International Journal of Statistics and Applied Mathematics

ISSN: 2456-1452
Maths 2023; 8(6): 165-171

https://www.mathsjournal.com
Received: 22-09-2023
Accepted: 25-10-2023

Rahul K Joshi
Ph.D. Scholar, Department of Agricultural Economics, C. P. C. A., S. D. A. U., Sardarkrushinagar, Gujarat, India

KP Thakar
Associate Professor, Department of Agricultural Economics, C. P. C. A., S. D. A. U., Sardarkrushinagar, Gujarat, India

Rajdeepsinh Jadeja
Assistant Professor, Department of Agricultural Economics, C. P. C. A., S. D. A. U., Sardarkrushinagar, Gujarat, India

Soumya C
Assistant Professor, Department of Agricultural Economics, C. P. C. A., S. D. A. U., Sardarkrushinagar, Gujarat, India

Corresponding Author:
KP Thakar
Associate Professor, Department of Agricultural Economics, C. P. C. A., S. D. A. U., Sardarkrushinagar, Gujarat, India

A statistical analysis of major oilseeds area, production and productivity in Gujarat state

Rahul K Joshi, KP Thakar, Rajdeepsinh Jadeja and Soumya C

Abstract
The study was carried out on growth rates area, production and productivity of major oilseeds crop in Gujarat state for the period 1988-89 to 2020-21. Four major crops of state *viz*. Castor, Rapeseed-Mustard, Groundnut and Sesame were selected for the study on the basis of their diversified cropping pattern in different regions depending upon agro-climatic conditions. Three districts were selected purposively for the study *viz*., Rajkot district for Groundnut, Banaskantha district for Rapeseed-Mustard and Castor and Kutch district for Sesame crop based on highest triennium average area occupied as per the year from 2016-17 to 2018-19. For further study compared different models *viz*., linear, quadratic, cubic, exponential, compound, logarithmic, inverse, power, S-curve and growth models for estimating the growth in area, production, and productivity and found the best fit using the statistical methods such as highest R^2 and adjusted R^2. Overall study revealed that cubic function model was best fitted model for the future estimation.

Keywords: Major oilseeds, growth rate, statistical models, highest R^2, adjusted R^2

Introduction
History of agriculture in India dates back to the Rigveda, written about 1100 BC. Agriculture is also called as farming or husbandry, is the cultivation of plants, fungi and other life forms for food, fiber, bio-fuel, medicinal and other products and rearing of animals used to sustain and enhance human life. The study of agriculture is known as agricultural science. In India, a number of oilseed crops are classified as edible or non-edible depending on their intended usage. Gujarat located in western India is one of the major oilseed-producing states in the country. The state's diverse agro-climatic conditions make it suitable for the cultivation of various oilseed crops Anonymous (2021) [1].

Methodology
Four major crops of state *viz*. Castor, Rapeseed-Mustard, Groundnut and Sesame were selected for the study on the basis of their diversified cropping pattern in different regions depending upon agro-climatic conditions. Three districts were selected purposively for the study *viz*., Rajkot district for Groundnut, Banaskantha district for Rapeseed-Mustard and Castor and Kutch district for Sesame crop based on highest triennium average area occupied as per the year from 2016-17 to 2018-19.

Data nature and their sources
Secondary time series data were used for the analysis to fulfill this objective. Four major crops, Castor, Rapeseed-Mustard, Groundnut and Sesame, were selected for the study based on highest triennium average area from the year 2016 to 2018. The data were collected from published records of Directorate of Agriculture Gujarat Anonymous (2021) [1].
The data from the year 1988-89 to 2020-21 was analysed to understand the overall performance of growth rates in area, production and productivity over the long period of 33 years. We were comparing different models *viz*., linear, quadratic, cubic, exponential, compound, logarithmic, inverse, power, S - curve and growth model for estimating the growth in area, production, and productivity and best fit was found using the statistical methods such as highest R^2 and adjusted R^2.

- Linear growth rate was estimated by using following linear function,

$Yt = a + bt + et$

- Quadratic trend equation which was used is

$Yt = a + bt + ct^2 + et$

- Cubic function is given by

$Yt = a + bt + ct^2 + dt^3$

- Exponential function

The fit is given by $Yt = ae^{bt}$

- Compound function

The function of this type can be given by $Yt = ab^t$

- Logarithmic function

The equation is given by $Yt = a + b\ ln\ (t)$

- Inverse Function

The mathematical equation is given by $Yt = a + b/t$

- Power function

The fit is given by $Yt = at^b$

- S- curve

The fit is given by $Yt = e^{(a + b/t)}$

- Growth function

The mathematical equation is given by $Yt = e^{(a + (b*t))}$

Where,

Yt = Dependent variable for which growth rate was estimated

a = Constant/intercept

b, c and d = Regression coefficients

t = Time variable in years (1, 2, 3, .t)

The goodness of fit was examined by using the co-efficient of determination.

