Applicability of Growth Models on Groundnut Research in the World

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Abstract

Growth models are used for understanding present status and predict future growth in any field. Three growth models mainly exponential, linear and logistic growth have been applied to data collected for the world on groundnut (Arachis hypogea). Reviews thirteen similar studies on growth models. The paper is based on analyses of 13394 papers collected from CAB Direct on the subject. Tests applicability of growth models forits future predication and found logistic and exponential growth models most suitable

Keywords: Groundnut, Arachis hypogea, Growth models, Exponential growth model, Linear growth model, Logistic growth model.

1 Introduction

The increase in the amount of literature over a specific period of time is termed as growth of literature. One of the important aspects in scientometric study is forecasting the trend and pattern in growth of literature. To predict the changes of any literature over a period growth models can be applied in scientomentric studies. These models measure the data on scientific level. Growth models in library and information science hold a place in the scientometric study as they predicate the expected changes in any literature in the future. It analyses and predicts the growth in scientific output & performance of research institutes, and increase in the quantity of research output of scientists and researchers. It has strong scientific base to measure the growth of literature with quantitative understanding. In other subject fields, growth models are important tools to help scientists and policy makers in management of their activities and predicate the future needs and required changes in the related areas. There are three growth models available and are fit here to measure the growth of any literature. Here literature is not in literary sense which means other forms of writing in a language but in the sense of 'production of writings.' Growth models are universally used for understanding present status and predict future growth in any field.

There are three models used in growth studies in an area of research. These are

a. Exponential growth model: - It is also known as the Malthusian growth model on the name of Thomas Robert Malthus (1766-1834). Exponential growth assumes that any species can potentially increase in numbers according to a geometric series.

b. Logistic growth model: -Logistic growth assumes that the growth rate is proportional to the product of present size and future growth. Compared to the exponential growth, here an upper limit to the growth curve exists. It follows a slow beginning, followed by sudden growth and then a long period of dispersion.

c. Linear growth model: -There is merely a constant increment in each time period. This model can approximate the growth in shorter periods.

The paper analyses publication activities of groundnut research in the world to find growth models best fitted to the study.

Groundnut is an important oilseeds crop in the world. Asian and African countries have suitable climatic conditions for the production of groundnut. Asia accounts for about 50% of area and 60% of groundnut production of world. Botanically it is known as Arachis Hypogaea.A report of United States Department of Agriculture (USDA) for the year 2018 forecasted that world groundnut production has decreased nearly 1.0 million tons to 44.6 million tons. India, Argentina, China and USA are likely to remain primary exporters in the world. Major oilseeds production for last five years has been shown in table-1.

Table-1
Major oilseeds exports (alphabetical)(commodity view)(in million metric tons)

	2017-18	2016-17	2015/16	2014/15	2013/14
Coconut	0.13	0.14	0.13	0.11	0.11
Cottonseed	1.04	0.89	0.71	0.72	0.94
Palm kernel	0.05	0.08	0.04	0.04	0.04
Groundnut	3.69	3.74	3.54	3.33	2.90
Rapeseed-mustard	16.65	15.80	14.35	15.11	15.10
Soybean	151.26	147.54	132.51	126.22	112.72
Sunflower	2.32	2.44	2.01	1.66	1.96
Total	**175.13**	**170.63**	**153.29**	**147.18**	**133.77**

Source: Oilseeds: World market trade from www.fas.usda.gov/data/oilseeds-world-markets-and-trade

