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Research performance and trends in Seed technology research: A scientometric assessment

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ABSTRACT

The study assesses the research performance and trends of global Seed technology research publications by using scientometric indicators i.e. publication growth pattern, author, institution and country research performance, the collaborative trend among countries. The study found that a total of 16613 publications contributed by 40588 authors from 1647 number of scholarly journals received with 350561 citations and h-index and g-index 182, 262 respectively, 148 countries have contributed in the Seed technology research. The English Language has the dominant language (96%) in Seed technology research. The research article title "Importance of pollinators in changing landscapes for world crops" has received 2215 citations. The *journal Seed Science and Technology* was productive journal and *Weed Science* highly performed journal. Lamont BB was the most productive author in terms of publications (50) and Herrera CM from Spain was highly performed author in the value of Y-index (j-20.52; θ -0.84) and MCI -0.02. USA was the top productive and high performed country. USA had high collaboration with other countries. India had 243international collaborative publications. Research performance of seed technology is in moderate condition and suggests that the researchers publish their research findings in open access journals for better research visibility and also the research institutions encourage the scientist to publish the research findings in their regional languages.

Keywords: *Seed technology, Agriculture, publication character, Web of Science, MCI, Y-index*

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1 INTRODUCTION

Agriculture plays a very important role in food production and employment. Agriculture inputs like fertilizer, irrigation, weed control; plant Insecticides will be useless if not selected quality seed. The use of good planting seeds is one of the most important requirements for successful agriculture. (1) defined "Seed technology as the methods through which the genetic and physical characteristics of seed could be improved. It involves such activities as variety development, evaluation and release, seed production, processing, storage, and certification." The statistical measurement of research productivity of Seed technology is helping to know the overall growth of literature. This data is most useful in general especially for the government for policy-making and research funding.

Scientometrics as "the science of measuring science"(2) can be defined as an application of quantitative techniques to scientific communication, which aims at measuring the impact of science on society; comparing the output as well as its impact at national and international levels. These include the measurement of impact articles, journals, and institutes, understanding of scientific citations, and mapping the research domains. Scientometric literature on Agriculture showed that global agricultural research output showed an upward trend. It revealed that the USA produced the highest number of papers and the most preferred journal was Agriculture Ecosystems and Environment publishing 533 papers(3). Seed technology[4]research publications during 2008-2017 based on the Scopus database and displays that the growth of literature follows the linear growth pattern and degree of collaboration (92%) significantly high in the study(4). Banana research output during the period 1978-2018 from the CAB Direct Online database and informs that India was the most productive Country with 399 papers (16.49%) followed by South Africa (10.91%) and Brazil (5.75%)(5).

3 MATERIALS AND METHODS

The primary data of this study were downloaded from the Web of Science database. Web of Science™ is the world's oldest, most trusted publisher-independent global citation database for research publication and citations. Based on the Science Citation Index, founded by Eugene Garfield in 1964, it has expanded its selective, balanced, and complete coverage of the world's leading research to cover around 34,000 journals today.

The database was searched under the following keywords and Boolean operators: keywords ("seed technology" OR "seed science" OR "seed production" "seed processing" OR "seed treatment" OR "seed handling" OR "seed storage")]. The publication period reviewed was between 1990 and 2019.The finally 16613 records were collected for the study.

Six type of analysis were conducted, (1) growth of publication and citations in the period of study, (2) languages of publications (3) Core journals (4) highly cited articles (5) authors production and performance (6) research collaboration among countries