This is most appropriate for nonlinear statistical model.

$$R^2 = 1 - \frac{\sum(\hat{y}_i - y_i)^2}{\sum(y_i - \bar{y}_i)^2}$$

It was used as the coefficient of determination for goodness of fit. The potential range of values of this R^2 is well defined with end points corresponding to perfect fit and complete lack of fit, such as $0 < R^2 < 1$, where $R^2 = 1$ corresponds to perfect fit and $R^2 \geq 1$ for any reasonable model specification. Growth models are that which describes the behaviour of a variable overtime.

The choice of the model amongst the available alternatives was judged on adjusted R^2 as the criterion of model selection.

Adjusted $R^2 = 1- [(1-R^2)\ n-1/n-p-1]$

Where, p is the number of parameters in the equation and n is the number of observations.

Results and Discussion

Growth rates in area, production and productivity of castor crop in Gujarat state

The annual growth rates in area, production and productivity of castor crop in Gujarat state have been estimated.

Table 1: Parametric values of fitted models for area of castor crop in Gujarat state (1988-89 to 2020-21)

Model	Coefficients				Goodness of fit	
	a	b	c	d	R^2	Adj R^2
Linear	2022.317	140.685	-	-	0.613	0.558
Quadratic	2689.069	26.385	3.362	-	0.638	0.586
Cubic	3102.518	-109.501	13.206	-0.193	0.644	0.593
Exponential	2408.658	0.032	-	-	0.657	0.608
Compound	2408.658	1.032	-	-	0.657	0.608
Logarithmic	866.17	1376.401	-	-	0.462	0.385
Inverse	4960.372	-4409.965	-	-	0.223	0.112
Power	1771.991	0.327	-	-	0.558	0.495
S-Curve	8.468	-1.171	-	-	0.336	0.241
Growth	7.787	0.32	-	-	0.657	0.608

The data presented in Table 1, for area of castor crop in Gujarat state revealed that the maximum value of highest R^2 (65.70%) and adjusted R^2 (60.80%) were found in exponential, compound and growth function models. So, these models are the best models for future projection of area of castor crop. Similar result was found by Vijay *et al*., (2023) [5], Sathish *et al*., (2017) [12].

Table 2: Parametric values of fitted models for production of castor crop in Gujarat state (1988-89 to 2020-21)

Model	Coefficients				Goodness of fit	
	a	b	c	d	R^2	Adj R^2
Linear	2509.883	344.955	-	-	0.656	0.607
Quadratic	4065.470	78.283	7.843	-	0.680	0.634
Cubic	5434.022	-371.512	40.428	-0.639	0.692	0.648
Exponential	3660.236	0.042	-	-	0.675	0.629
Compound	3660.236	1.043	-	-	0.675	0.629
Logarithmic	-272.777	3354.878	-	-	0.489	0.416
Inverse	9667.698	-10440.321	-	-	0.223	0.112
Power	2421.902	0.436	-	-	0.578	0.518
S-Curve	9.108	-1.540	-	-	0.338	0.243
Growth	8.205	0.042	-	-	0.675	0.629

The data presented in Table 2, for production of castor crop in Gujarat state revealed that the maximum value of highest R^2 (69.20%) and adjusted R^2 (64.80%) were found in cubic function model. So, this model is the best model for future projection of production of castor crop.

Table 3: Parametric values of fitted models for Productivity of castor crop in Gujarat state (1988-89 to 2020-21)

Model	Coefficients				Goodness of fit	
	a	B	c	D	R^2	Adj R^2
Linear	1512.957	18.803	-	-	0.448	0.369
Quadratic	1511.340	19.081	-0.008	-	0.448	0.369
Cubic	1565.098	1.412	1.272	-0.025	0.452	0.374
Exponential	1519.616	0.010	-	-	0.420	0.337
Compound	1519.616	1.010	-	-	0.420	0.337
Logarithmic	1323.481	197.537	-	-	0.390	0.303
Inverse	1914.230	-658.703	-	-	0.204	0.090
Power	1366.768	0.109	-	-	0.369	0.279
S-Curve	7.548	-0.369	-	-	0.198	0.083
Growth	7.326	0.010	-	-	0.420	0.337

The data presented in Table 3, for productivity of castor crop in Gujarat state revealed that the maximum value of highest R^2 (45.20%) and adjusted R^2 (37.40%) were found in cubic function model. So, this model is the best model for future projection of productivity of castor crop.