2 Review of literature

The growth models have been applied in many scientometric studies in library and information science. Growth of science literature by Gilbert (1978) measured different growth models in science. It also described the indicators of growth study. Hall (1981) has studied growth rate of computerized database of geosciences. Parvathamma and Gunjal (1993) have studied growth pattern and authors' productivity in the field of Indian earth science. Mahapatra (1994) has analysed correlation between growth of publication and citation data of library and information science from 10 leading journals. Studies on application of growth models by Arunachalam and Umarani (2001) on agriculture research in India, Sangam and Keshva (2003) on social science literature, Garg and others (2010) on genetics and heredity research in India,and Mishra and Balhara (2013) on medical science are otherworth mentioning published works on this topic.Dhoble and Kumar (2017) studied international publication trends in groundnut and mustard research for 14 years. Provides tables for yearly distribution and calculates activity index, relative growth rate and doubling time. Finds India on top followed by USA and UK in activity index. Values of RGR ranges between 0.31 to 0.04 in various years. Doubling time has increased. Also provides tables for communication channels, languages and authorship patterns. Dhoble and Kumar (2018)analyse yearly distribution of 7463 research papers on groundnut and mustard research in India. Activity index of 14 years shows decreasing trend from 141 to 74. RGR has decreasing trend consequently doubling time show increasing trend. Communication channels and authorship pattern have been analysed. Used Chi-square test to test hypotheses.

3 Formula and Methodology

The research data on groundnut in the world has been collected from CAB Direct from Directorate of Soybean Research, Indore for duration of 14 years (2000-2014). The search has been made on various terms like 'groundnut' and 'Arachis Hypogaea'. The data is transferred to M S Excel for further tabulation and analysis.

For the purpose of analysing research publication activity following statistical formulae have been used:-

(a) Exponential growth model:

$$F(t) = ae^{bt}$$

Where a = the initial size of literature, t = time after which growth has to be calculated; b = continuous growth rate = R/100 and R = percentage by which the size increases in each fixed time unit.

(s) Linear growth model:

$$F_o(t) = \text{Log } a + bt$$

Where a = the initial size of literature, t = time after which growth has to be calculated, and b = continuous growth rate.

(t) **Logistic growth model:**

$$Ut = K / 1+\mu$$

Where U = expected size of literature; K and μ are two constants; t = time.

4. Hypotheses

To analysis the growth rate of publications in groundnut hypotheses is as follows:-

a) Exponential growth model is fitted in the groundnut research growth in the world.

Mathematically represented as

$$H_0: \mu_e - \mu_0 \leq \pm 100$$
$$H_1: \mu_e - \mu_0 > \pm 100$$

Here μ_0= Mean of observed values

μ_e= Mean of expected values

5. Analysis

The paper has analysed growth of literature on the basis of research output of the world in groundnut research. The data for India and the world have been retrieved on groundnut. It has3875 and 13394 records retrieving during 2000 to 2013.Total 91 countries have published articles on groundnut as available in the database.

a. Yearly publication activities

Number of research publications of top five countries have been shown in table 2. India leads with highest 3875 (28.93%) research articles, followed by USA with 2423 (18.09%), UK with 1646 (12.29%), China 811(6.05%) and Netherlands with 702 (5.24%). Remaining 86 countries contributed 3937 (29.39%) research publications as shown in table 2. Year wise distribution shows that number of publications in groundnut have increased from 745 to 1251 publications per year during 14 years in the whole world. Average number of publications are 957 papers per year for the world. India is at the top with 277 publications year on an average.

Table-2
Country wise distribution of publications on groundnut research in the world

S. N.	Year	India	USA	UK	China	Netherlands	Others	Total	%
1	**2000**	329	98	56	29	49	184	745	5.56%
2	**2001**	300	128	71	22	37	214	772	5.76%
3	**2002**	305	164	81	32	55	204	841	6.28%
4	**2003**	226	144	86	35	54	212	757	5.65%
5	**2004**	281	141	87	34	60	229	832	6.21%
6	**2005**	299	178	112	32	53	235	909	6.79%
7	**2006**	243	163	94	40	50	236	826	6.17%
8	**2007**	272	177	114	50	66	283	962	7.18%
9	**2008**	286	195	140	75	58	288	1042	7.78%
10	**2009**	280	169	117	71	75	311	1023	7.64%
11	**2010**	319	183	164	86	34	355	1141	8.52%
12	**2011**	240	209	165	108	36	343	1101	8.22%
13	**2012**	254	216	178	97	33	414	1192	8.90%
14	**2013**	241	258	181	100	42	429	1251	9.34%
	Total	**3875**	**2423**	**1646**	**811**	**702**	**3937**	**13394**	**100.00%**
	%	**28.93%**	**18.09%**	**12.29%**	**6.05%**	**5.24%**	**29.39%**	**100.00%**	

Table-3 analyses central tendencies of the world for top five countries. The mean value for the world is 957%. The values of median (935.50), geometric mean (943) and harmonic mean(929.6) are also very near to mean. Standard deviation is 170 for the world which is quite less in the context of world.

