Modelling the Growth of Global Agricultural Literature: A Scienometric Study Based on CAB-Abstracts

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Abstract *- This paper is an attempt to map the growth of literature on agriculture in global and national levels. The paper throws light on various growth models and applicability on global agricultural literature. It also compares growth and dynamics of top ten countries in the field. This study compares literature published for the period 1930 to 2016 with recent twenty years data. Further the study emphasises on various scientometric parameters like Relative Growth Rate (RGR), Doubling Time (Dt), Skewness, Kurtosis, Regression (r^2), supplementing with different growth patterns to check whether agriculture literature fits exponential, linear, logistic or power models. The results of the study indicate that the dynamics of world agricultural literature follows the linear and exponential growth model for recent years. The study concludes that there has been a consistent trend towards increased growth of literature in the field of agriculture.*

Keywords: Scientometrics; Relative Growth Rate; Doubling Time; Agricultural Literature; Exponential Model; Growth Models; Linear Model.

1. INTRODUCTION:

The Spectacular development in scientific discoveries has led growth of knowledge in substantial manner. It eventually causes the need for study of growth of knowledge and its dynamics. Many scholars have studied the growth and dynamics of science and technology discipline. Some earlier studies Price (1966, 1975) found that exponential model best fits for growth data of publications. In early 1990s the studies by Wolfram et. al. found that linear and power model perform equally well as that of exponential model. Egghe and Ravichandra Rao analysed Wolfram data in 1992 and concluded that power model explains well the growth of science and technology literature.

Growth of literature refers to change in size of literature over a period of time. A systemic study on the increase of scholarly communication facilitates quantitative and qualitative understanding of various aspects of science. The assessments of research performance are prominent in further research studies and policy making. Scientometric indicators provide more quantitative objectivity and help to identify, compare and evaluate the strength and weakness of scientific achievement.

Agriculture has been significant area ever since the evolution of mankind. Agriculture is backbone for any countries socio-economic development. In spite of their valuable contribution to economic growth, farmers in developing countries often lack tools, money, and skill to respond to agricultural developmental challenges. Agricultural research helps to generate new technologies and improved policies which are key aspects for growth in agricultural productivity. The new agricultural research fort polio concentrates on advancing productivity, sustainable intensification and improving food safety and nutrition and thereby contributing to the area of knowledge in terms of scholarly communication. This paper is an attempt to identify, analyse and report the growth of agriculture literature in the world.

2. REVIEW OF LITERATURE

Modelling the growth of the literature using scientometrics techniques in various disciplines is prevailing from a long time. Earlier in 1963 Price argued that the scientific literature doubles approximately in 10 years and journals double in the 15 years of span.
Earlier studies by Gilberts' (1978) assess the weakness and strength by evaluating the growth of knowledge and growth of manpower by using some indicators to measuring it.

The studies carried by Gupta et al. (1999) reveals that the growth of Indian physics literature follows a logistic model and dynamics of world physics literature fits for combination of logistic and power models.

Comparison study on growth trends produced by Food scientists of India and abroad on growth of Food Science and Technology (FST) literature was carried out by Seetharam and Ravichandra Rao (1999) for covering a period between 1950 and 1990. Fitness for various models is tested in their study.

Gupta and Karisiddappa (2000) in their paper for studying the growth of scientific knowledge as reflected through publications and authors in the field of genetics from 1907-1980 concluded that the power model is best fitted for the cumulative growth of publication and author counts.

Tsay (2008) concentrate on the characteristics of hydrogen energy literature from 1965-2005 based on the database of Science Citation Index Expanded (SCIE), where the study reveals that the cumulative literature on hydrogen energy may be fitted relatively well by an exponential model.

Ramakrishna (2009) examines the growth of references over the past fifteen years (1994-2008). The results show that the linear growth model provides better fits to the observed data, whereas the exponential model provided the poorest fit.

Sangam et al. (2010) study the growth and dynamics of Indian and Chinese publications in the field of liquid crystals research (1997-2006) by applying growth models as suggested by Egghe and Ravichandra Rao (1992). The authors conclude that power model best fits for the growth of Indian literature while linear and power growth models applicable in the growth of Chinese liquid crystals literature.

Hadagali & Anandhalli (2015) study demonstrates the growth of neurology literature for the perion 1961-2010 and interprets that the observed data fits to exponential growth model. It compares Relative Growth Rate and doubling time for India and China and reveals that linear and logistic growth models does not fit for the given set of data.

Sangam and Arali (2015) study concentrates on the Growth pattern, doubling time of world and Indian Genetics literature, it inferred that the Logarithmic and Linear growth models fit well for World's genetics literature whereas for India Exponential and Logistic models fit well.

3. OBJECTIVES OF THE STUDY

The specific objectives of the study are

- To study the growth of Global Agricultural literature and compare the growth rate as reflected in the CAB Abstracts database among the world and the top ten countries.
- To examine the Relative Growth Rate(RGR) and Doubling Time (Dt.) for the Agricultural literature.
- To analyze the growth of agricultural literature for numbers of publications using different growth models

4. METHODOLOGY:

CAB Abstracts database is used as the source for the literature for this study. CAB Abstracts is the leading English-language bibliographic information service providing access to the world's applied life sciences literature. CAB Abstract claims to be the first choice to agriculture and related applied sciences in coverage. Studies carried out by Kawasaki(2004) illustrate that CAB abstracts covers 100% of Agricola, Biological & Agricultural Index Plus CAB Abstracts covers 93% of primary agricultural literature while Web of Science covers 74%, Agris 62%, Agricola 68%, Biosis 58% and other databases cover less than 50% of world agricultural literature. Therefore CAB Abstracts has a longstanding reputation for comprehensive, quality abstracting and indexing, and integrity of its data. This stands to be the first stop for the serious agricultural research.

