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Mapping the Research Output of Select Research Institutes in India: A Scientometric Approach

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ABSTRACT

The study identified the research performance of different government institutes namely, All India Institute of Speech and Hearing (AIISH), Mysore, Central Power Research Institute (CPRI), Bangalore, and Indian Council of Agricultural Research - National Institute of Animal Nutrition and Physiology (ICAR-NIANP), Bangalore. The study covers the period 2006-2019 to retrieve the data from Web of Science database. All three institutes produced 898 records. AIISH published 151 articles and got 810 citations, CPRI published 365 articles and received 3049 citations and ICAR-NIANP published 382 articles and gained 2827 citations during the period. AIISH and ICAR-NIANP have published maximum number of papers in "Article Type". In contrast, CPRI has published good number of papers in "Proceedings Paper". The H-index of AIISH was 15, the H-index of CPRI was 27 and the H-index of ICAR-NIANP was 26. Further, the study analyzed productive authors of the institutions, highly cited articles, author collaboration, and suitability of Lotka's law of scientific productivity.

KEYWORDS: AIISH; CPRI; ICAR-NIANP; Scientometrics; Mapping; Research; India

INTRODUCTION

All India Institute of Speech and Hearing (AIISH), Mysore

The All India Institute of Speech and Hearing (AIISH 2020) was established in 1966. The campus spread over 32 acres of greenery in the city of Mysore adjacent to the University of Mysore in Manasagangothri, Mysore. The autonomous institute is coming under the Ministry of Health and Family Welfare, Government of India. The institute mainly focuses on teaching and conducting research and training in clinical services. It has eleven departments with state-of-the-art facilities to offer inter-disciplinary training to the students. The institute offers Certificate course, Diploma courses, Under Graduate, Post Graduate, PG Diploma, Ph.D. in (Audiology, Speech-Language Pathology, Speech and Hearing, Special Education and Linguistic) and Post Doctoral Fellowships. The institute has a modernized Library and Information Centre, which has the World's best collection in the form of print and digital in the field of speech and hearing information sources.

Central Power Research Institute (CPRI), Bangalore

The Central Power Research Institute (CPRI 2020) was started in 1960 at Bangalore, Karnataka, under the Ministry of Power, Government of India. It is the center for excellence in the field of electrical engineering in India. CPRI also serves as an independent authority for testing and certification of power equipment. The institute runs their own journal called "Power Research: A Journal of CPRI" and it is a biannual publication devoted to research in the power and energy sectors. The institute "Department/Units" was set up in different locations at Guwahati, Kolkata, Noida, Bhopal, Nagpur, and Hyderabad. The institute has an automated library with a large number of collections in electrical, power engineering in India.

ICAR-National Institute of Animal Nutrition and Physiology (NIANP), Bangalore

The ICAR-National Institute of Animal Nutrition and Physiology (ICAR-NIANP, 2020) was established in 1995 at Bangalore, Karnataka, under the umbrella of the Indian Council of Agricultural Research (ICAR), New Delhi. The Institute is completing 25 years of its inception. The institute is broadly divided into three divisions: Animal Nutrition Division, Animal Physiology Division and Bioenergetics and Environmental Sciences. The institute's focus is to perform research on animal feed resource management, animal productivity, and livestock farmers.

LITERATURE REVIEW

(Pandita, Singh, and Gaur 2014) carried out the study on research publications of some selected medical institutions using the WoS database. They chose four major medical institutions in India, namely, AIIMS, New Delhi, JIPMER, Pondicherry, PGIMER, Chandigarh, and SGPGIMS, Lucknow, and the study period was 2007-2011 in the 89 subject fields. The study analyzed 9296 records for the said period for the four institutions. AIIMS, New Delhi was registered the highest number of records 5184, compare to other institutions where JIPMER, Pondicherry scored a very less number of articles 472 for the five-year period. The paper discussed the increase and decrease percentage of publications year by year. Further, the study results show that the top ten subject areas of all the four institutes and AIIMS have the more papers in all the subjects. The following are the top five subject areas of all the four institutes "Pediatrics, Neurosciences Neurology, Surgery, General Internal Medicine, Oncology".

(Batcha 2018) studied research performance of six universities in Tamil Nadu for the period 2000-2017. The researcher used the Web of Science database as the source to download the data. The selected universities are Madras University, Annamalai University, Bharathiyar University, Bharathidasan University, Alagappa Univerisity, and Madurai Kamaraj University. The study analyzed 25569 records during the period. Madras University has published 6898 papers and has got 1st position followed by Annamalai University 6046 papers has got 2nd position and Bharathiyar University 3900 papers has got 3rd position and so on. Article type is the highest number of percentage 94.66%, followed by Review with 1.63%, Proceedings Paper with 1.47%, etc. Madras University has the highest H-index as 88 followed by Annamalai University with 86

and Bharathiyar University with 75. Further, the study analyzed the citations and un-cited publications of all the six universities. The first three papers from Madras University have the highest citations followed by papers from Bharathiyar University.

(Prabahar and Radhakrishnan 2020) carried out the study on the National Institute of Mental Health and Neurosciences for ten years period as the data appeared in the Web of Science database. The study retrieved 2984 publications and was limited to "Article" only by document type and investigated 1694 articles for 2009-2018. The study compared the neuroscience research with India and abroad, and it is proved that the USA tops with 226320 (36.087%) publications in 1st position and India with 14153 (2.257%) publications in 15th position. The total numbers of 1694 papers received 20158 citations, and they analyzed TLCS (Total Local Citation Score), TGCS (Total Global Citation Score). The degree of collaboration is 0.99. The NIMHANS researcher mostly preferred Indian journal to publish their research work with "Neurology India". The institute mostly collaborated with IISC, Bangalore, followed by Manipal University, Department of Science and Technology, Johns Hopkins University, USA, etc. The study displayed most collaborating country, highly cited articles, and tested Lotka's Law of scientific productivity.