Growth rates in area, production and productivity of rapeseed-mustard crop in Gujarat state

The annual growth rates of the rapeseed-mustard crop in Gujarat state have been estimated.

Table 4: Parametric values of fitted models for area of rapeseed-mustard crop in Gujarat state (1988-89 to 2020-21)

Model	Coefficients				Goodness of fit	
	a	B	c	D	R^2	Adj R^2
Linear	3780.733	-58.069	-	-	0.517	0.448
Quadratic	3699.886	-44.209	-0.408	-	0.519	0.450
Cubic	3335.411	75.581	-9.086	0.170	0.541	0.475
Exponential	3827.602	-0.021	-	-	0.496	0.424
Compound	3827.602	0.979	-	-	0.496	0.424
Logarithmic	4150.464	-526.460	-	-	0.335	0.240
Inverse	2677.488	936.803	-	-	0.050	-0.086
Power	4361.247	-0.188	-	-	0.319	0.222
S-Curve	7.853	0.350	-	-	0.052	-0.083
Growth	8.250	-0.021	-	-	0.496	0.424

According to Table 4, for rapeseed-mustard crop area in Gujarat state, the cubic function model had the highest R^2 value (54.10%) and adjusted R^2 (47.50%). As a result, this model is the best model for predicting the area of rapeseed-mustard crop in future. Similar result was found by Delvadiya *et al*., (2023) [3].

Table 5: Parametric values of fitted models for production of rapeseed-mustard crop in Gujarat state (1988-89 to 2020-21)

Model	Coefficients				Goodness of fit	
	a	B	c	D	R^2	Adj R^2
Linear	4001.157	-11.156	-	-	0.016	-0.125
Quadratic	4048.160	-19.214	0.237	-	0.017	-0.123
Cubic	3934.157	18.255	-2.477	0.053	0.019	-0.121
Exponential	3876.997	-0.003	-	-	0.010	-0.131
Compound	3876.997	0.997	-	-	0.010	-0.131
Logarithmic	4036.405	-87.261	-	-	0.008	-0.134
Inverse	3826.555	-121.522	-	-	0.001	-0.142
Power	3961.542	-0.025	-	-	0.008	-0.134
S-Curve	8.220	-0.005	-	-	0.000	-0.143
Growth	8.263	-0.003	-	-	0.010	-0.131

According to Table 5, for rapeseed-mustard production in Gujarat state, the cubic function model had the highest R^2 value (1.90%) and adjusted R^2 (-12.10%). As a result, this model is the best model for predicting the production of rapeseed-mustard crop in future.

Table 6: Parametric values of fitted models for productivity of rapeseed-mustard crop in Gujarat state (1988-89 to 2020-21)

Model	Coefficients				Goodness of fit	
	A	B	c	D	R^2	Adj R^2
Linear	972.338	25.977	-	-	0.688	0.643
Quadratic	1142.964	-3.273	0.860	-	0.742	0.705
Cubic	1240.180	-35.225	3.175	-0.045	0.753	0.718
Exponential	1012.905	0.018	-	-	0.649	0.599
Compound	1012.905	1.018	-	-	0.649	0.599
Logarithmic	820.382	230.294	-	-	0.426	0.344
Inverse	1477.801	-515.369	-	-	0.100	-0.029
Power	908.351	0.163	-	-	0.406	0.321
S-Curve	7.275	-0.355	-	-	0.091	-0.039
Growth	6.921	0.018	-	-	0.649	0.599

According to Table 6, for rapeseed-mustard productivity in Gujarat state, the cubic function model had the highest R^2 value (75.30%) and adjusted R^2 (71.80%). As a result, this model is the best model for predicting the productivity of rapeseed-mustard crop in future.

Growth rates in area, production and productivity of *kharif*, summer and total groundnut crop in Gujarat state

For groundnut crop season wise (*kharif*, summer and total) annual growth rate of Gujarat state have been estimated.

The annual growth rates of the *kharif* groundnut crop in Gujarat state have been estimated.