A total of 8522261 articles for world agricultural literature has been extracted using keywords called as CABICODE by CAB thesaurus for the period 1930 to 2016. The retrieved records were examined, classified, and analyzed keeping the objectives in view. Further, the data is analyzed using MS Excel spreadsheet.

Relative Growth Rate (RGR) and Doubling Time (Dt.) of agricultural literature have been calculated, supplementing with different growth patterns to check whether the dynamics of literature best fits for exponential, linear, or logistic models.

RELATIVE GROWTH RATE (RGR) AND DOUBLING TIME (DT.)

The **Relative Growth Rate (RGR)** is the increase in number of articles / pages per unit of time. The mean Relative Growth Rate (RGR) over the specific period of interval can be calculated from the following equation:

$$\mathbf{R(P)} = \frac{\mathbf{logeW2 - logeW1}}{\mathbf{T2 - T1}}$$

Whereas R(P) → Mean relative growth rate over the specific period of interval
logeW1 → natural logarithm of initial number of articles
logeW2 → natural logarithm of final number of articles after a specific period of interval
T2 – T1 → the unit difference between the initial time and the final time

Doubling Time (Dt.)

The **doubling time(Dt.)** is the period requires for a quantity to doublein size or value.
This can be calculated by the formula
$\boldsymbol{Dt(P)} = \frac{\boldsymbol{Loge2}}{\boldsymbol{R(P)}} = \frac{\mathbf{0.693}}{\boldsymbol{R(P)}}$ Where Dt(P) →Average doubling time of publications

STATISTICAL APPLICATIONS:

Statistical techniques have been applied to study the concentration and consistency of articles by calculating standard deviation, coefficient of variance, kurtosis and skewness.
Standard Deviation : It is used to determine how the data is spread out from the mean. The greater the standard deviation, the data is spread over greater extent.
Co-efficient of variance: It reveals the variability of distribution for different time periods.
Skewness: It is the extent to which the data are not symmetrical. Skewness value reveals the shape of the data.
Kurtosis: It is the extent to which the data is concentrated in the graph. It refers to the flatness or peakedness of the curve

GROWTH MODELS

The growth and dynamics of Agricultural Literature is analysed by applying various growth patterns and these models describe the changing size of literature over time.

Linear Growth Model: The linear growth pattern equation to calculate the least squares fit for a line is $\boldsymbol{y = mx + b}$ where m is the slope and b is the intercept.

Logistic Model: A logistic model is common sigmoid function which produces s-shaped curve. The initial stage of growth is approximately exponential, then at saturation growth slows and at maturity growth stops.
The equation is $\mathbf{Pt} = \frac{\mathbf{Pequil}}{\mathbf{Pstart} + [(\mathbf{Pequil} - \mathbf{Pstart})^{(\mathbf{1-kt})}]}$ where Pstart is starting publication at the initial time, Pequil is Equilibrium publication, K is growth constant related to doubling time(Dt) & $\boldsymbol{K} = \mathbf{ln(2)} / \boldsymbol{Dt}$ where ln is natural logarithm

Logarithmic Growth Model: The Logarithmic growth pattern equation to calculate the least squares fit through points is $\boldsymbol{y = c} \ln \boldsymbol{x} + \mathbf{b}$ **where** *c* and *b* are constants and ln is the natural logarithm function.

Power Model: According to Ravichandra Rao(2010) is a functional relationship between two quantity varies as the power of the other .The Power Growth pattern equation to calculate the least squares fit through points is represented by $\boldsymbol{y = cx^b}$ where c & b are constants.

Exponential Growth Model: Exponential model fits to data when the growth rate is proportionate to the increase of publications for each unit of time. The Exponential Growth Pattern equation to calculate the least squares fit through points is mathematically represented $\boldsymbol{y = ce^{bx}}$ where *c* and *b* are constants, and *e* is the base of the natural logarithm.

Polynomial Model: A polynomial is a mathematical expression consisting of a sum of terms, each term including a variable or variables raised to a power and multiplied by co-efficient. It is mathematically represented by $\boldsymbol{y = ax^2 + bx + c}$ where a, b and c are constants

5. RESULTS AND DISCUSSIONS

Year wise Distribution of World Agricultural Literature 1930-2016

Table 1 depicts Year wise Distribution of World Agricultural Literature for the period 1930-2016. The global agricultural output is 8522252 records in which USA stands first with 549744 records (6.603%) followed by South Africa with 297629(3.574%), China with 295402(3.545%) and India by 196738(2.363%) records.