(Prabahar et al. 2017) analyzed research performance of IIAP, Bangalore for the period 2005-2014. IIAP produced 1005 articles during the period. The study proved that the three author's production was high, and collaborated work gets more citations. The researcher of IIAP mostly preferred to publish their work in "Astrophysical Journal" published by AAS, USA. The study did not match with Lotka's law of scientific productivity. Further, the study resulted in degree of collaboration, authorship pattern, most prolific authors, citations, highly cited articles and, H-index.

(Senthil Kumar et al. 2018) focused the research trend of CSIR-CECRI, Karaikudi, Tamil Nadu, for 2010-2015 using the Web of Science database by Clarivate Analytics. The study shows that the researcher of the CECRI published 650 articles. The study highlighted the document type analysis, and it is proved that the "Article" type is highest as compared with "Proceedings Papers", "Reviews", and Editorial Materials". The analysis of the subject domain of CECRI shows that "Chemistry" was top followed by Materials Science, Electrochemistry, Physics, Engineering, etc. The research also analyzed the most favored journals to publish their research, author productivity, highly productive author, country collaboration, and highly cited articles.

(Prabahar, Senthil Kumar, and Radhakrishnan 2019) conducted the study on CFTRI research productivity for the period 2008-2017 as the data harvested from the Web of Science database. The study resulted in 1761 papers, which has received 18,222 citations. The study results proved that the CFTRI authors mostly preferred to publish their research work in Indian journal. The subject wise analysis shows that the "Food Science Technology" domain gets more attention of CFTRI researcher. The study also found out the highly cited papers, citations, top authors, H-index, collaborating countries, top institutions collaboration, and suitability of Lotka's Law of scientific productivity.

The study by (Dotson 2020) revealed the characteristics of 100 highly cited papers of 15 institutions in USA, citation counts, top journals and publishers. The data were downloaded from Scopus database. The document type "Journals" were highly cited with 96.3% where as "Books, Conference proceedings, magazines, etc.," cited with 3.7%. In top three places of "Journal Titles" were "Science, Nature and New England Journal of Medicine" which forms 20.9% publications. The commercial publisher like "Springer Nature, Elsevier, Wiley etc.," topped in the publication list.

(Salisbury, Chowdhury, and Smith 2017) studied faculty research publications of University of Arkansas, USA for the period 2005 to 2015 and the data were extracted from Web of Science database. The study analyzed OA and non-OA articles published by faculties of the University. There were 368 Open Access papers and 8291 non-Open Access papers published during the period. Open access articles were highly published in the area of science and technology rather than other subject areas. The average citation was higher for non-OA publications compared to OA publications for the total years.

OBJECTIVES OF THE STUDY

- To find out the year-wise research output of AIISH, CPRI and ICAR-NIANP.
- To reveal the document type of the three institutes.
- To identify the top productive authors.
- To draw highly cited papers.
- To bring out the most preferred journals to publish the research findings.
- To graph top country collaboration.
- To find out the top institution collaboration.

METHODOLOGY

The study analyzed the research output of three institutes, namely, All Indian Institute of Speech and Hearing (AIISH), Mysore, Central Power Research Institute (CPRI), Bangalore, and ICAR-National Institute of Animal and Nutrition Physiology (NIANP), Bangalore, using the Web of Science database developed by Clarivate Analytics for the period 2006 to 2019. The researcher used the advance search field to download the data and issued search string as "OO=All India Inst Speech & Hearing AND PY=2006-2019, OO=Cent Power Res Inst AND PY=2006-2019 and OG=ICAR - National Institute of Animal Nutrition & Physiology AND PY=2006-2019". AIISH produced 151 articles, CPRI produced 365 articles, and NIANP produced 382 articles during the period, which forms a total number of 898 articles. The data were downloaded on 13th March 2020. Further, the data was analyzed using MS-Exel software, VOSviewer to visualize the authorship network and the R program to display the author's publications, citations, h-index, etc.

Note: The present work is a part of Ph.D. level research which is in progress.

ANALYSIS AND DISCUSSION

Document type

The study focused categorization of research publications of all the three institutes during the period 2006-2019. AIISH registered "Article Type" which is highest with 138 (91.39%) followed by "Proceedings Paper" with 9 (5.96%), and "Review" with 4 (2.64%). CPRI has registered the highest number of papers in "Proceedings Paper" as 187 (51.23%), followed by "Article Type" with 176 (48.21%), the other type of documents are very less in number. ICAR-NIANP registered the highest number with "Article Type" as 352 (92.14%), followed by "Review" as 19 (4.97%), "Meeting Abstract as 6 (1.57%) & "Proceedings Paper" as 3 (0.78%) and so on.

Table.1. Document wise analysis

Document Type	AIISH	%	CPRI	%	ICAR-NIANP	%
Article	138	91.39	176	48.21	352	92.14
Proceedings Paper	9	5.96	187	51.23	3	0.78
Review	4	2.64	0	0	19	4.97
Letter	0	0	0	0	1	0.26
Meeting Abstract	0	0	0	0	6	1.57
Correction	0	0	2	0.54	1	0.26
Total	**151**	**100%**	**365**	**100%**	**382**	**100%**