Table 7: Parametric values of fitted models for area of *kharif* groundnut crop in Gujarat state (1988-89 to 2020-21)

Model	Coefficients				Goodness of fit	
	a	B	c	d	R^2	Adj R^2
Linear	18667.780	-77.330	-	-	0.152	0.031
Quadratic	18400.386	-29.776	-1.399	-	0.155	0.034
Cubic	15799.153	825.157	-63.333	1.214	0.343	0.249
Exponential	18740.699	-0.005	-	-	0.159	0.039
Compound	18740.699	0.995	-	-	0.159	0.039
Logarithmic	19049.092	-654.113	-	-	0.085	-0.046
Inverse	17210.857	1229.328	-	-	0.014	-0.127
Power	19187.572	-0.041	-	-	0.090	-0.040
S-Curve	9.746	0.080	-	-	0.016	-0.125
Growth	9.838	-0.005	-	-	0.159	0.039

According to Table 7, the cubic model had highest R^2 value (34.30%) and adjusted R^2 (24.90%) for *kharif* groundnut area in Gujarat state. As a result, this model is the best one for projecting future *kharif* groundnut area.

Table 8: Parametric values of fitted models for production of *kharif* groundnut crop in Gujarat state (1988-89 to 2020-21)

Model	Coefficients				Goodness of fit	
	a	b	c	d	R^2	Adj R^2
Linear	11050.184	673.716	-	-	0.277	0.174
Quadratic	14871.789	18.584	19.269	-	0.294	0.193
Cubic	14864.716	20.908	19.100	0.003	0.294	0.193
Exponential	10561.919	0.034	-	-	0.243	0.135
Compound	10561.919	1.034	-	-	0.243	0.135
Logarithmic	7236.549	5923.317	-	-	0.169	0.050
Inverse	23825.976	-10674.654	-	-	0.026	-0.113
Power	8756.098	0.296	-	-	0.147	0.025
S-Curve	9.895	-0.450	-	-	0.016	-0.125
Growth	9.265	0.034	-	-	0.243	0.135

According to Table 8, the quadratic and cubic models had highest R^2 value (29.40%) and adjusted R^2 (19.30%) for *kharif* groundnut production in Gujarat state. As a result, these models are the best one for projecting future *kharif* groundnut production.

Table 9: Parametric values of fitted models for productivity of *kharif* groundnut crop in Gujarat state (1988-89 to 2020-21)

Model	Coefficients				Goodness of fit	
	a	B	C	d	R^2	Adj R^2
Linear	560.924	43.795	-	-	0.352	0.259
Quadratic	814.025	0.406	1.276	-	0.373	0.283
Cubic	1006.527	-62.863	5.860	-0.090	0.381	0.293
Exponential	563.582	0.039	-	-	0.315	0.217
Compound	563.582	1.039	-	-	0.315	0.217
Logarithmic	323.299	381.055	-	-	0.210	0.097
Inverse	1390.026	-682.741	-	-	0.032	-0.106
Power	456.343	0.337	-	-	0.188	0.072
S-Curve	7.057	-0.530	-	-	0.022	-0.118
Growth	6.334	0.039	-	-	0.315	0.217

According to Table 9, the cubic model had highest R^2 value (38.10%) and adjusted R^2 (29.30%) for *kharif* groundnut productivity in Gujarat state. As a result, this model is the best one for projecting future *kharif* groundnut productivity.

Table 10: Parametric values of fitted models for area of summer groundnut crop in Gujarat state (1988-89 to 2020-21)

Model	Coefficients				Goodness of fit	
	a	B	C	D	R^2	Adj R^2
Linear	1112.762	-11.414	-	-	0.055	-0.080
Quadratic	991.764	9.329	-0.610	-	0.066	-0.067
Cubic	1501.252	-158.122	11.521	-0.238	0.185	0.069
Exponential	1111.559	-0.018	-	-	0.127	0.002
Compound	1111.559	0.982	-	-	0.127	0.002
Logarithmic	1227.124	-119.654	-	-	0.047	-0.089
Inverse	864.676	436.239	-	-	0.030	-0.109
Power	1339.095	-0.191	-	-	0.112	-0.015
S-Curve	6.625	0.663	-	-	0.064	-0.070
Growth	7.014	-0.018	-	-	0.127	0.002

The data presented in Table 10, for area of summer groundnut crop in Gujarat state revealed that the maximum value of highest R^2 (18.50%) and adjusted R^2 (6.90%) were found in cubic function model. So, this model is the best model for future projection of area of summer groundnut crop.