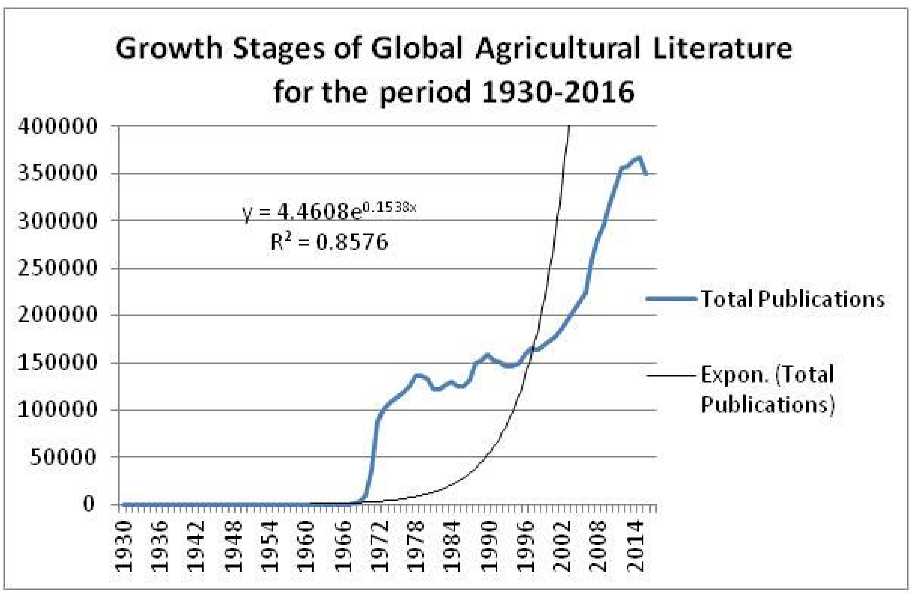
As observed by Price (1963), Michael Mabe(2003) & many other The growth of publication passes through four stages. In the preliminary period i.e first stage of growth in which the absolute increment in the growth of publications less but growth rate is increasing. During second stage the growth is exponential, while during the third stage annual increments remains same and growth rate decreases, during the final stage both annual increment rate and growth rate tend towards zero.

From the Table 1 it is clear that the growth in global Agricultural Literature during the preliminary period of 1930 to 1970) is growing with smaller annual increment rate. Graph 1 clearly explains the second stage from the period 1970 to 2016. A fluctuating trend was observed but the growth is exponential in nature. The maximum world contribution is observed during 2015 (366329 publications). The table also presents the Relative Growth Rate (RGR) and Doubling Time (Dt.) of global publications. The RGR of publications decreased from 0.381195 in the year 1930 to 0.042 in 2016. Simultaneously the value of doubling time increased from 2.059 in 1930 to 16.514 in 2016. It is evident from the study that research in the field of global agriculture has increased over a period of time.

Table 1: Year wise Distribution of World Agricultural Literature 1930-2016, Relative Growth Rate and Doubling Time