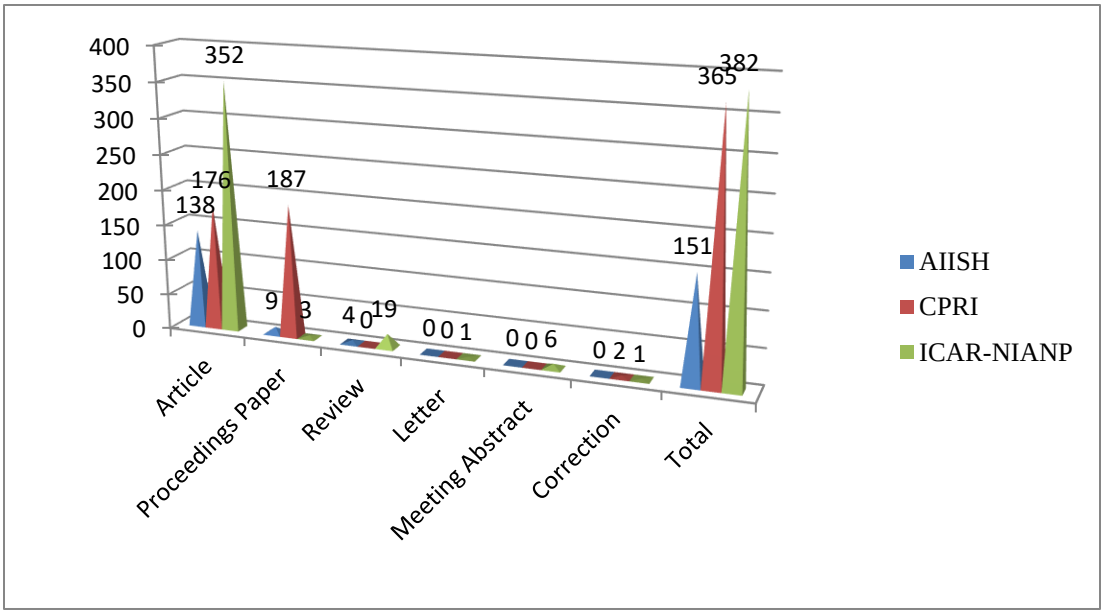

Fig.1.Document type of AIISH, CPRI, and ICAR-NIANP

Year-wise publications

Table.2. demonstrate the growth of year-wise publications of all the three institutes for the period 2006-2019. AIISH has published the highest number of articles in the year 2019 with 31 (20.52%) and the lowest number of articles in 2006 with 2(1.32%). CPRI produced the highest number of articles in 2016 with 48 (13.15%) and the lowest number 2011 with 8 (2.19%). ICAR-NIANP registered the highest number of articles in the year 2018 with 52 (13.33%) and the lowest number of articles in 2006 with 9 (2.30%).

Table.2. Year-wise publications

Years	AIISH Papers	%	CPRI Papers	%	ICAR-NIANP Papers	%
2006	2	1.32	14	3.83	9	2.3
2007	4	2.64	15	4.1	24	6.15
2008	5	3.31	16	4.38	36	9.23
2009	4	2.64	22	6.02	24	6.15
2010	4	2.64	10	2.73	16	4.1
2011	3	1.98	8	2.19	19	4.87
2012	7	4.63	46	12.6	29	7.43
2013	13	8.6	16	4.38	23	5.89
2014	10	6.62	39	10.68	11	2.82
2015	13	8.6	37	10.13	33	8.46
2016	16	10.59	48	13.15	26	6.66
2017	22	14.56	43	11.78	38	9.74
2018	17	11.25	31	8.49	52	13.33
2019	31	20.52	20	5.47	42	10.76
Total	**151**	**100%**	**365**	**100%**	**382**	**100%**

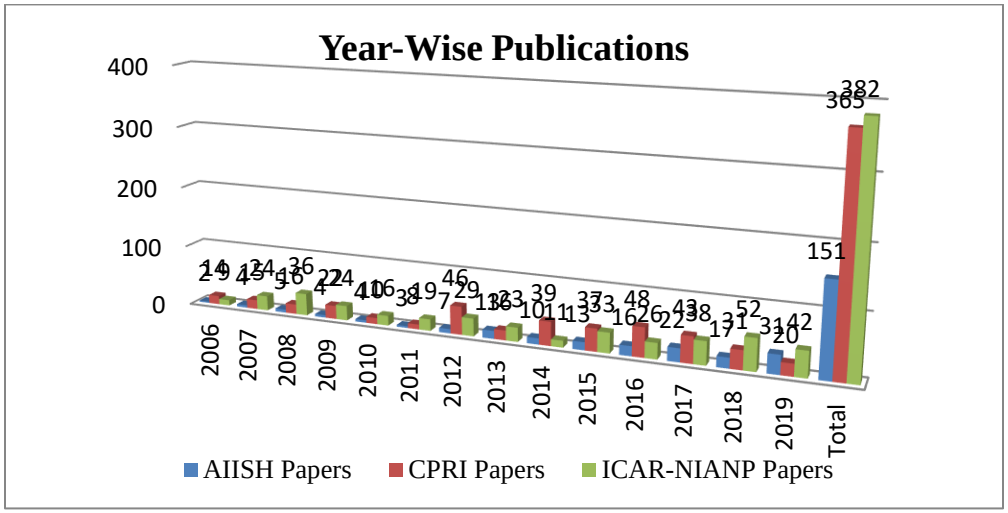

Fig.2. Year-wise publications of AIISH, CPRI, and ICAR-NIANP

Citation analysis

Table.3. indicates the citation analysis for all the three institutes. AIISH has published 151 articles which have received 810 citations, and 5.36 is the Citation per Paper (CPP). 99 (65.56%) articles of AIISH were cited, and 52(34.43%) articles were uncited. AIISH has got the H-index of 15. CPRI has published 365 articles, have got 3049 citations, and 8.35 is the Citation per Paper (CPP). 198 (54.24%) articles of CPRI were cited, and 167 (45.75%) articles were uncited. CPRI has got the H-index of 27. ICAR-NIANP have published 382 articles and have got 2827 citations, and 7.4 is the Citation per Paper (CPP). 291(74.61%) articles of ICAR-NIANP were cited, and 99(25.38%) were uncited. ICAR-NIANP has got the H-index of 26.