Table 11: Parametric values of fitted models for production of summer groundnut crop in Gujarat state (1988-89 to 2020-21)

Model	Coefficients				Goodness of fit	
	a	B	c	D	R^2	Adj R^2
Linear	1705.621	-5.614	-	-	0.004	-0.138
Quadratic	1484.017	32.375	-1.117	-	0.016	-0.125
Cubic	2288.135	-231.910	18.028	-0.375	0.109	-0.018
Exponential	1658.260	-0.008	-	-	0.028	-0.111
Compound	1658.260	0.992	-	-	0.028	-0.111
Logarithmic	1726.822	-45.254	-	-	0.002	-0.141
Inverse	1603.263	55.860	-	-	0.000	-0.143
Power	1806.848	-0.087	-	-	0.025	-0.114
S-Curve	7.244	0.245	-	-	0.009	-0.133
Growth	7.414	-0.008	-	-	0.028	-0.111

The data presented in Table 11, for production of summer groundnut crop in Gujarat state revealed that the maximum value of highest R^2 (10.90%) and adjusted R^2 (-1.8%) were found in cubic function model. So, this model is the best model for future projection of production of summer groundnut crop.

Table 12: Parametric values of fitted models for productivity of summer groundnut crop in Gujarat state (1988-89 to 2020-21)

Model	Coefficients				Goodness of fit	
	a	B	c	D	R^2	Adj R^2
Linear	1474.571	17.838	-	-	0.509	0.439
Quadratic	1600.603	-3.768	0.635	-	0.555	0.491
Cubic	1434.623	50.784	-3.316	0.077	0.603	0.546
Exponential	1491.832	0.010	-	-	0.513	0.443
Compound	1491.832	1.010	-	-	0.513	0.443
Logarithmic	1312.940	180.364	-	-	0.410	0.326
Inverse	1861.820	-678.024	-	-	0.272	0.168
Power	1349.305	0.104	-	-	0.451	0.373
S-Curve	7.526	-0.417	-	-	0.344	0.250
Growth	7.308	0.010	-	-	0.513	0.443

The data presented in Table 12 for productivity of summer groundnut crop in Gujarat state revealed that the maximum value of highest R^2 (60.30%) and adjusted R^2 (54.60%) were found in cubic function model. So, this model is the best model for future projection of productivity of summer groundnut crop.

Table 13: Parametric values of fitted models for area of total groundnut crop in Gujarat state (1988-89 to 2020-21)

Model	Coefficients				Goodness of fit	
	a	b	c	d	R^2	Adj R^2
Linear	19795.655	-88.972	-	-	0.193	0.078
Quadratic	19493.555	-21.761	-1.977	-	0.200	0.086
Cubic	17320.653	662.828	-51.571	0.972	0.315	0.217
Exponential	19883.076	-0.005	-	-	0.197	0.082
Compound	19883.076	0.995	-	-	0.197	0.082
Logarithmic	20889.363	-778.389	-	-	0.116	-0.010
Inverse	18072.644	1698.847	-	-	0.026	-0.113
Power	20473.085	-0.046	-	-	0.118	-0.008
S-Curve	9.795	0.103	-	-	0.027	-0.112
Growth	9.898	-0.005	-	-	0.197	0.082

According to Table 13, for total groundnut area in Gujarat state, the cubic function model had the highest R^2 value (31.50%) and adjusted R^2 (21.70%). As a result, this model is the best model for predicting the area of total groundnut crop in future.

Table 14: Parametric values of fitted models for production of total groundnut crop in Gujarat state (1988-89 to 2020-21)

Model	Coefficients				Goodness of fit	
	a	b	c	d	R^2	Adj R^2
Linear	12592.215	674.178	-	-	0.270	0.166
Quadratic	16209.572	54.060	18.239	-	0.284	0.182
Cubic	17217.379	-277.171	42.234	-0.470	0.285	0.183
Exponential	12126.036	0.031	-	-	0.237	0.128
Compound	12126.036	1.031	-	-	0.237	0.128
Logarithmic	8792.308	5921.040	-	-	0.164	0.045
Inverse	25369.616	-10624.208	-	-	0.025	-0.114
Power	10327.215	0.266	-	-	0.139	0.016
S-Curve	9.977	-0.392	-	-	0.014	-0.127
Growth	9.403	0.031	-	-	0.237	0.128

According to Table 14, for total groundnut production in Gujarat state, the cubic function model had the highest R^2 value (28.50%) and adjusted R^2 (18.30%). As a result, this model is the best model for predicting the production of total groundnut crop in future.