Ho(6)&(7) proposed Y-index for solving the deficiencies of previous indices and evaluating the validity of the researchers' scientific publications. Y index is considered as a proper criterion for evaluating and ranking authors based on first author publications (FP) and corresponding or reprint author publications (RP). Unlike other existing indices such as h-index which is mono-parametric, Y-index is the first one using two parameters (j, θ) and the formula is

$$J=(FP^2+RP^2)$$

$$\theta = tan^{-1}(RP/FP)$$

j shows the quantity of production based on important situations which depend on the number of first authors and corresponding author publications. If j in a university is greater, it means that the authors of that university have published more articles as the first author or the corresponding author. Another parameter (θ) is calculated to make sure who plays an important role among the authors. θ indicates the distribution of the first and the corresponding authors' publications. If $\theta > 0.7854$, it means more RP. If $\theta < 0.7854$, it means more FP. If $\theta = 0.7854$ it means the same quantity of FP and RP

Chuang KY (8) has proposed the Major contributor index, was used to assess the extent a researcher contributed to publishing an article. The MCI is calculated as the sum of first-author articles and corresponding articles divided by two times the total number of articles. It implies the percentage of instances one takes on the leadership role (first author or corresponding author) out of the total possible available opportunities. The equation is:

$$MCI = (FP - RP)/2TP,$$

Where FP is the number of first-author articles, RP is the number of corresponding author articles or reprint author, and TP is the number of total articles. When MCI = 0, there is no first- or corresponding-author article. When MCI = 1, all articles are either first- or corresponding-author articles. MCI has two implications. First, it probably indicates a higher capability or productivity in conducting independent research. Second, it could, as well, indicate a more prominent role in collaborations. On the contrary, a low MCI is probably a sign of heavy reliance on collaboration, as well as relying on others to provide a leadership role in conducting research.

4 RESULTS

4.1 The year-wise analysis of publications and citations

Table1 shows the year-wise analysis of publication and citations during the period of study. Out of 16,613 publications, 14,840 (89.32%) publications were cited and 1773 (10.67%) publications remaining uncited. In the year 2004 has received the highest citations with 19814 (5.65%) followed by 2007 with 18611 citations (5.61%). Similarly, the lowest citation was in the year 1990 with 3271 citations (0.90%). It was noticed that the highest Citation per Publication (CPP) was reported in the year 2001 with a value of 40.12 and the minimum CPP was reported in the year 2019 with a value of 1.35. The average Citation per Publication (CPP) for the study period was 21.10. Citation density shown a consistent increase from 287.72 in 1991 to 1286.00 in 2019.

Table 1. The year-wise analysis of publications and citations

Year	Publications	No. of Publications Cited	Citation	No. of Publications Not Cited	Citation density	CPP
1990	121	106	3271	15	109.03	27.03
1991	316	299	8344	17	287.72	26.41
1992	300	283	8047	17	287.39	26.82

Year	Publications	No. of Publications Cited	Citation	No. of Publications Not Cited	Citation density	CPP
1993	342	310	10380	32	384.44	30.35
1994	362	326	8859	36	340.73	24.47
1995	375	349	11231	26	449.24	29.95
1996	378	354	12327	24	513.63	32.61
1997	389	363	12684	26	551.48	32.61
1998	426	410	14419	16	655.41	33.85
1999	382	362	12225	20	582.14	32
2000	442	431	16532	11	826.60	37.4
2001	417	398	16728	19	880.42	40.12
2002	447	425	16625	22	923.61	37.19
2003	472	448	15694	24	923.18	33.25
2004	508	485	19814	23	1238.38	39
2005	529	506	18176	23	1211.73	34.36
2006	514	490	14933	24	1066.64	29.05
2007	610	586	18611	24	1431.62	30.51
2008	660	627	16214	33	1351.17	24.57
2009	673	621	14330	52	1302.73	21.29
2010	682	637	12973	45	1297.30	19.02
2011	690	642	12289	48	1365.44	17.81
2012	678	627	10524	51	1315.50	15.52
2013	711	661	9683	50	1383.29	13.62
2014	790	723	9181	67	1530.17	11.62
2015	808	733	8480	75	1696.00	10.5
2016	862	780	7731	82	1932.75	8.97
2017	880	743	5708	137	1902.67	6.49
2018	897	657	3262	240	1631.00	3.64
2019	952	458	1286	494	1286.00	1.35
	16613	**14840**	**350561**	**1773**		**731.38**

4.2 Language-wise Distribution of research Publications

Table2 displays the language-wise distribution of research output. The publications were found to be in 17 languages, among which English was predominant with 15952 (96%) with 347365 citations of total output. Non-English contributions belonging to the other 16 languages shared 4% of the total output forming a meager number.