Table.3. Citations analysis

Institutes Name	TNP	TNC	CPP	H-Index	Cited	Cited %	Uncited	Uncited %
AIISH	151	810	5.36	15	99	65.56	52	34.43
CPRI	365	3049	8.35	27	198	54.24	167	45.75
ICAR-NIANP	382	2827	7.4	26	291	74.61	99	25.38

Highly productive authors of AIISH

Table.4. shows that the top 20 productive authors of the AIISH based on the number of publications. “Singh, NK., with 24 articles gained 1st position followed by Maruthy, S., with 20 articles is in 2nd position, and Narne, V.K. and Prabhu, P., with 14 articles is in 3rd position. Moore, BCJ published 12 articles and received 219 citations, followed by Vinay with 8 articles, received 185 citations, and Singh, NK with 24 articles, received 149 citations. Singh, NK and Moore, BCJ stands in 1st position with H-index 7, followed by Murthy, S., Narne, V.K., Barman, A., and Vinay occupied 2nd position (H-index 6), Kumar, UA., Sinha, S.K., and Vanaja, CS reached 3rd position (H-index 5).

Table.4. Top 20 productive authors of AIISH

Author	NP	TC	h-index	g-index	m-index	PY start
SINGH NK	24	149	7	11	0.875	2013
MARUTHY S	20	70	6	8	0.429	2007
NARNE VK	14	121	6	11	0.462	2008
PRABHU P	14	24	3	4	0.3	2011
BARMAN A	13	95	6	9	0.6	2011

KUMAR UA	12	123	5	11	0.333	2006
MOORE BCJ	12	219	7	12	0.5	2007
YATHIRAJ A	12	39	4	6	0.267	2006
KUMAR P	10	37	3	6	0.333	2012
VINAY	8	185	6	8	0.429	2007
SINHA SK	7	53	5	7	0.455	2010
VANAJA CS	7	85	5	7	0.385	2008
APEKSHA K	5	28	3	5	0.429	2014
GNANATEJA GN	5	16	2	4	0.25	2013
SHETTY HN	5	7	2	2	0.4	2016
AZAD RK	3	8	2	2	0.222	2012
BANSAL S	3	10	1	3	0.2	2016
CHENGAPPA S	3	1	1	1	0.111	2012
DEVADAS U	3	5	1	2	0.25	2017
GARGESHWARI A	3	8	2	2	0.667	2018

NP: Number of Papers, TC: Total Citations, PY: Publication Year

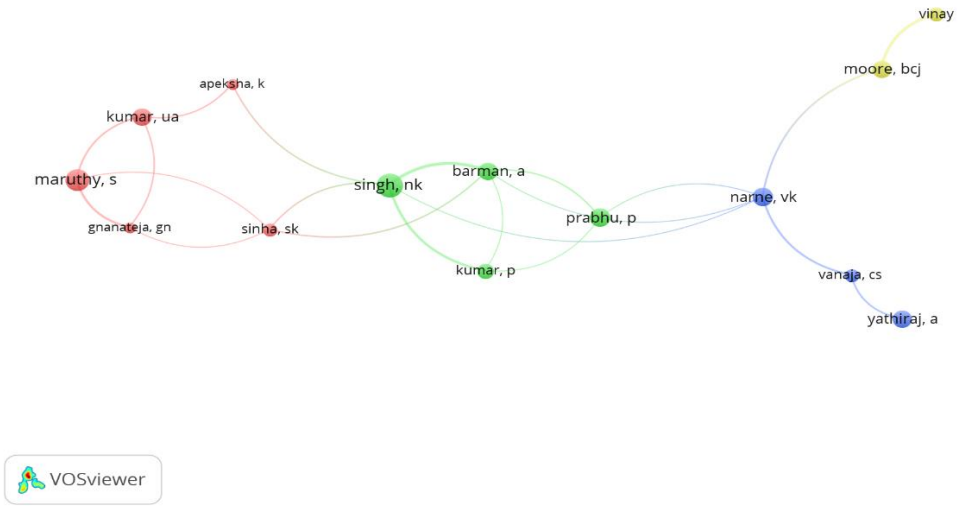

Fig.3.VOSviewer co-authorship network visualization of AIISH

Highly productive authors of CPRI

Table.5. presents the top 20 productive authors of CPRI based on the number of publications. “Seetharamu, S., with 39 articles reached first position followed by Rajan, JS., with 37 articles with 2nd position and Thomas, P., with 35 articles is in 3rd position. Varughese, KT has published 34 articles which received 1217 citations. Thomas, S., published 32 articles and received 952 citations. Thomas, P., with 37 articles received 696 citations. Varughese, KT., has gained H-index 17 followed by Thomas, S., with H-index 16. Seetharamu, S., and Thomas, P., with H-index 13.

Table.5. Top 20 productive authors of CPRI

Author	NP	TC	h-index	g-index	m-index	PY start
SEETHARAMU S	39	626	13	24	0.867	2006
RAJAN JS	37	149	7	10	0.538	2008
THOMAS P	37	696	13	26	0.929	2007
VARUGHESE KT	34	1217	17	34	1.133	2006
THOMAS S	32	952	16	30	1.067	2006
RAO BN	23	27	2	4	0.167	2009
SAMPATHKUMARAN P	21	300	9	17	0.6	2006
SINGH M	20	128	5	11	0.625	2013
JAIN A	18	20	2	4	0.286	2014
VASUDEV N	15	52	4	7	0.286	2007
SAILAJA RRN	13	202	6	13	0.462	2008
VARMA KBR	11	529	9	11	0.643	2007
VYNATHEYA S	11	15	2	3	0.222	2012
BHATT MS	10	52	5	7	0.333	2006
MEERA KS	9	11	2	3	0.133	2006
NAGAMANI HN	9	17	2	4	0.222	2012
RANGANATHAIAH C	9	28	3	4	0.231	2008