Table-3
Measures of central tendencies of publications on groundnut research in the world

Formulae	India	USA	UK	China	Netherlands	Others	World
Mean	276.79	173.07	117.57	57.93	50.14	281	956.71
Median	280.50	173.00	113.00	45.00	51.50	259.5	935.50
G. M.	275.05	168.66	110.66	50.72	48.66	262.73	942.95
H. M.	273.29	164.02	103.90	44.58	47.19	271.55	929.61
S.D.	32.04	39.91	41.52	30.39	12.62	79.08	169.97

H.M. = Harmonic mean G.M. = Geometric mean S.D. = Standard deviation

For India the mean is highest (276.79). Geometric mean and harmonic mean values are near to mean. So it can be said that research publications of the India stable without a major increase.Inspite of highest figure for India in number of publications, SD value of UK is highest 41.52. It means that research performance of UK is more active than India.Table 2 also shows that UK and USA have substantial increase in their contributions in groundnut research but the figures are almost static in India rather have decreased in 14 years of the study.

b. Exponential Growth

Table 4 shows the calculation for the expected growth of groundnut research in the world. The value of constant 'a' = 745is the initial size of literature in the worldfor the year 2000, t = time after which growth has to be calculated which is one in this study. Aconstant 'b'is calculated the continuous growth rate represented by r= R/100 where R represents percentage by which the size increases in each fixed time unit.

For example (year 2000)

$$R_1 = \frac{(772-745)}{745} \times 100 = 3.62$$

and so on for other rows

In the same way R2 to R14 for the year 2001 to 2013 have been calculated. As shown in the table 4. The average of these values is 0.04. This is value of r in the formula.

$R = (R_{1,} + R_{2,} + R_3 + \ldots\ldots + R_{14}) / 14$

The values of yearly exponential calculated with the help of the exponential growth formula in table 4. Exponential growth (E) in the table 4 shows cumulative exponential growth in the given time period. the table also calculates difference between exponential growth model and actual growth of records and finds that it is only 310 records. So, it is suitable for predict future growth of groundnut research publications in the world.

Table-4
Exponential growth (Expected) on publications of groundnut research in the world

S.N.	Year	Total Papers	Cumulative total (O)	R	a*exp (r*x!)	Exponential growth (E)	O-E	% of (O-E)
1	2000	745	745	3.62	745	745	**0**	**0.00%**
2	2001	772	1517	8.94	775	1520	**-3**	**-0.22%**
3	2002	841	2358	-9.99	807	2327	**31**	**1.31%**
4	2003	757	3115	9.91	840	3167	**-52**	**-1.66%**
5	2004	832	3947	9.25	874	4042	**-95**	**-2.34%**
6	2005	909	4856	-9.13	910	4952	**-96**	**-1.93%**
7	2006	826	5682	16.46	947	5899	**-217**	**-3.67%**
8	2007	962	6644	8.32	986	6884	**-240**	**-3.49%**
9	2008	1042	7686	-1.82	1026	7910	**-224**	**-2.84%**
10	2009	1023	8709	11.53	1068	8978	**-269**	**-3.00%**
11	2010	1141	9850	-3.51	1111	10090	**-240**	**-2.38%**
12	2011	1101	10951	8.27	1157	11246	**-295**	**-2.63%**
13	2012	1192	12143	4.95	1204	12450	**-307**	**-2.47%**
14	2013	1251	13394	r=0.04	1253	13704	**-310**	**-2.26%**

c. Linear Growth

Table 5 calculates the linear growth of groundnut research in the world. The values of linear growth are calculated at many stages. Constant a = 745is the initial size of literature which is world publication in groundnut research of 2000 and convert it to its log value which is, t = time after which growth has to be calculated which is one in this study. One constant b is calculated the continuous growth rate represented by R/100, where R represents percentage by which the size increases in each fixed time unit(as calculates above table).