Table 15: Parametric values of fitted models for productivity of total groundnut crop in Gujarat state (1988-89 to 2020-21)

Model	Coefficients				Goodness of fit	
	a	B	c	d	R^2	Adj R^2
Linear	596.430	42.778	-	-	0.360	0.269
Quadratic	849.881	-0.671	1.278	-	0.383	0.295
Cubic	1046.893	-65.422	5.969	-0.092	0.391	0.304
Exponential	609.868	0.036	-	-	0.324	0.227
Compound	609.868	1.037	-	-	0.324	0.227
Logarithmic	364.654	372.077	-	-	0.214	0.102
Inverse	1408.063	-681.295	-	-	0.034	-0.104
Power	504.429	0.312	-	-	0.190	0.074
S-Curve	7.090	-0.494	-	-	0.022	-0.118
Growth	6.413	0.036	-	-	0.324	0.227

According to Table 15, for total groundnut productivity in Gujarat state, the cubic function model had the highest R^2 value (39.10%) and adjusted R^2 (30.40%). As a result, this model is the best model for predicting the productivity of total groundnut crop in future.

Growth rates in area, production and productivity of *kharif*, summer and total sesame crop in Gujarat state

For sesame crop season wise (*kharif*, summer and total) annual growth rate of Gujarat state have been estimated. The annual growth rates of the *kharif* sesame crop in Gujarat state have been estimated.

Table 16: Parametric values of fitted models for area of *kharif* sesame crop in Gujarat state (1988-89 to 2020-21)

Model	Coefficients				Goodness of fit	
	a	B	c	d	R^2	Adj R^2
Linear	-410.917	58.869	-	-	0.503	0.432
Quadratic	-303.346	40.428	0.542	-	0.506	0.435
Cubic	562.960	-244.296	21.169	-0.404	0.625	0.571
Exponential	-	-	-	-	-	-
Compound	-	-	-	-	-	-
Logarithmic	-839.618	554.616	-	-	0.352	0.259
Inverse	774.112	-1487.122	-	-	0.119	-0.007
Power		-	-	-	-	-
S-Curve	-	-	-	-	-	-
Growth	-	-	-	-	-	-

***Note:** *Kharif* sesame (1988-89 to 2008-09) data is not available

According to Table 16, the cubic model had highest R^2 value (62.50%) and adjusted R^2 (57.10%) for *kharif* sesame area in Gujarat state. As a result, this model is the best one for projecting future *kharif* sesame area.

Table 17: Parametric values of fitted models for production of *kharif* sesame crop in Gujarat state (1988-89 to 2020-21)

Model	Coefficients				Goodness of fit	
	a	B	c	D	R^2	Adj R^2
Linear	-179.804	25.244	-	-	0.526	0.458
Quadratic	-129.580	16.634	0.253	-	0.530	0.463
Cubic	285.095	-119.655	10.126	-0.194	0.685	0.640
Exponential	-	-	-	-	-	-
Compound	-	-	-	-	-	-
Logarithmic	-360.527	236.620	-	-	0.364	0.273
Inverse	327.491	-630.749	-	-	0.122	-0.003
Power	-	-	-	-	-	-
S-Curve	-	-	-	-	-	-
Growth	-	-	-	-	-	-

According to Table 17, the cubic model had highest R^2 value (68.50%) and adjusted R^2 (64.00%) for *kharif* sesame production in Gujarat state. As a result, this model is the best one for projecting future *kharif* sesame production.

Table 18: Parametric values of fitted models for productivity of *kharif* sesame crop in Gujarat state (1988-89 to 2020-21)

Model	Coefficients				Goodness of fit	
	a	B	c	D	R^2	Adj R^2
Linear	-154.311	19.216	-	-	0.661	0.613
Quadratic	-30.962	-1.929	0.622	-	0.711	0.670
Cubic	173.109	-69.000	5.481	-0.095	0.792	0.762
Exponential	-	-	-	-	-	-
Compound	-	-	-	-	-	-
Logarithmic	-271.537	172.228	-	-	0.418	0.335
Inverse	227.280	-443.215	-	-	0.130	0.006
Power	-	-	-	-	-	-
S-Curve	-	-	-	-	-	-
Growth	-	-	-	-	-	-

According to Table 18, the cubic model had highest R^2 value (79.20%) and adjusted R^2 (76.20%) for *kharif* sesame productivity in Gujarat state. As a result, this model is the best one for projecting future *kharif* sesame productivity.

Table 19: Parametric values of fitted models for area of summer sesame crop in Gujarat state (1988-89 to 2020-21)

Model	Coefficients				Goodness of fit	
	a	B	c	D	R^2	Adj R^2
Linear	-168.808	19.169	-	-	0.372	0.282
Quadratic	50.683	-18.458	1.107	-	0.462	0.385
Cubic	24.391	-9.817	0.481	0.012	0.463	0.386
Exponential	-	-	-	-	-	-
Compound	-	-	-	-	-	-
Logarithmic	-266.703	164.418	-	-	0.216	0.104
Inverse	207.829	-409.669	-	-	0.063	-0.071
Power	-	-	-	-	-	-
S-Curve	-	-	-	-	-	-
Growth	-	-	-	-	-	-

***Note:** Summer sesame (1988-89 to 2010-11) data is not available

The data presented in Table 19, for area of summer sesame crop in Gujarat state revealed that the maximum value of highest R^2 (46.30%) and adjusted R^2 (38.60%) were found in cubic function model. So, this model is the best model for future projection of area of summer sesame crop.