Year	Total Articles	% of articles	Cumulative Articles	ln (p)	W1	W2	W2-W1/t2-	mean	dt (P)	mean
1930	1	1.17E-05	10	2.302585		2.30259				
1931	4	4.69E-05	14	2.639057	2.30259	2.63906	0.3365		2.059605	
1932	20	0.000235	34	3.526361	2.63906	3.52636	0.8873		0.781018	
1933	49	0.000575	83	4.418841	3.52636	4.41884	0.8925	0.381195	0.776488	2.730055
1934	32	0.000375	115	4.744932	4.41884	4.74493	0.3261		2.12517	
1935	43	0.000505	158	5.062595	4.74493	5.0626	0.3177		2.181558	
1936	31	0.000364	189	5.241747	5.0626	5.24175	0.1792		3.868224	
1937	38	0.000446	227	5.42495	5.24175	5.42495	0.1832		3.782689	
1938	39	0.000458	0.266	5.583496	5.42495	5.5835	0.1585		4.370963	
1939	43	0.000505	309	5.733341	5.5835	5.73334	0.1498		4.62478	
1940	45	0.000528	354	*5.869297*	5.73334	5.8693	0.136		5.097251	
1941	26	0.000305	380	5.940171	5.8693	5.94017	0.0709		9.777869	
1942	31	0.000364	411	6.018593	5.94017	6.01859	0.0784		8.83681	
1943	21	0.000246	432	6.068426	6.01859	6.06843	0.0498	0.048923	13.90662	21.37925
1944	9	0.000106	441	6.089045	6.06843	6.08904	0.0206		33.60931	
1945	13	0.000153	454	6.118097	6.08904	6.1181	0.0291		23.85351	
1946	10	0.000117	464	6.139885	6.1181	6.13988	0.0218		31.80744	
1947	8	9.39E-05	472	6.156979	6.13988	6.15698	0.0171		40.53951	
1948	11	0.000129	483	6.180017	6.15698	6.18002	0.023		30.08117	
1949	21	0.000246	504	6.222576	6.18002	6.22258	0.0426		16.28304	
1950	18	0.000211	522	6.257668	6.22258	6.25767	0.0351		19.74847	
1951	40	0.000469	562	6.331502	6.25767	6.3315	0.0738		9.385886	
1952	50	0.000587	612	6.416732	6.3315	6.41673	0.0852		8.130899	
1953	50	0.000587	662	6.495266	6.41673	6.49527	0.0785	0.073682	8.824285	10.06458
1954	50	0.000587	712	6.568078	6.49527	6.56808	0.0728		9.517615	
1955	72	0.000845	784	6.664409	6.56808	6.66441	0.0963		7.193938	
1956	60	0.000704	844	6.738152	6.66441	6.73815	0.0737		9.397442	
1957	73	0.000857	917	6.821107	6.73815	6.82111	0.083		8.353929	
1958	69	0.00081	986	6.893656	6.82111	6.89366	0.0725		9.55218	
1959	67	0.000786	1053	6.959399	6.89366	6.9594	0.0657		10.54118	
1960	97	0.001138	1150	7.047517	6.9594	7.04752	0.0881		7.864391	
1961	129	0.001514	1279	7.153834	7.04752	7.15383	0.1063		6.518268	
1962	101	0.001185	1380	7.229839	7.15383	7.22984	0.076		9.117824	
1963	211	0.002476	1591	7.372118	7.22984	7.37212	0.1423	0.198763	4.870703	4.752044
1964	279	0.003274	1870	7.533694	7.37212	7.53369	0.1616		4.289012	
1965	385	0.004518	2255	7.720905	7.53369	7.72091	0.1872		3.701695	
1966	399	0.004682	2654	7.883823	7.72091	7.88382	0.1629		4.253675	
1967	595	0.006982	3249	8.086103	7.88382	8.0861	0.2023		3.425956	
1968	1194	0.01401	4443	8.399085	8.0861	8.39909	0.313		2.214181	
1969	3242	0.038042	7685	8.947026	8.39909	8.94703	0.5479		1.264736	
1970	9807	0.115075	17492	9.769499	8.94703	9.7695	0.8225		0.842581	
1971	36216	0.424958	53708	10.89132	9.7695	10.8913	1.1218		0.617747	
1972	88360	1.036815	142068	11.86406	10.8913	11.8641	0.9727		0.712418	
1973	101765	1.194109	243833	12.40424	11.8641	12.4042	0.5402	0.485298	1.282911	2.304098
1974	109773	1.288075	353606	12.77594	12.4042	12.7759	0.3717		1.864408	
1975	114209	1.340127	467815	13.05583	12.7759	13.0558	0.2799		2.475976	
1976	118679	1.392578	586494	13.28192	13.0558	13.2819	0.2261		3.065158	
1977	124941	1.466056	711435	13.47504	13.2819	13.475	0.1931		3.588412	
1978	137077	1.60846	848512	13.65124	13.475	13.6512	0.1762		3.933027	
1979	136102	1.597019	984614	13.8	13.6512	13.8	0.1488		4.658339	
1980	133329	1.564481	1117943	13.927	13.8	13.927	0.127		5.456866	
1981	122254	1.434527	1240197	14.03078	13.927	14.0308	0.1038		6.677597	
1982	122666	1.439361	1362863	14.1251	14.0308	14.1251	0.0943		7.347531	
1983	127221	1.49281	1490084	14.21434	14.1251	14.2143	0.0892	0.084989	7.765153	8.481396
1984	129845	1.5236	1619929	14.29789	14.2143	14.2979	0.0835		8.294452	
1985	125111	1.468051	1745040	14.37229	14.2979	14.3723	0.0744		9.315123	
1986	125134	1.468321	1870174	14.44154	14.3723	14.4415	0.0693		10.00664	
1987	131475	1.542726	2001649	14.50948	14.4415	14.5095	0.0679		10.2002	
1988	148657	1.744339	2150306	14.58112	14.5095	14.5811	0.0716		9.673527	
1989	153083	1.796274	2303389	14.64989	14.5811	14.6499	0.0688		10.07687	
1990	158151	1.855742	2461540	14.7163	14.6499	14.7163	0.0664		10.43586	
1991	152062	1.784294	2613602	14.77624	14.7163	14.7762	0.0599		11.56114	
1992	150791	1.76938	2764393	14.83233	14.7762	14.8323	0.0561		12.35476	

1993	146471	1.718689	2910864	14.88396	14.8323	14.884	0.0516	0.051702	13.42272	13.60548
1994	146248	1.716072	3057112	14.93298	14.884	14.933	0.049		14.13687	
1995	149563	1.75497	3206675	14.98075	14.933	14.9807	0.0478		14.50887	
1996	159046	1.866244	3365721	15.02915	14.9807	15.0292	0.0484		14.31593	
1997	165093	1.937199	3530814	15.07704	15.0292	15.077	0.0479		14.4718	
1998	163868	1.922825	3694682	15.12241	15.077	15.1224	0.0454		15.27574	
1999	168148	1.973047	3862830	15.16691	15.1224	15.1669	0.0445		15.57108	
2000	173370	2.034321	4036200	15.21081	15.1669	15.2108	0.0439		15.78459	
2001	177152	2.078699	4213352	15.25377	15.2108	15.2538	0.043		16.13321	
2002	185802	2.180198	4399154	15.29692	15.2538	15.2969	0.0432		16.05887	
2003	195649	2.295743	4594803	15.34044	15.2969	15.3404	0.0435	0.045256	15.92604	15.36465
2004	205510	2.411452	4800313	15.38419	15.3404	15.3842	0.0438		15.8381	
2005	214060	2.511777	5014373	15.42782	15.3842	15.4278	0.0436		15.88456	
2006	224202	2.630784	5238575	15.47156	15.4278	15.4716	0.0437		15.84321	
2007	258441	3.032544	5497016	15.51972	15.4716	15.5197	0.0482		14.39076	
2008	280828	3.295232	5777844	15.56954	15.5197	15.5695	0.0498		13.90862	
2009	295832	3.471289	6073676	15.61947	15.5695	15.6195	0.0499		13.87848	
2010	317214	3.722185	6390890	15.67038	15.6195	15.6704	0.0509		13.61239	
2011	336834	3.952406	6727724	15.72175	15.6704	15.7217	0.0514		13.49211	
2012	356230	4.179998	7083954	15.77334	15.7217	15.7733	0.0516	0.048388	13.43145	14.39121
2013	357953	4.200216	7441907	15.82264	15.7733	15.8226	0.0493		14.05825	
2014	363794	4.268754	7805701	15.87036	15.8226	15.8704	0.0477		14.52001	
2015	366329	4.2985	8172030	15.91623	15.8704	15.9162	0.0459		15.11022	
2016	350231	4.109606	8522261	15.95819	15.9162	15.9582	0.042		16.51402	