RENUKAPPA NM	9	59	5	7	0.417	2009
AKSHATHA A	8	10	2	3	0.222	2012
ARADHYA RSS	8	90	1	8	0.071	2007

NP: Number of Papers, TC: Total Citations, PY: Publication Year

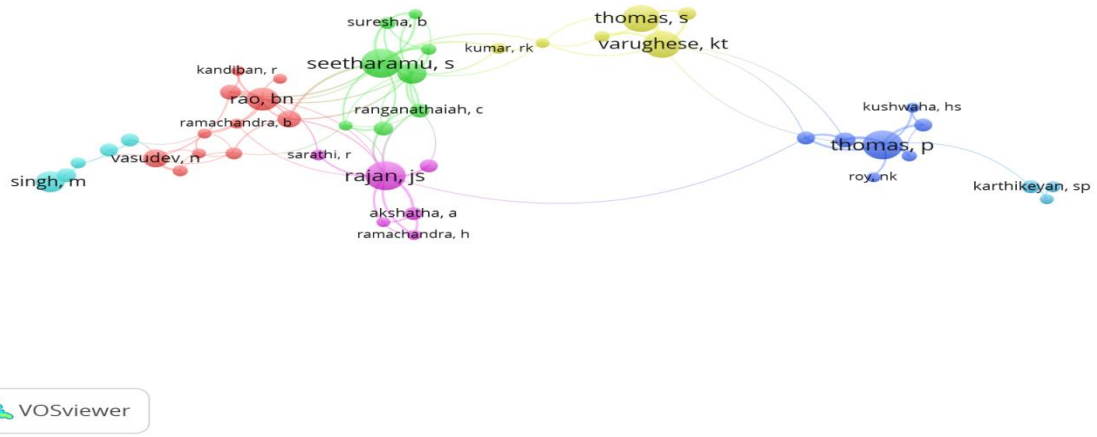

Fig.4.VOSviewer co-authorship network visualization of CPRI

Highly productive authors of ICAR-NIANP

Table.6. indicates the top 20 productive authors of ICAR-NIANP based on the number of publications. “Nandi S” has published 56 articles and gained 1st position followed by Ravindra, JP, Sejian, V., and Selvaraju, S. with 55 articles placed 2nd position and Gupta, PSP., produced 50 articles and reached 3rd position. Ravindra, JP., has published 55 articles received 666 citations, followed by Selvaraju, S., with 55 articles and gained 661 citations. Nandi, S., with 56 articles received 565 citations. Ravindra, JP., with H-index 15 stands 1st position followed by Nandi, S., Selvaraju, S., with H-index 14 stands 2nd position and Gupta, PSP., with H-index 12 stands 3rd position. Further, the table has produced g-index and m-index of the authors.

Table.6. Top 20 productive authors of ICAR-NIANP

Author	NP	TC	h-index	g-index	m-index	PY start
NANDI S	56	565	14	22	0.933	2006
RAVINDRA JP	55	666	15	23	1	2006

SEJIAN V	55	479	11	20	1.22	2012
SELVARAJU S	55	661	14	24	1.077	2008
GUPTA PSP	50	559	12	22	0.8	2006
BHATTA R	43	467	11	20	0.733	2006
GOWDA NKS	35	420	8	20	0.571	2007
MONDAL S	35	191	8	12	0.533	2006
SRIDHAR M	33	403	10	19	0.667	2006
REDDY IJ	31	190	8	12	0.571	2007
SAMPATH KT	31	426	10	20	0.714	2007
KOLTE AP	29	402	11	19	1.1	2011
PAL DT	27	131	6	10	0.429	2007
SAMANTA AK	27	341	8	18	0.571	2007
BAGATH M	24	255	10	15	1	2011
ARANGASAMY A	23	152	7	11	1.167	2015
RAO SBN	22	144	7	11	0.467	2006
DHALI A	21	71	5	7	0.38	2008
PARTHIPAN S	20	149	7	11	0.778	2012
PRASAD CS	20	160	6	12	0.429	2007

NP: Number of Papers, TC: Total Citations, PY: Publication Year

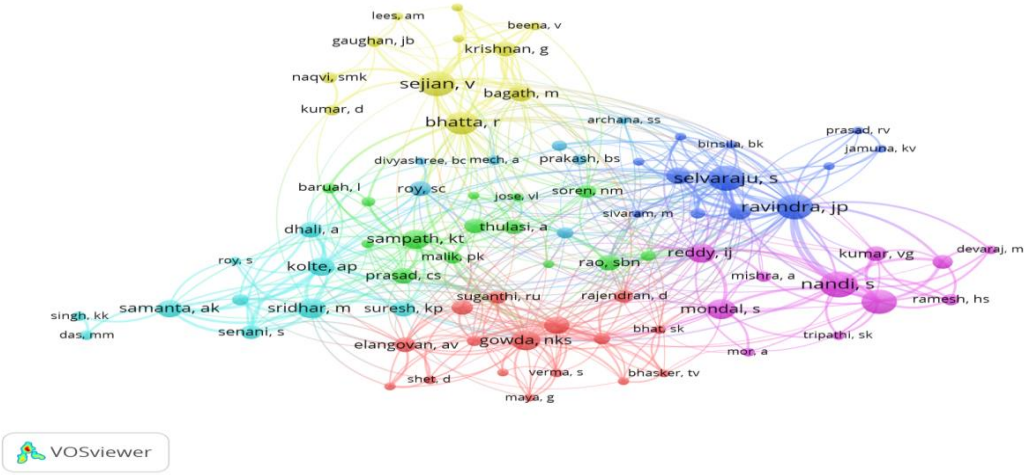

Fig.5.VOSviewer co-authorship network visualization of ICAR-NIANP

Comparison of highly cited papers

Table.7. showed the comparative analysis of the top 10 rankings of highly cited articles during the period. The article titled "Dielectric properties of poly... authored by Thomas, P., et al. from CPRI has got highest citations and ranked 1st position with 180 citations followed by the article "Dynamical mechanical analysis of sisal/oil... authored by Jacob, M., ...et al. from CPRI has got 161 citations which ranks 2nd position. Article entitled "The presence, role and clinical use of ... authored by Meritxell, J., ...et al. from ICAR-NIANP has got 150 citations which got ranked 3rd position.