For the year 2000: -

$F_0 (t_0)$ = Log (745) + 0.04x0 Where a = 745 is the initial value

= 2.52-0 b = 0.04 as calculated above

= 2.87 t = 0 for initial year

$L (t_0)$ = Antilog $F_o (t_0)$

= Antilog 2.87

= 745

The table-5calculates and shows growth of literature is 6921 records more than the actual growth of records found.

Table-5

Linear growth (Expected) on publications of groundnut research in the world

S. N.	Year	Total papers	Cumulative total(O)	F(t)= Log(a)+bt	Power (10,F(t))	Linear growth(E)	O-E	%
1	2000	745	745	2.87	745	745	**0**	**0.00%**
2	2001	772	1517	2.91	817	1562	**-45**	**-2.87%**
3	2002	841	2358	2.95	896	2458	**-100**	**-4.05%**
4	2003	757	3115	2.99	982	3440	**-325**	**-9.44%**
5	2004	832	3947	3.03	1077	4517	**-570**	**-12.61%**
6	2005	909	4856	3.07	1181	5697	**-841**	**-14.77%**
7	2006	826	5682	3.11	1295	6992	**-1310**	**-18.73%**
8	2007	962	6644	3.15	1420	8411	**-1767**	**-21.01%**
9	2008	1042	7686	3.19	1557	9968	**-2282**	**-22.89%**
10	2009	1023	8709	3.23	1707	11675	**-2966**	**-25.40%**
11	2010	1141	9850	3.27	1871	13546	**-3696**	**-27.29%**
12	2011	1101	10951	3.31	2052	15598	**-4647**	**-29.79%**
13	2012	1192	12143	3.35	2250	17848	**-5705**	**-31.96%**
14	2013	1251	13394	3.39	2467	20315	**-6921**	**-34.07%**

d. Logistic Growth

Table 6 calculates the expected logistic growth of groundnut research in world. First we take the 745, 772 and 841 as the base values of literature to calculate three constant K, a, b and t = time after which growth has to be calculated.

Initially the values of constant K and μ have been calculated using the formula.

$$K = \frac{(U_2)^2 (U_1 + U_3) - 2U_1U_2U_3}{(U_2)^2 - U_1U_3}$$

Here $U_1 = 745$, $U_2 = 772$, $U_3 = 841$ $t_1 = 1$, $t_2 = 3$, $t_3 = 5$,

$$K = \frac{772^2 (745+841) - 2x745x305x841}{772^2 - 745 \times 841}$$

K = 832.69

Now for calculating μ, two other values b and a have been calculated

1. $b = [\text{Log}_e\{(U_1(K-U_2)) / (U_2(K-U_1))\}] \, 1/(t_2-t_1)$

$b = [\text{Log}_e\{(745 (832.69-772)) / (772 (832.69-745))\}] \, 1/(3-1)$

$b = -3.75$ (approximate)

2. $a = \text{Log}_e ((K/ U_1) -1) - bt_1$
   $= \text{Log}_e ((832.69/745) -1) - (- 0.3.75x1) = 1.03$

3. $x=a+bt = 1.03+ (-3.75)x\ 1 = -2.14$
4. $y=x/2.3026 = -2.14 /2.3026 = -0.93$

5. $\mu = \text{antilog}(Y) = \text{antilog}(-0.93) = 0.12$

Then calculate each year data by using the formula logistic growth

6. $Ut = K / 1+\mu = 832.69/1+0.12$

The table shows growth of literature is 1828 records less than the actual growth of records found.