Graph 1: Growth of Global Agricultural Literature for the period 1930-2016

Block wise Distribution of Top ten countries Agricultural Literature with Relative Growth Rate and Doubling Time

Table 2 provides an overview of block wise distribution of Agricultural literature for top ten countries with the Relative Growth Rate and doubling time. For USA, the RGR of publications decreased from 0.159 in the block period 1930-40 to 0.036 in 2011-16. Simultaneously the value of doubling time increased from 2.679 in first block period to 19.602 for last block period. It is evident from the study that research in the field of American agriculture has increased over a period of eighty seven years. Similarly in African, Chinese, Indian and other countries the literature has increased over the period.

The table 2.1 clearly states the Mean relative growth rate for the period 1930-2016 lies in between 0.1185 to 0.1506 while Mean doubling Time for top ten countries lies between 5 to 12 years.

Table 2 : Block wise Distribution of Top ten countries Agricultural Literature for the period 1930-2016 for different block periods and Relative Growth Rate and Doubling Time

Geographical location	**Publication Block period**	**1930-1940**	**1941 – 1950**	**1951-1960**	**1961-1970**	**1971-1980**	**1981-1990**	**1991-2000**	**2001-2010**	**2011-2016**
United State	TA	23	11	60	864	90209	103937	111704	137469	105467
	RGR	0.159	0.039	0.102	0.232	0.456	0.076	0.045	0.037	0.036
	Dt	2.679	6.988	7.295	4.388	2.528	9.491	15.522	18.759	19.602
South Africa	TA	19	8	28	784	31857	43429	52653	78044	90807
	RGR	0.205	0.035	0.071	0.272	0.366	0.085	0.053	0.047	0.061
	Dt	1.527	5.681	10.16	3.437	2.713	8.350	13.387	14.907	11.792
China	TA	3	0	20	162	3083	18361	40399	98139	135235
	RGR	0.037	0.000	0.204	0.208	0.287	0.189	0.105	0.095	0.102
	Dt	0.155	0.000	3.419	4.501	2.676	4.235	6.658	7.614	6.914
India	TA	7	2	1	372	18121	27198	45197	58456	47384
	RGR	0.114	0.025	0.011	0.364	0.388	0.090	0.069	0.050	0.046
	Dt	1.127	1.107	0.658	1.752	2.872	7.713	10.295	14.003	15.196
Brazil	TA	2	4	28	301	12427	17308	29160	67347	69575
	RGR	0.000	0.110	0.173	0.229	0.364	0.086	0.068	0.076	0.073
	Dt	0.000	0.456	2.462	4.172	2.541	8.688	10.351	9.175	9.570
UK	TA	10	7	25	223	31651	33140	32855	34606	23720
	RGR	0.209	0.053	0.090	0.184	0.479	0.071	0.041	0.030	0.027
	Dt	1.500	3.843	8.022	5.535	2.316	10.386	17.152	22.924	25.414
Australia	TA	18	6	29	282	18722	21886	29073	36164	27161
	RGR	0.116	0.029	0.079	0.184	0.404	0.076	0.054	0.042	0.038
	Dt	2.121	5.127	8.379	5.731	2.503	9.495	13.084	16.709	18.333
Germany	TA	18	5	23	290	24732	28752	30056	29671	19383
	RGR	0.137	0.025	0.069	0.199	0.431	0.076	0.044	0.030	0.026
	Dt	1.977	1.904	12.06	5.227	2.529	9.411	15.922	22.946	26.694
Canada	TA	16	4	28	356	18486	21723	24838	30783	22636
	RGR	0.189	0.022	0.088	0.213	0.384	0.077	0.048	0.039	0.035
	Dt	2.205	4.988	9.684	5.177	2.760	9.316	14.880	18.024	19.830
Nordic countries	TA	31	9	33	188	15180	18924	25224	30921	21911
	RGR	0.149	0.025	0.060	0.127	0.408	0.080	0.055	0.042	0.036
	Dt	3.094	12.392	12.286	11.494	2.601	8.892	12.684	16.633	19.320

TA →Total Articles ; RGR→Relative Growth Rate; Dt→Doubling Time

Table 2.1 : Country wise Distribution Mean Relative Growth Rate and Mean Doubling Time of Growth in Agricultural Literature for the period 1930-2016

Country Name	USA	South Africa	China	India	Brazil	UK	Australia	Germany	Canada	Nordic countries
MRG**	0.1408	0.143	0.1506	0.1385	0.1492	0.1374	0.123	0.1239	0.132	0.1185
MDt**	10.215	8.12	5.14	7.99	5.66	10.008	8.958	10.499	9.536	11.081

MRG→ **Mean Relative Growth; MDt→ Mean Doubling Time

Descriptive Statistics: Comparative statistics for different Periods 1930-2016 (87 years) and 1997-2016 (20 Years) Table 3 helps to interpret dispersion, using statistical parameters.