Table 2. Language-wise Distribution of Publications

Language	publications	Percentage	No. of Citations	CPP
English	15952	96	347365	21.78
Portuguese	281	1.7	1550	5.52
Spanish	105	0.6	502	4.78
German	61	0.4	378	6.2
French	60	0.4	267	4.45
Japanese	48	0.3	282	5.88
Czech	29	0.2	21	0.72
Russian	18	0.1	54	3
Chinese	17	0.1	61	3.59
Hungarian	16	0.1	29	1.81

4.3 Productive Vs Performed Journals

Table 3 presented the top 10 highly productive qualitative journals in terms of publications in the Seed technology. Totally 1647 journals contributed to the Seed technology research. It was found that the Seed Science and Technology published by International Seed Testing Association, Switzerland was at the top position with 257 (1.55%) publications followed by the Weed Science published by Cambridge University Press, USA with 242 (1.46%) publications and Crop Science published by Crop Science Society of America., the USA with 434 (1.34%) publications. The quality indicators of journals such as Impact Factor (IF2019), h-index and SCImago Journal Rank (SJR) The Journal "Ecology" has received the highest impact factor 2019 value of 5.55 h-index 77 and SCImago Journal Rank (SJR) 2.507 followed by Weed Science with the impact factor 2019 value of 3.05 h-index 37 and SCImago Journal Rank (SJR) 0.765 and Plos One with the impact factor 2019 value of 2.83 h-index 26 and SCImago Journal Rank (SJR) 1.023

Table 3. Productive Vs Quality Journals

Name of the Journal	Country	Publications	Citations	Impact Factor (2019)	h index	SCImago Journal Rank
Seed Science and Technology	Switzerland	257	1731	0.59	21	0.209

Weed Science	USA	242	5527	3.05	37	0.765
Crop Science	USA	222	3158	2.2	28	0.831
American Journal of Botany	USA	219	8034	2	52	1.417
Ecology	USA	205	16733	5.5	77	2.507
Oecologia	Germany	193	7509	0	52	1.435
Plos One	USA	191	3145	2.83	26	1.023
Crop Protection	England	179	2811	2	28	0.805
Indian Journal of Agricultural Sciences	India	177	268	1.89	7	0.209
Euphytica	Netherland	175	2505	1.13	26	0.706

4.4 Highly Cited Publications

Table 4 shows the highly cited publications in the Seed technology research. An article titled "Importance of pollinators in changing landscapes for world crops" by Klein AM etal. published in the *Proceedings of The Royal Society B-Biological Sciences* in the year 2007 has received maximum number of citations (2215). The Second highest cited article titled "*The conservation of plant-pollinator*

interactions" by Kearns CA. published in the Annual *Review of Ecology and Systematics* in the year 1998 has 980 citations. The article titled, "*Evolution of the magnitude and timing of inbreeding depression in plants*" by Husband BC published in the journal *Evolution.*in the year 1996 has received 871 citations and held the third position among highly cited publications.

