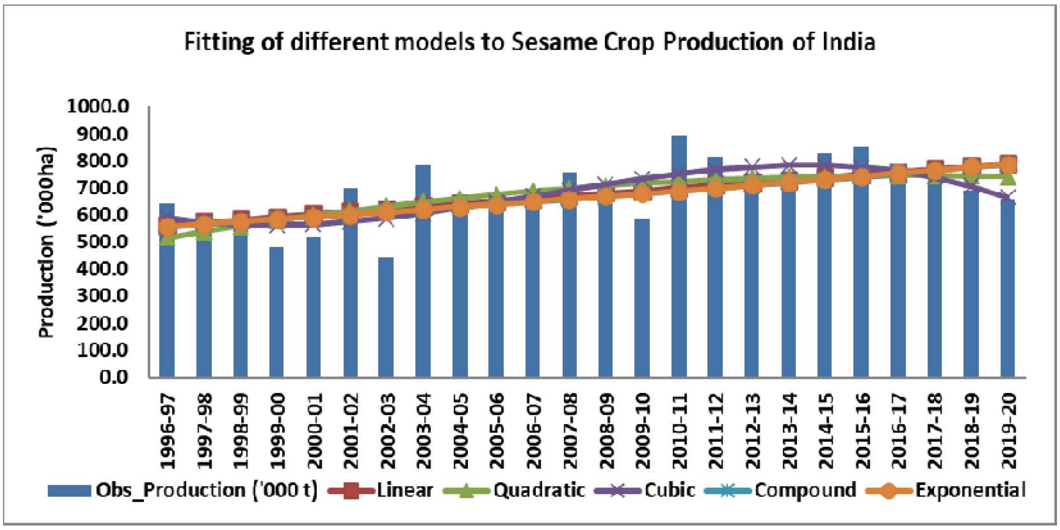

Figure 10 fitting of different model to sesame crop production in India

Table 16: Value of different criterion (model wise) on Sesame Productivity in India

Models	t=24				
	Equation	R^2(%)	Adj R^2	Std. Err. Of est.	RMSS
Linear	Y=313.86+6.13t	.521	.499	42.549	1810.400
Quadratic	$Y=316.11+5.60t+0.02t^2$	.521	.476	43.540	1895.712
Cubic	$Y=322.61+2.78t+0.29t^2-0.001t^3$	.522	.451	44.566	1986.111
Compound	$Y=316.24*1.01^t$	.515	.493	.112	.013
Exponential	$Y=316.24*e^{0.01t}$	.515	.493	.112	.013

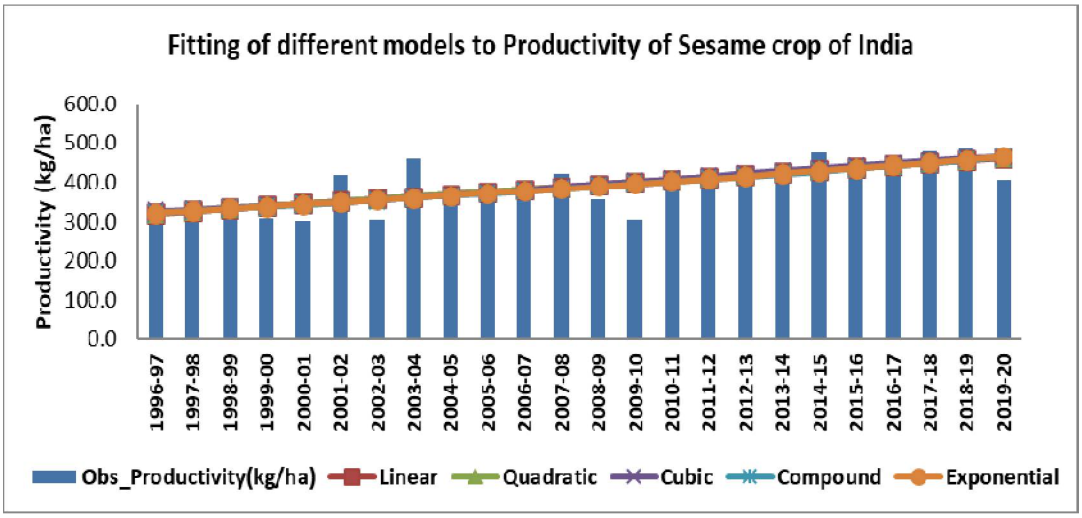

Figure 11. fitting of different model to sesame crop productivity in India

Table 17: Value of different criterion (model wise) on Sesame MSP inMP and India

Models	t=24				
	Equation	R^2(%)	AdjR^2	Std. Err. Of est.	RMSS
Linear	Y=-176.35+243.73t	.909	.905	557.450	310750.141
Quadratic	$Y=995.95-26.79t+10.82t^2$	.977	.975	284.625	81011.160
Cubic	$Y=1169.79-102.61t+18.25t^2-0.19t^3$	.978	.975	286.225	81924.998
Compound	$Y=760.16*1.09^t$	.962	.960	.130	.017
Exponential	$Y=760.16*e^{0.09t}$	.962	.960	.130	.017