Standard deviation for is an important absolute measure of dispersion. The value of standard deviation clearly shows that the publications are dispersed largely for both the periods, the dispersion is very high for 1930-2016 period.

Co-efficient of variance reveals the country wise variability of distribution for different time periods. The variability little more during 1930-2016 periods compared to 20 years span. The country-wise comparison shows that the mean number of articles observed for USA (6318.9) and least mean is observed for Nordic Countries (1292.19) The consistency level is larger and is almost similar with all the countries varying from 0.9% to 1.7% for 87 years and 0.09% to 0.6% for 20 years span.

Skewness helps to study the shape of the distribution while kurtosis refers to the flatness or peachiness of the curve. The distribution for USA literature is positively skewed by 0.264 degree for the whole period of 87 years while in the recent 20 years the distribution of data is negatively skewed by 0,028 degrees. The distribution of literature is positively skewed for all the literature from period 1930 to 2016 and countries like South Africa, China, India, Brazil, Australia and Nordic Countries for 1996-2016 and negatively skewed for UK, Germany and Canada for the same period.

For measuring **Kurtosis**, the coefficient value β2 for China is 4.175 which is greater than normal curve value (β2=3) for the period 1930 - 2016. So it follows leptokurtic curve distribution while South Africa for the same period follows platykurtic curve as β2 value is 2.116. For the other countries for the both periods they follows platykurtic curve as β2 value is negative.

Table 3: Descriptive Statistics : Comparative statistics for different Periods 1930-2016 (87 years) and 1997-2016 (20 Years)

Country	Period	Mean	Median	Standard Deviation	Sample Variance	Kurtosis	Skewness (β2)	Co-Ef. Variance (%)
USA	1930 -2016	6318.89	8014	6429.246	41335202	-1.505	0.264	1.017
	1997-2016	14445.05	14323	2736.084	7486156	-1.692	-0.028	0.189
South Africa	1930 -2016	3421.02	2759	4335.487	18796448	2.116	1.524	1.267
	1997-2016	9539.9	8250.5	4319.134	18654919	-1.043	0.674	0.453
China	1930 -2016	3395.42	226	6335.605	40139891	4.175	2.274	1.866
	1997-2016	12664.85	9741.5	7743.58	59963028	-1.709	0.369	0.611
India	1930 -2016	2261.356	1692	2637.039	6953976	-0.492	0.847	1.166
	1997-2016	6243.2	6098	1362.858	1857383	-0.662	0.605	0.218
Brazil	1930 -2016	2254.620	895	3404.999	11594018	2.187	1.781	1.510
	1997-2016	7613.8	6742.5	3238.727	10489351	-1.707	0.191	0.425
UK	1930 -2016	1795.827	2442	1770.679	3135304	-1.884	0.055	0.986
	1997-2016	3592.65	3629	371.5569	138054.6	-1.190	-0.105	0.103
Australia	1930 -2016	1532.655	1489	1618.922	2620909	-1.256	0.444	1.056
	1997-2016	3787.35	3659	634.6542	402785.9	-1.631	0.158	0.168
Germany	1930 -2016	1527.931	2133	1489.457	2218481	-1.948	0.008	0.975
	1997-2016	3069.15	3081.5	303.5418	92137.61	-0.386	-0.099	0.099
Canada	1930 -2016	1366.321	1761	1393.814	1942718	-1.477	0.290	1.020
	1997-2016	3155.3	3344	594.8979	353903.5	-1.609	-0.240	0.189
Nordiac Countries	1930 -2016	1292.1954	1281	1350.849	1824794	-1.428	0.373	1.045
	1997-2016	3193.75	3133.5	378.2223	143052.1	-1.347	0.154	0.118

Application of Growth Models

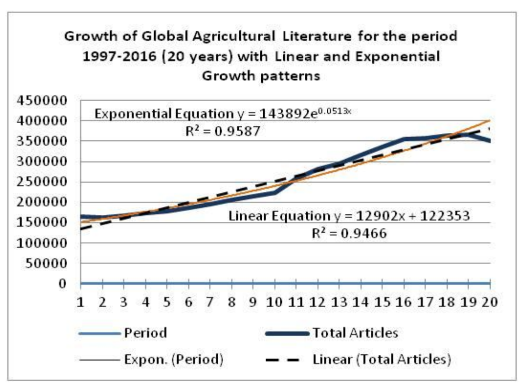
Table 3 shows the application of various growth models on different sets of agricultural literature produced by top ten countries during different span of time. The R^2 value for each set of data is reflected in table. It is clear from the table that the during the period 1999-2016 that growth of agricultural literature for countries Brazil, China, India, best fits in exponential, linear and polynomial of order two curve and least fits for Germany. For the total time span it best fits for polynomial of order 2.