Table.7. Top 10 highly cited papers

Rank	Articles	TNC	IF 2019	Institutes
1	Dielectric properties of Poly(vinylidene fluoride)/CaCu3Ti4O12 composites., Thomas, P.; Varughese, K. T.; Dwarakanath, K.; Varma, K. B. R., COMPOSITES SCIENCE AND TECHNOLOGY, Vol.70, No.3. 2010, pp.539-545.	180	7.094	**CPRI**
2	Dynamical mechanical analysis of sisal/oil palm hybrid fiber-reinforced natural rubber composites.,Jacob, Maya; Francis, Bejoy; Thomas, Sabu; Varughese, K. T., POLYMER COMPOSITES, Vol.27, No.6,2006, pp.671-680.	161	2.265	**CPRI**
3	The presence, role and clinical use of spermatozoal RNAs, Meritxell, J… [et al.].,HUMAN REPRODUCTION UPDATE, Vol.19,No.6.,2013,pp.604-624	150	12.684	**ICAR-NIANP**
4	Effect of chemical modification on properties of hybrid fiber biocomposites, John, Maya Jacob; Francis, Bejoy; Varughese, K. T.; Thomas, Sabu.,COMPOSITES PART A-APPLIED SCIENCE AND MANUFACTURING, Vol.39, No.2.,2008, pp.352-363.	129	6.444	**CPRI**
5	Mechanical and thermal characteristics of high density polyethylene-fly ash Cenospheres composites, Deepthi, M.V.	126	6.289	**CPRI**

	…[et al.], MATERIALS & DESIGN.,Vol.31, No.4., 2010, pp. 2051-2060.			
6	Effects of turmeric (Curcuma longa) on the expression of hepatic genes associated with biotransformation, antioxidant, and immune systems in broiler chicks fed aflatoxin, Yarru, L.P. …[et al.], POULTRY SCIENCE, Vol.88, No.12, 2009, pp. 2620-2627.	104	2.659	**ICAR-NIANP**
7	Progress in hydrotalcite like compounds and metal-based oxides for CO2 capture: a review. Bhatta, L.K.G. …[et al.],JOURNAL OF CLEANER PRODUCTION, Vol.103, pp.171-196.	93	7.246	**CPRI**
8	Dielectric properties of poly(vinylidene fluoride)/CaCu3Ti4O12 nanocrystal composite thick films, Thomas, P.; Satapathy, S.; Dwarakanath, K.; Varma, K. B. R. EXPRESS POLYMER LETTERS,Vol.4, No.10, 2010, pp. 632-643.	90	3.083	**CPRI**
9	Influence of extremely low frequency magnetic fields on Ca2+ signaling and NMDA receptor functions in rat hippocampus, Manikonda, Pavan K.,…[et al.],NEUROSCIENCE LETTERS, Vol.413, No.2, 2007, pp.145-149.	85	2.274	**CPRI**
10	Efficacy of turmeric (Curcuma longa), containing a known level of curcumin, and a hydrated sodium calcium aluminosilicate to ameliorate the adverse effects of aflatoxin in broiler chicks, Gowda, N.K.S., …[et al.], POULTRY SCIENCE, Vol.87, No.6, 2008, pp.1125-1130.	84	2.659	**ICAR-NIANP**

Most preferred journals

Table.8. shows the most preferred journals for publishing the research papers. ICAR-NIANP authors preferred to publish their articles in the journal "Indian Journal of Animal Sciences" with 78 (20.41%) articles followed by CPRI authors who preferred to publish their articles in the proceedings "2012 IEEE 10th International Conference on the properties and applications of..." with 26 (7.12%) articles. AIISH authors highly preferred to publish their articles in the journal "European Archives of Oto Rhino Laryngology" with 16 (1.59%) articles.

Table.8. Top 15 ranking of preferred journals

Rank	Journal	Papers	%	IF 2019	Institutes
1	Indian Journal Of Animal Sciences	78	20.41	0.278	**ICAR-NIANP**
2	2012 IEEE 10th International Conference On The Properties And Applications Of Dielectric Materials Icpadm	26	7.12	--	**CPRI**
3	Theriogenology	21	5.49	2.094	**ICAR-NIANP**
4	IEEE Transactions On Dielectrics And Electrical Insulation	19	5.2	2.554	**CPRI**
5	International Conference On Properties And Applications Of Dielectric Materials	18	4.93	--	**CPRI**
5	Indian Veterinary Journal	18	4.71	--	**ICAR-NIANP**
6	Biological Rhythm Research	17	4.45	0.826	**ICAR-NIANP**
6	Reproduction In Domestic Animals	17	4.45	1.641	**ICAR-NIANP**
7	Animal Reproduction Science	16	4.18	1.66	**ICAR-NIANP**
7	European Archives Of Oto Rhino Laryngology	16	10.59	1.809	**AIISH**

7	Journal Of International Advanced Otology	16	10.59	0.848	**AIISH**
8	International Journal Of Audiology	14	9.27	1.832	**AIISH**
9	Animal Nutrition And Feed Technology	13	3.4	0.146	**ICAR-NIANP**
10	2017 3rd International Conference On Condition Assessment Techniques In Electrical Systems Catcon	11	3.01	--	**CPRI**
11	Journal Of The Acoustical Society Of America	10	6.62	1.78	**AIISH**
11	Journal Of Applied Polymer Science	10	2.73	2.52	**CPRI**
11	Journal Of Animal Physiology And Animal Nutrition	10	2.61	1.597	**ICAR-NIANP**
11	Tropical Animal Health And Production	10	2.61	1.333	**ICAR-NIANP**
12	American Journal Of Audiology	9	5.96	1.558	**AIISH**
12	International Journal Of Pediatric Otorhinolaryngology	9	5.96	1.241	**AIISH**
12	Journal Of The American Academy Of Audiology	9	5.96	1.657	**AIISH**
13	International Conference On Properties And Applications Of Dielectric Materials Icpadm	8	2.19	--	**CPRI**
13	Small Ruminant Research	8	2.09	1.273	**ICAR-NIANP**
14	Ear And Hearing	7	4.63	3.129	**AIISH**
14	Journal Of Voice	7	4.63	1.903	**AIISH**