Table 4. Highly Cited Publications

Sl. No.	Year	Author / Title of the Publication	Source/Journal	Total Citations	Average Citation Per Year	Rank
1	2007	Klein AM/Importance of pollinators in changing landscapes for world crops	Proceedings of The Royal Society B-Biological Sciences.	2215	158.21	1
2	1998	Kearns CA/Endangered mutualisms: The conservation of plant-pollinator interactions	Annual Review of Ecology and Systematics.	980	42.61	2
3	1996	Husband BC/ Evolution of the magnitude and timing of inbreeding depression in plants	Evolution.	871	34.84	3
4	2002	Obeso JR / The costs of reproduction in plants	New Phytologist	764	40.21	4
5	2002	Top of Form Shewry PR / Cereal seed storage proteins: structures, properties and role in grain utilization	Journal of Experimental Botany	737	38.79	5
6	2004	Ashman TL/Pollen limitation of plant reproduction: Ecological and evolutionary causes and consequences	Ecology	693	40.76	6
7	2010	Mullin CA/ High Levels of Miticides and Agrochemicals in North American Apiaries: Implications for Honey Bee Health	Plos One	660	60.00	7
8	1995			639	24.58	8

Sl. No.	Year	Author / Title of the Publication	Source/Journal	Total Citations	Average Citation Per Year	Rank
		Shewry PR/Seed Storage Proteins - Structures and Biosynthesis	Plant Cell			
9	2005	Knight TM /Pollen limitation of plant reproduction: Pattern and process	Annual Review of Ecology Evolution and Systematics	627	39.19	9
10	2003	Broughton WJ /Beans (Phaseolus spp.) - model food legumes	Plant and Soil	617	34.28	10

4.5 Highly Productive authors

Table 5 shows the top10 highly prolific authors based on their publications. Out of 40588 authors, Lamont ,BB. affiliated to Curtin University, Perth from Australia became a highly productive author with 50 publications (0.30%). Ellis, RH from the School of agriculture policy, and development, England became the second-highest contributor with 47 publications (0.28%), and Johnson SD. from the University of Cape Town, South Africa became the third-highest contributor with 46 publications (0.28%) respectively. It was also noted that 5 Asian Authors were in the top 10 Prolific Authors in the Seed technology research.

Table 3. Highly Productive authors

Author	Papers	Country	Organization	Rank
Lamont BB	50	Australia	Curtin University, Perth, Western Australia	1
Ellis RH	47	England	School of agriculture, policy and development	2
Johnson SD	46	South Africa.	University of Cape Town	3
Takaiwa F	42	Japan	National Agriculture and Food Research Organization	4
Shimada T	41	Japan	Tohoku Research Center Forestry and Forest Products Research Institute	5
Wang Y	41	China	Jilin University, School of Biological and Agricultural Engineering	6
Hara-Nishimura I	40	Japan	Konan University	7

Kumar A	38	India	Indian Agr Res Inst, Div Seed Sci & Technol, New Delhi, India	8
Shewry PR	37	England	Rothamsted Research,Harpenden	9
Kumar V	36	USA	Cornell Horticulture - Cornell University	10

4.5 Top 10 Highly performed authors

In all, there were 40588 authors and 3096 authors were published highly cited publications in Seed technology during the study period. Table 6 presents a list of top 10 authors having highly cited publications. by calculating Y index based on j parameter. In addition, θ shows that most of the authors are related to corresponding authors Herrera CM from Spain was highly performed author with Y-index (j-20.52 ; θ -0.84) and MCI -0.02 followed by Totland O from Norway had Y-index (j-17.80 ; θ -1.00) and MCI -0.06 and Eckert CG from Canada had Y-index (j-17.03 ; θ -0.93) and MCI -0.05.

It was found that all the high performed authors had the negative value of MCI is a sign of heavy reliance on collaboration.