Table 3: Application of Growth Models : R^2 value for different Periods 1930-2016 (87 years) and 1997-2016 (20 Years)

Countries	Period	Exponential	linear	logarithmic	power	Polynomial of order 2
USA	1930 -2016	NA	0.856	0.5535	NA	0.885
	1997-2016	0.8599	0.8717	0.645	0.6421	0.8735
South Africa	1930 -2016	NA	0.7434	0.4176	NA	0.9007
	1997-2016	0.8824	0.824	0.5871	0.6629	0.8522
China	1930 -2016	NA	0.5268	0.2471	NA	0.8474
	1997-2016	0.9307	0.9093	0.6545	0.7275	0.9397
India	1930 -2016	NA	0.8492	0.488	NA	0.9792
	1997-2016	0.9175	0.8835	0.6858	0.7504	0.9
Brazil	1930 -2016	NA	0.6586	0.3353	NA	0.9227
	1997-2016	0.9694	0.958	0.7626	0.8559	0.963
UK	1930 -2016	NA	0.7614	0.5376	NA	0.7615
	1997-2016	0.5245	0.5284	0.3007	0.2954	0.5388
Australia	1930 -2016	NA	0.8723	0.5404	NA	0.9306
	1997-2016	0.8351	0.836	0.6193	0.6281	0.8447
Germany	1930 -2016	NA	0.7896	0.5548	NA	0.7897
	1997-2016	0.1119	0.1015	0.0162	0.021	0.1146
Canada	1930 -2016	NA	0.8678	0.5561	NA	0.9018
	1997-2016	0.8417	0.8511	0.7097	0.7106	0.8652
Nordic Countries	1930 -2016	NA	0.8878	0.5503	NA	0.9378
	1997-2016	0.8538	0.8478	0.6785	0.6943	0.8478

Graphical Presentation of Growth of Literature: The graphs help to know the growth pattern of dynamics of global agricultural literature and agricultural literature of top countries.

Graph 2 reveals Growth of Global Agricultural Literature for the period 1997-2016 (20 years). In the present graph the literature grows exponentially with the rate 0.0513 with coefficient of regression value 0.9587 and linear growth pattern with R^2 value 0.9466



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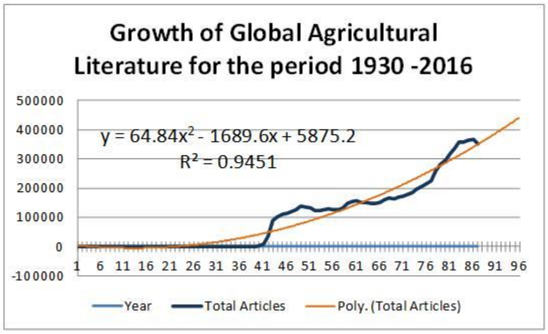
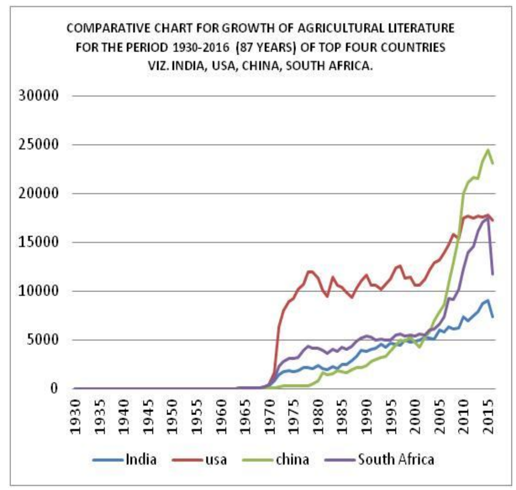


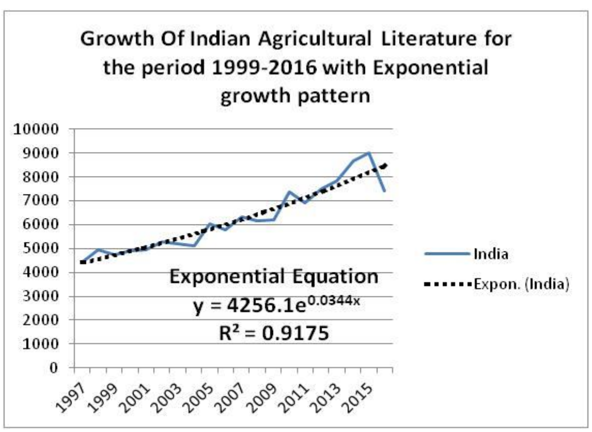
Graph 3 : Growth of Global Agricultural Literature - Polynomial of order 2

Graph 3 concentrates on Growth of Global Agricultural Literature for the period 1930-2016 (87 years). In the present graph the literature growth best fits the polynomial of order 2 with coefficient of regression value 0.9451.