14	Icpadm 2009 Proceedings Of The 9th International Conference On Properties And Applications Of Dielectric Materials Vols 1 3	7	1.91	--	**CPRI**
14	Asian Australasian Journal Of Animal Sciences	7	1.83	1.664	**ICAR-NIANP**
14	Indian Journal Of Animal Research	7	1.83	0.395	**ICAR-NIANP**
14	International Journal Of Biometeorology	7	1.83	2.68	**ICAR-NIANP**
15	Hearing Research	6	3.97	3.693	**AIISH**
15	Journal Of Laryngology And Otology	6	3.97	1.098	**AIISH**
15	Proceedings Of The 2016 Ieee Region 10 Conference Tencon	6	1.64	--	**CPRI**
15	Animal Feed Science And Technology	6	1.57	2.582	**ICAR-NIANP**
15	Current Science	6	1.57	0.725	**ICAR-NIANP**
15	Reproduction Fertility And Development	6	1.57	1.718	**ICAR-NIANP**

Collaborations of AIISH, CPRI, and ICAR-NIANP

Table.9. indicates that the top country collaborations among the three institutes. AIISH institute's authors mostly collaborated with England (13 articles), followed by the USA (6 articles) and Australia (5 articles). CPRI authors collaborated with South Korea (12 articles), followed by the USA (9 articles), and South Africa (6 articles). ICAR-NIANP author mostly collaborated with Australia (18 articles) and followed by the USA (13 articles) and Brazil (6 articles).

Table.9. Top country collaborations

Country	AIISH	CPRI	ICAR-NIANP
USA	6	9	13
England	13	2	1
Australia	5	3	18

Peoples R China	5	-	-
Canada	4	1	3
U Arab Emirates	4	-	-
South Korea	-	12	1
South Africa	-	6	-
Malaysia	-	5	-
Slovenia	-	4	-
Brazil	-	-	6
Japan	-	2	3
Nigeria	-	-	2

NOTABLE COLLABORATIONS

AIISH

Table.10. provides that the top institutional collaborations of AIISH during the study period. They have collaborated with "University of Cambridge" (12 articles), followed by "Manipal Academy of Higher Education Mahe" (9 articles) and "Bharati Vidyapeeth Deemed University" (4 articles). Academics of AIISH collaborated with "University of Toronto" (1.32%) at a minimum level.

Table.10. Top five ranking of institution collaborations (AIISH)

Rank	Organizations	Articles	% of 151
1	UNIVERSITY OF CAMBRIDGE	12	7.94
2	MANIPAL ACADEMY OF HIGHER EDUCATION MAHE	9	5.96
3	BHARATI VIDYAPEETH DEEMED UNIVERSITY	4	2.64
3	GULF MED UNIV	4	2.64
3	MACQUARIE UNIVERSITY	4	2.64
3	SAMVAAD INST SPEECH HEARING	4	2.64
4	CHINESE UNIVERSITY OF HONG KONG	3	1.98
4	INDIAN INSTITUTE OF TECHNOLOGY IIT GUWAHATI	3	1.98
4	INDIAN INSTITUTE OF TECHNOLOGY SYSTEM IIT SYSTEM	3	1.98

4	INDIRA GANDHI MEDICAL COLLEGE HOSPITAL SHIMLA	3	1.98
5	DR BHIM RAO AMBEDKAR MEM HOSP	2	1.32
5	INDIAN INSTITUTE OF TECHNOLOGY IIT DHARWAD	2	1.32
5	JSS INST SPEECH HEARING	2	1.32
5	NATIONAL ACOUSTIC LABORATORIES	2	1.32
5	NATIONAL INSTITUTE OF MENTAL HEALTH NEUROSCIENCES INDIA	2	1.32
5	NETAJI SUBHASH CHANDRA BOSE MED COLL	2	1.32
5	PURDUE UNIVERSITY	2	1.32
5	PURDUE UNIVERSITY SYSTEM	2	1.32
5	SRI RAMACHANDRA INSTITUTE OF HIGHER EDUCATION RESEARCH	2	1.32
5	UNIVERSITY OF MELBOURNE	2	1.32
5	UNIVERSITY OF MYSORE	2	1.32
5	UNIVERSITY OF TORONTO	2	1.32

CPRI

Table.11. reveals that the top ten collaborations of CPRI. They collaborated with “IIT System” (38 articles) followed by “Mahatma Gandhi University, Kerala” (31 articles) and IISC, Bangalore (26 articles). CPRI collaborated with “Siddaganga Institute of Technology” (1.64%) which is very minimum.

Table.11. Top ten ranking of institution collaborations (CPRI)

Rank	Organizations	Articles	% of 365
1	INDIAN INSTITUTE OF TECHNOLOGY SYSTEM IIT SYSTEM	38	10.41

2	MAHATMA GANDHI UNIVERSITY KERALA	31	8.49
3	INDIAN INSTITUTE OF SCIENCE IISC BANGALORE	26	7.12
4	INDIAN INSTITUTE OF TECHNOLOGY IIT MADRAS	16	4.38
5	SRI JAYACHAMARAJENDRA COLLEGE OF ENGINEERING	13	3.56
6	INDIAN INSTITUTE OF TECHNOLOGY IIT MANDI	11	3.01
6	R V COLLEGE OF ENGINEERING	11	3.01
7	NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA	9	2.46
8	COUNCIL OF SCIENTIFIC INDUSTRIAL RESEARCH CSIR INDIA	8	2.19
8	PES COLL ENGN	8	2.19
9	MANIPAL ACADEMY OF HIGHER EDUCATION MAHE	7	1.91
9	NATIONAL INSTITUTE OF ENGINEERING NIE	7	1.91
9	UNIVERSITY OF MYSORE	7	1.91
9	VELLORE INSTITUTE OF TECHNOLOGY	7	1.91
9	VISVESVARAYA TECHNOLOGICAL UNIVERSITY	7	1.91
10	BHARAT HEAVY ELECT LTD	6	1.64
10	DR AMBEDKAR INST TECHNOL	6	1.64
10	SIDDAGANGA INSTITUTE OF TECHNOLOGY	6	1.64

ICAR-NIANP

Table.12. shows the top ten collaborations of ICAR-NIANP during the period 2006-2019. ICAR-NIANP authors collaborated with “ICAR National Dairy Research Institute”(8.90%) articles followed by “ICAR-Indian Veterinary Research Institute” (7.85%) articles and “Jain University” (6.02%) articles. The least collaborated institution was “University of New England” (1.04%) articles.