Table-6

Logistic growth (Expected) on publications of groundnut research in the world

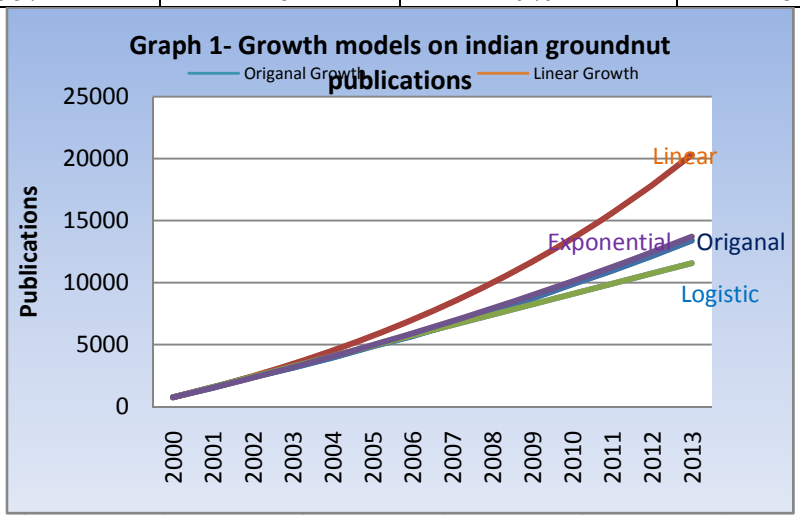
S. N	Year	Total Papers	Cumulative Total	x=a+bt	y=x/ 2.3026	Ut	Logistic growth	O-E	%
1	2000	745	745	-2.14	-0.93	745	745	**0**	**0.00%**
2	2001	772	1517	-5.31	-2.31	829	1574	**-57**	**-3.60%**
3	2002	841	2358	-8.48	-3.68	833	2406	**-48**	**-2.00%**
4	2003	757	3115	-11.65	-5.06	833	3239	**-124**	**-3.82%**
5	2004	832	3947	-14.82	-6.44	833	4072	**-125**	**-3.06%**
6	2005	909	4856	-17.99	-7.81	833	4904	**-48**	**-0.98%**
7	2006	826	5682	-21.16	-9.19	833	5737	**-55**	**-0.96%**
8	2007	962	6644	-24.33	-10.57	833	6570	**74**	**1.13%**
9	2008	1042	7686	-27.5	-11.94	833	7402	**284**	**3.83%**
10	2009	1023	8709	-30.67	-13.32	833	8235	**474**	**5.76%**
11	2010	1141	9850	-33.84	-14.70	833	9068	**782**	**8.63%**
12	2011	1101	10951	-37.01	-16.07	833	9900	**1051**	**10.61%**
13	2012	1192	12143	-40.18	-17.45	833	10733	**1410**	**13.14%**
14	2013	1251	13394	-43.35	-18.83	833	11566	**1828**	**15.81%**

e. Comparison of three models

All these models play an important role to measures the prediction of growth of any subject in near future and help the policy makers to take necessary actions to improve the results. The differences of values from original cumulative growth are already shown in above tables. Table 7compare different three growth models. Graphical representation in graph 1 exhibits that exponential growth is very near to original growth. Whereas, logistic growth is less than the original growth. Linear growth is higher to original growth.

Table-7
Comparison of growth models (cumulative)

Year	Original Growth	Linear Growth	Exponential Growth	Logistic Growth
2000	745	745	745	745
2001	1517	1562	1520	1574
2002	2358	2458	2327	2406
2003	3115	3440	3167	3239
2004	3947	4517	4042	4072
2005	4856	5697	4952	4904
2006	5682	6992	5899	5737
2007	6644	8411	6884	6570
2008	7686	9968	7910	7402
2009	8709	11675	8978	8235
2010	9850	13546	10090	9068
2011	10951	15598	11246	9900
2012	12143	17848	12450	10733
2013	13394	20315	13704	11566
Mean	957	1451	979	826