Table 20: Parametric values of fitted models for production of summer sesame crop in Gujarat state (1988-89 to 2020-21)

Model	Coefficients				Goodness of fit	
	a	B	c	D	R^2	Adj R^2
Linear	-125.971	13.362	-	-	0.382	0.294
Quadratic	79.115	-21.796	1.034	-	0.547	0.482
Cubic	-45.538	19.173	-1.934	0.058	0.583	0.523
Exponential	-	-	-	-	-	-
Compound	-	-	-	-	-	-
Logarithmic	-183.542	110.469	-	-	0.206	0.093
Inverse	134.309	-267.360	-	-	0.057	-0.078
Power	-	-	-	-	-	-
S-Curve	-	-	-	-	-	-
Growth	-	-	-	-	-	-

The data presented in Table 20, for production of summer sesame crop in Gujarat state revealed that the maximum value of highest R^2 (58.30%) and adjusted R^2 (52.30%) were found in cubic function model. So, this model is the best model for future projection of production of summer sesame crop.

Table 21: Parametric values of fitted models for productivity of summer sesame crop in Gujarat state (1988-89 to 2020-21)

Model	Coefficients				Goodness of fit	
	a	B	C	D	R^2	Adj R^2
Linear	-254.584	27.529	-	-	0.675	0.629
Quadratic	106.386	-34.352	1.820	-	0.889	0.873
Cubic	78.943	-25.332	1.167	0.013	0.889	0.873
Exponential	-	-	-	-	-	-
Compound	-	-	-	-	-	-
Logarithmic	-381.803	230.934	-	-	0.374	0.285
Inverse	283.165	-562.992	-	-	0.105	-0.023
Power	-	-	-	-	-	-
S-Curve	-	-	-	-	-	-
Growth	-	-	-	-	-	-

The data presented in Table 21, for productivity of summer sesame crop in Gujarat state revealed that the maximum value of highest R^2 (88.90%) and adjusted R^2 (87.30%) were found in cubic and Quadratic function models. So, these models are the best models for future projection of productivity of summer sesame crop. Similar result was found by Rao and Naidu (2021) [11].

Table 22: Parametric values of fitted models for area of total sesame crop in Gujarat state (1988-89 to 2020-21)

Model	Coefficients				Goodness of fit	
	a	B	C	D	R^2	Adj R^2
Linear	3036.282	-29.511	-	-	0.124	-0.001
Quadratic	1693.298	200.715	-6.771	-	0.595	0.537
Cubic	868.686	471.736	-26.405	0.385	0.700	0.657
Exponential	3081.064	-0.015	-	-	0.160	0.040
Compound	3081.064	0.985	-	-	0.160	0.040
Logarithmic	2668.809	-52.075	-	-	0.003	-0.139
Inverse	2644.793	-889.429	-	-	0.042	-0.095
Power	2682.745	-0.044	-	-	0.011	-0.130
S-Curve	7.822	-0.336	-	-	0.030	-0.109
Growth	8.033	-0.015	-	-	0.160	0.040

According to Table 22, for total sesame area in Gujarat state, the cubic function model had the highest R^2 value (70.00%) and adjusted R^2 (65.70%). As a result, this model is the best model for predicting the area of total sesame crop in future.

Table 23: Parametric values of fitted models for production of total sesame crop in Gujarat state (1988-89 to 2020-21)

Model	Coefficients				Goodness of fit	
	a	B	c	D	R^2	Adj R^2
Linear	1139.984	-3.580	-	-	0.005	-0.137
Quadratic	640.411	82.061	-2.519	-	0.199	0.085
Cubic	221.574	219.718	-12.491	0.196	0.280	0.177
Exponential	1002.759	-0.001	-	-	0.001	-0.142
Compound	1002.759	0.999	-	-	0.001	-0.142
Logarithmic	944.742	52.140	-	-	0.009	-0.133
Inverse	1133.010	-434.875	-	-	0.030	-0.109
Power	829.331	0.067	-	-	0.017	-0.123
S-Curve	6.942	-0.401	-	-	0.028	-0.111
Growth	6.911	-0.001	-	-	0.001	-0.142

According to Table 23, for total sesame production in Gujarat state, the cubic function model had the highest R^2 value (28.00%) and adjusted R^2 (17.70%). As a result, this model is the best model for predicting the production of total sesame crop in future.