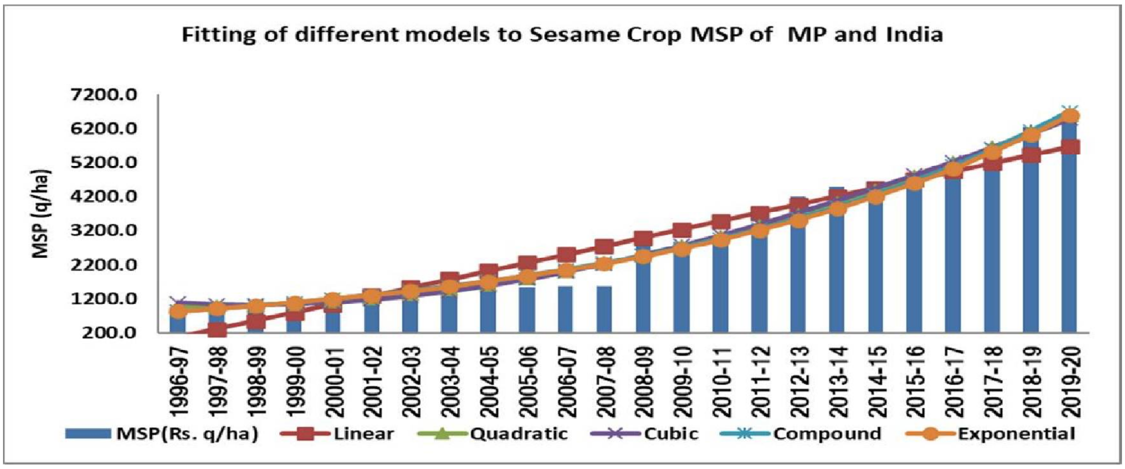

Figure 12. fitting of different model to sesame crop MSP of Madhya Pradeshand India

DISCUSSION

In the present study an attempt has been made to determine the growth pattern of sesame crop in Madhya Pradesh and India. During the study it was found that from 2017-18 there is a decrease in Area, production and productivity of sesame crop in Madhya Pradesh and India. The values of the coefficients of variation revealed the existence of greater inconsistency (fluctuation) in the data. The authors [8] were also reported that there was no significant expansion in area of sesame and groundnut over the study period. Instability in production and a high degree of variability on productivity of oilseeds was also found in most of the states. The maximum linear and compound growth rates was found for Minimum support price of sesame for both in India and Madhya Pradesh followed by production in Madhya Pradesh and productivity in India respectively. The minimum linear growth rate and compound growth rate have been observed with respect to area in India, and in productivity in Madhya Pradesh. The authors [9] found that growth rates of oilseed production accelerated both due to the increasing contribution of both area and productivity.

The maximum coefficient of variation was observed for minimum support price both in India as well as in Madhya Pradesh. The minimum coefficient of variation was observed for productivity in Madhya Pradesh and for area in India. Hence, it concluded that the most stable factors were area and productivity in India and Madhya Pradesh, respectively. The decomposition analysis depicts that area was the primary factor responsible for the increase in sesame crop production in MP, while yield and interaction impact were secondary. In the case of sesame production in India, yield was the primary responsible element for a growth in sesame crop production,while area and interaction impact were secondary and have negative effect. The authors [10] also uses decomposition analysis for groundnut crop and found that the production of groundnut was completely due the change in area under the crop and the yield and interaction effects were very small.

Sesame production was positively and significantly correlated with sesame area, productivity and minimum support price. These factors were interconnected with each other. The results indicated that the productivity of sesame had a highly positive and significant correlation with sesame production in India followed by area and MSP. The oilseed crops also utilizes correlation and path analysis and found that area and productivity were positively and significantly correlated with production in all the regions and the direct effect of area was higher than the direct effect of productivity on oilseed production [11]. In our study, we the Path analysis result reveals that the most direct influencing factor for sesame production was area, followed by productivity and minimum support price The total indirect effect of the other factors was ranked first in case of MSP followed by productivity and area. Except for the minimum support price, all of the factors had a direct positive impact on sesame production in India.

Five statistical models linear, quadratic, cubic, compound, and exponential were tested to determine the changing pattern of area,production, productivity and MSP of sesame crop in Madhya Pradesh and India. On the basis of Adjusted R^2 value and the number of parameters in the model Cubic followed by Quadratic is found the most suitable model for representing the growth pattern of all the factors of sesame crop in Madhya Pradesh and India, except for India the linear model was found best suitable for productivity.

CONCLUSION

From the present investigations, it is concluded that, The Maximum growth rate has been obtained in minimum support price followed by production in Madhya Pradesh and productivity in India. Minimum support price has been found the most unstable factor followed by production in both Madhya Pradesh and India. Area was the primary factor responsible for the increase in sesamecrop production in MP, while yield and interaction impact were secondary. In India productivity was the primary responsible element for a growth in sesame crop production, while area and interaction impact were secondary and have negative effect. The cubic and quadratic growth model are the most suitable models for area, production, productivity and MSP in MP as well as India, except in India the linear model was found best suitable for productivity. By studying the path coefficient analysis, we came to know which all major factors are influencing more to the sesame production and helpto sustainable sesame production with improved productivity to ensure oil security in the country. Some non-linear stochastic models should be fitted for the predictions of sesame production. Since the data related to time, hence time series analysis may be performed and forecasting may be done using time series models.

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