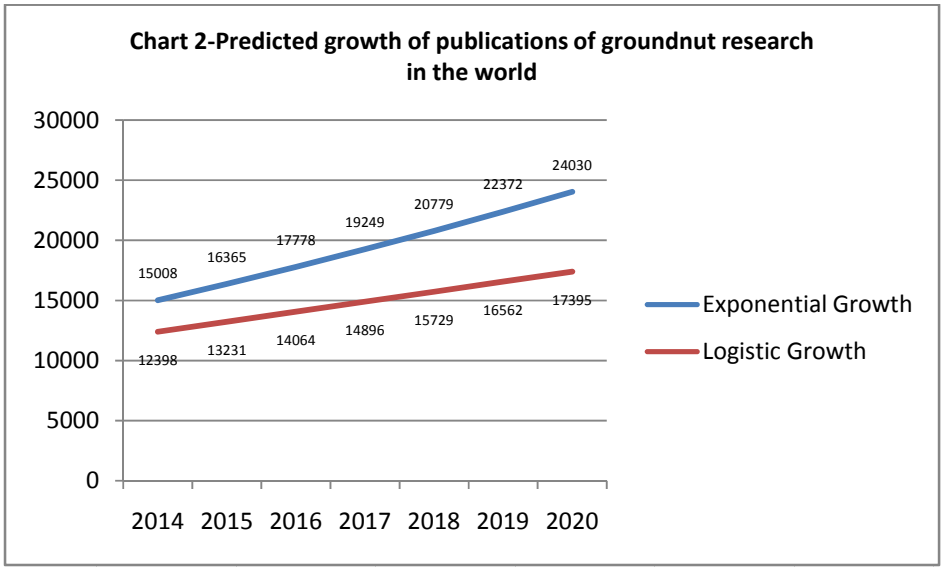
f. Predicted growth

Exponential growth is very near to original growth of literature in this study. The logistic growth is also nearer but lesser than original growth. Table 8 calculates predicted growth of publicationsby the year 2020 on the basis of two most suitable models which are logistic and exponential growth models. The predicted growth for the year 2014 to 2020 has been calculated by these models. The table shows that by the year 2020 there will be substantial growth of publications in groundnut research in the world. Oilseeds are still short in the present by the year 2020 it will be shorter than present due to increase in population and slow growth in production. This requires increase in per ha yield through more research in all countries.

Table-8
Predicting growth of publications of groundnut research in the world

Year	Exponential Growth	Logistic Growth
2013	13704	11566
2014	15008	12398
2015	16365	13231
2016	17778	14064
2017	19249	14896
2018	20779	15729
2019	22372	16562
2020	24030	17395

** data of 2013 is used base for the growth model



6. Test of hypotheses

Exponential growth model is fit in the groundnut research growth in the world.

Table 4 gives the cumulative original growth values and calculated exponential growth values. These values have been used to test hypothesis on the basis of their means:

Mathematically as: -

$$H_0: \mu_e - \mu_0 \leq \pm 100$$

H_1: $\mu_e - \mu_0 >\pm 100$

To test the hypothesis, mean of each growth model have been calculated in the table 9. These values are calculated from the total of each growth model in table 4 divided by n=14(total years)

Table-9
Mean values of growth on groundnut research in the world

Growth models	Original	Exponential	Linear	Logistic
Mean	957	979	1451	826
Difference		Fit (-22)	Unfit (-494)	Fit (131)

The difference of original and exponential growth is 22 but for other it is 131 and -494.So,it can be concluded that exponential model is suitable for calculating growth of groundnut research in the world. Therefore, the hypothesis is accepted.

7. Conclusion

The study shows that exponential growth model is best fitted for groundnut research in the study. Decreasing trend of publications in India is clearly visible while on the other hand it is increasing in UK and USA. The paper predicted number of paper by the year 2020. The predicted research is not very encouraging. Looking to the heavy import and high oil prices of groundnut and other oilseeds India truly need to increase per ha yield which is possible only with more research.

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