Table 24: Parametric values of fitted models for productivity of total sesame crop in Gujarat state (1988-89 to 2020-21)

Model	Coefficients				Goodness of fit	
	A	B	c	D	R^2	Adj R^2
Linear	351.232	4.827	-	-	0.130	0.006
Quadratic	411.349	-5.479	0.303	-	0.167	0.048
Cubic	386.680	2.630	-0.284	0.012	0.171	0.053
Exponential	325.460	0.014	-	-	0.147	0.025
Compound	325.460	1.014	-	-	0.147	0.025
Logarithmic	339.929	36.225	-	-	0.058	-0.077
Inverse	434.100	-6.488	-	-	0.000	-0.143
Power	309.138	0.111	-	-	0.075	-0.057
S-Curve	6.028	-0.066	-	-	0.001	-0.142
Growth	5.785	0.014	-	-	0.147	0.025

According to Table 24, for total sesame productivity in Gujarat state, the cubic function model had the highest R^2 value (17.10%) and adjusted R^2 (5.30%). As a result, this model is the best model for predicting the productivity of total sesame crop in future.

It was found that in most of the crops, the cubic model is the best fitted, for its highest R^2 and adjusted R^2. This model is best for future projection trends with respect to area, production and productivity of major oilseed crops in Gujarat state. The findings for this model is in accordance with results with Kalpana P. (2016) [4], Meena and Prabakaran (2017) [6], Rajan and Palanivel (2018) [10], Murthy and Babu (2018) [7], Pusadekar *et al*., (2020) [8], Biswas *et al*., (2020) [13], Raj *et al*., (2023) [9].

Conclusion

From statically analysis of the data of major oilseeds it can be concluded that the different models *viz*., expotential, compound, growth, quadratic and cubic function models where found fitted model for future estimation of area, production and productivity of major oilseeds in Gujarat state, among these cubic model function should be found best fitted model for future estimation.

References

1. Anonymous. Directorate of Oilseeds Development India; c2021. https://oilseeds.dac.gov.in/Introduction.aspx Accessed on 11th June 2023.
2. Anonymous[1]. Report of agricultural data. Directorate of Agriculture, Government of Gujarat, Gandhinagar; c2021.
3. Delvadiya JB, Patel UB, Padaliya M, Gohil VM. An application of ARIMA for forecasting rapeseed and mustard area in Gujarat. Int. J Stat Appl Math. 2023;8(5):524-527.
4. Kalpana P. Statistical modeling on growth rates of groundnut crop from 1990 to 2014, in India. Int J Eng Sci Res. 2016;4(10):1-7.
5. Vijay M, Surendra HS, Kamble AS. Statistical analysis on area and production of maize crop in Karnataka. Int. J Creative Res Thoughts. 2023;11(2):e373-e388.
6. Meena PS, Prabakaran K. Linear and non-linear models on paddy crop in different agroclimatic zones of Tamil Nadu. Int J Stat Appl Math. 2017;2(6):277-281.
7. Murthy B, Babu O. A statistical trend analysis of mango area, production, and productivity in Andhra Pradesh. Int. J Agric Stat Sci. 2018;14(1):337-342.
8. Pusadekar NN, Dangore UT, Baviskar PP, Gaware UP, Pusdekar MG. Trend and decomposition analysis of groundnut in Gujarat. J Pharmacogn Phytochem. 2020;9(5):145-147.

9. Raj S, Sinha S, Singh R. Dynamics of production and trend of groundnut and soybean in India. Pharma Innov J. 2023;12(10):949-955.
10. Rajan MS, Palanivel M. Application of regression models for area, production, and productivity growth trends of cotton crop in India. Int. J Stat Distr Appl. 2018;4(2):1-5.
11. Rao SG, Naidu GM. Statistical modeling on area, production, and productivity of wheat in India. Int. J Agricult Stat Sci. 2021;17(2):539-543.
12. Sathish G, Supriya K, Bhave MHV, Samrat L. An analysis of growth rate and trend of chilli in Telangana. Int. J Res Appl Nat Soc Sci. 2017;5(7):113-120.
13. Biswas R, Bhattacharyy B, Chiphang DY. Future prospects of crop productivity in Manipur state. Int. J Creative Res Thoughts. 2020;8(10):2153-2157.