Authors	Country	TP	TC	FP	RP	MCI	Y-index	
							j	θ
Shewry PR	England	37	3495	9	12	-0.04	15.00	1.05
Ashman TL	USA	25	2274	9	11	-0.04	14.21	0.96
Tatham AS	England	22	1900	6	7	-0.02	9.22	0.92
Eckert CG	Canada	22	1866	11	13	-0.05	17.03	0.93
Herrera CM	Spain	23	1355	14	15	-0.02	20.52	0.84
Takaiwa F	Japan	42	2441	5	8	-0.04	9.43	1.26
Agren J	Sweden.	31	1673	9	14	-0.08	16.64	1.22
Kondo M	Japan	22	1156	0	6	-0.14	6.00	0.00
Totland O	Norway	24	1246	11	14	-0.06	17.80	1.00
Irwin RE	USA	24	1234	9	12	-0.06	15.00	1.05

TP- Total Publications; TC-Total Citations; FP- First authored articles; RP-Reprint or Corresponding authored articles; MCI - Major contributor index

Table 4. Top 10 Highly performed authors

4.8 Most Productive Countries

Table 7 described the most productive countries, out of 148 countries have contributed to Seed technology research during the study period and the most productive 10 countries have been displayed in table 7, USA stood in the first place with 4408 Publications (26.5%) with 124641 citations. China stood at second place with 1212 (7.3%) publications with 16550 citations and India became the third topper with a share of 1165 (7.0%) publications and 11646 citations. USA had 32 h-index value followed by England 81 and Canada 75 h-index values respectively.

Table 8. Most productive countries

Country	Publications	Citations	h-index	Rank
USA	4408	124641	132	1
China	1212	16550	54	2
India	1165	11646	50	3
Canada	1105	27886	75	4
Japan	1003	22647	71	5
Australia	973	25641	66	6
Brazil	876	7401	35	7
England	820	28612	81	8
Spain	703	17828	59	9
Germany	698	17181	64	10

4.9 Collaboration relationship

Table 8 showed the collaboration relationship among most productive countries. The highest number of collaborative links 176 exist between the USA and China, followed by 170 links between the USA and Canada, 92 links between the USA and Australia, 78 links between the USA and Spain, 77 links between the USA and Germany, 60 links between USA and Brazil, 48 links between England and Germany.

Table 9. Collaboration relationship

Countries	USA	China	India	Canada	Japan	Australia	Brazil	UK	Spain	Germany
USA	-	176	44	170	47	92	60	70	78	77
China	176	-	11	52	34	52	3	34	9	30
India	44	11	-	7	16	19	1	11	2	14
Canada	170	52	7	-	16	30	6	17	14	21
Japan	47	34	19	16	-	6	2	8	2	9
Australia	92	52	19	30	6	-	12	39	0	32
Brazil	60	3	1	6	2	12	-	19	11	15

UK	70	34	11	17	8	39	19	-	40	48
Spain	78	9	2	14	2	0	11	40	-	28
Germany	77	30	14	21	9	32	15	48	28	-

5 DISCUSSION

The study found that a total of 16613 publications contributed by 40588 authors from 1647 number of scholarly journals received with 350561 citations and h-index and g-index 182, 262 respectively, 148 countries have contributed in the Seed technology research. Comparing to other scientific literature, seed technology research is a moderate condition, heavy investment is needed in terms of research and development activities from the authorities to upgrade this field and increase research output. The English Language has the dominant language in Seed technology research and the research institutions encourage the scientist to publish the research in their regional language and the researchers may be motivated to publish their research findings in open access journals. The study identified that the journal Seed Science and Technology was productive journal and Weed Science highly performed journal. Lamont BB was the most productive author in terms of publications and Herrera CM from Spain was highly performed author in the value of MCI and Y-index. USA was the top productive and high performed country. USA had high collaboration with other countries. India had 243international collaborative publications.

6 CONCLUSIONS

Agriculture plays a vital for the economic growth and per capita income of any country Hence, research output in seed technology is a moderate condition, India ranks second in agriculture production contradictory the research output of Seed technology 1165 for 30 years is really below par. Indian government may establish a separate ‘research institute’ with heavy investment to improve the focused research activities on Seed technology research in India. Databases such as Scopus and CAB Direct Online Database would have been an appropriate source of data for future research to reveal the research output of seed technology. The findings of this study apply only to the Seed technology research field and related disciplines used from the Web of Science Database.

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