Graph 4 gives comparative chart for growth of Agricultural Literature for the period 1930-2016 (87 years) of top four countries viz. USA, China, South Africa, India. The growth of literature for the countries was very minimal for first 40 years for all the countries. United States of America (USA) stands first with maximum publications from the period 1972-2005. The growth rate of China is trending after 2005. India stands fourth position in its contribution towards growth of global agricultural literature.



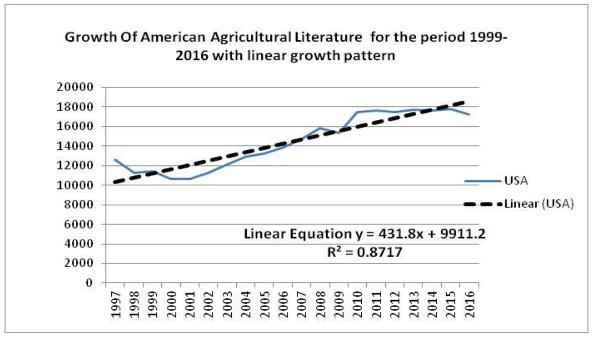
Graph 4: Growth of Agricultural Literature for the period 1930-2016 - USA, China, South Africa and India.



Graph 5 plots Growth of Indian Agricultural Literature for the period 1997-2016 (20 years). In the present graph the literature grows exponentially with the rate 0.0344 with coefficient of regression value 0.9175.

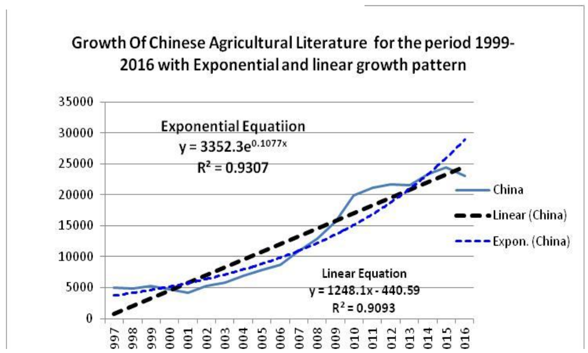
Graph 5 : Growth of Indian Agricultural Literature for the period 1997-2016 (20 years)

Growth Of American Agricultural Literature for the period 1999-2016 Graph 6 plots Growth of American Agricultural Literature for the period 1997-2016 (20 years) where the growth pattern is linear with coefficient of regression value 0.8717.

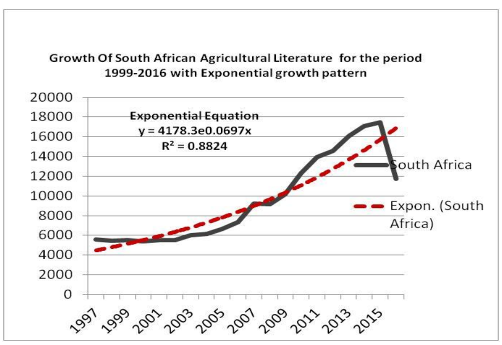


Graph 6 Growth of American Agricultural Literature for the period 1997-2016 (20 years)

Growth Of Chinese Agricultural Literature for the period 1999-2016 : Graph 7 shows Growth of Chinese Agricultural Literature for the period 1997-2016 (20 years). In the present graph the literature grows exponentially with the rate 0.1077 with coefficient of regression value 0.9307.



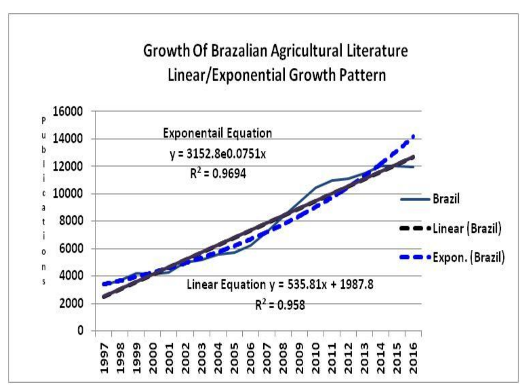
Graph 7 : Growth Of Chinese Agricultural Literature for the period 1999-2016



Growth of South African Agricultural Literature for the period 1999-2016: Graph 8 provides details about Growth of African Agricultural Literature for the period 1997-2016 (20 years). In the present graph the literature grows exponentially with the rate 0.0697 with coefficient of regression value 0.8824.

Graph 8 : Growth of South African Agricultural Literature for the period 1999-2016

Growth of Brazilian Agriculture Literature: Graph 9 provides details about Growth of Brazilian Agricultural Literature for the period 1997-2016 (20 years). In the present graph the literature grows exponentially with the rate 0.0751 with coefficient of regression value 0.9694 and with linear growth curve best fits for the literature with R^2 value 0.958.



Graph 9 : Growth of Brazilian Agriculture Literature

Conclusion

The literature review on the topic divulges that scientometric techniques are considered to be the most powerful methods for conduction of quantitative studies. An attempt is made to measure the trends in various aspects of published literature in the field of agricultural literature which shows that there is a steady growth of publications. By comparing the results obtained from actual statistical fits of the different growth models and the most appropriate growth model is likely to fit. The growth of global literature in agriculture follows both the Linear Growth Model and Exponential Growth Model for 1997-2016 span while it best fits for polynomial graph function of order 2 for 1930-2016 periods. The study concludes that there has been a consistent trend towards increased growth of literature in the field of agriculture science.

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