Table.12. Top ten ranking of collaborations of ICAR-NIANP

Rank	Organizations	Articles	% of 382
1	ICAR NATIONAL DAIRY RESEARCH INSTITUTE	34	8.90
2	ICAR INDIAN VETERINARY RESEARCH INSTITUTE	30	7.85
3	JAIN UNIVERSITY	23	6.02
	ICAR NATIONAL INSTITUTE OF VETERINARY EPIDEMIOLOGY DISEASE		
4	INFORMATICS	15	3.92
4	KERALA AGR UNIV	15	3.92
5	ICAR CENTRAL SHEEP WOOL RESEARCH INSTITUTE	13	3.40
5	KERALA VET ANIM SCI UNIV	13	3.40
5	KVAFSU	13	3.40
6	UNIVERSITY OF QUEENSLAND	10	2.61
6	VET COLL	10	2.61
7	ICAR INDIAN GRASSLAND FODDER RESEARCH INSTITUTE	8	2.09
8	ICAR NATIONAL RESEARCH CENTRE ON YAK	6	1.57
8	UNIVERSIDADE DE SAO PAULO	6	1.57
9	ICAR NATIONAL BUREAU OF AGRICULTURAL INSECT RESOURCES	5	1.3
9	ICAR NATIONAL RESEARCH CENTRE ON MITHUN	5	1.3
9	KARNATAKA VET ANIM FISHERIES SCI UNIV	5	1.3

9	TAMIL NADU VETERINARY ANIMAL SCIENCES UNIVERSITY	5	1.3
10	ICAR CENTRAL AVIAN RESEARCH INSTITUTE	4	1.04
10	KARNATAKA VET ANIM FISHERY SCI UNIV	4	1.04
10	UNIVERSITY OF MISSOURI COLUMBIA	4	1.04
10	UNIVERSITY OF MISSOURI SYSTEM	4	1.04
10	UNIVERSITY OF NEW ENGLAND	4	1.04

TESTING OF LOTKA'S LAW OF SCIENTIFIC PRODUCTIVITY

Lotka's law is one of the laws of bibliometrics which will enable us to find out the frequency distribution of authors on scientific productivity. (Lotka 1926) coined a law; it states that the number of authors making 'n' publications is approximately equal to $1/n^2$ of the number of authors that produce only one paper. i.e., in a given field, about 60% of authors out of one hundred will have one paper each, 15% will have two papers each, 7% will have 3 papers each, and so on. Lotka's Law is defined as follows:

$Y_x = C/X^n$

Where Y is the number of authors credited with X (1, 2, 3, 4, 5, 6,.. papers C is the number of authors contributing one paper and n is a rate.

$X^n * Y_x = C$ **(Where X = 1)**

Lotka's law of scientific productivity of AIISH

i.e., 1 * 176 = C (C = 176, number of authors contributing one paper)

When X= 2

$2^n * 27 = 176$ (C=176)

$2^n * 27 = 176$

$2^n = 176/27 = 6.51$ (by applying log)

n log 2 = log (6.51)

n = log (6.51) / log 2

n =0.813 / 0.301

n =2.7

Where Y is the number of authors credited with X (1, 2, 3, 5, 7, 8, 10, 12, 13, 14, 20, and 24) papers, C are the number of authors contributing one article.

Table 13: Lotka's law of scientific productivity of AIISH

No. of Articles	No. of Authors(Observed)	Observed	No. of Authors(Expected)	Expected
X	**238**	**%**	**216**	**%**
1	176	73.94	176	81.48
2	27	11.34	27	12.5
3	20	8.4	9	4.16
5	3	1.26	2	0.92
7	2	0.84	1	0.46
8	1	0.42	1	0.46
10	1	0.42	0	0
12	3	1.26	0	0
13	1	0.42	0	0
14	2	0.84	0	0
20	1	0.42	0	0
24	1	0.42	0	0

AIISH published 151 articles (438 authors) during the period 2006-2019. Table.13. provides the academics' observed value i.e,176 (73.94%) authors who made one article. 27 (11.34%) authors who published two articles, 20 (8.4%) authors who contributed three articles, and so on. As per Lotka's law, there will be 27 (12.5%) authors who produced two articles, 9 (4.16%) authors who brought out three articles, 2 (0.92%) authors who produced five articles. Hence, the study non-confirms Lotka's law of scientific productivity.

Lotka's law of scientific productivity of CPRI

i.e., 1 * 356 = C (C = 356, number of authors contributing one paper)

When X= 2

$2^n * 116 = 356$ (C=356)

$2^n * 116 = 356$

$2^n = 356/116 = 3.06$ (by applying log)

n log 2 = log (3.06)

n = log (3.06) / log 2

n =0.485 / 0.301 **n =1.6**

Where, Y is the number of authors credited with X (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 15, 18, 20, 21, 23, 32, 34, 37 and 39) papers, C are the number of authors contributing one article.

Table 14: Lotka's law of scientific productivity of CPRI

No. of Articles	**No. of Authors(Observed)**	**Observed**	**No. of Authors(Expected)**	**Expected**
X	**588**	**%**	**701**	**%**
1	356	60.54	356	50.78
2	116	19.72	117	16.69
3	42	7.14	61	8.7
4	21	3.57	39	5.56
5	15	2.55	27	3.85
6	9	1.53	20	2.85
7	2	0.34	16	2.28
8	9	0.15	13	1.85
9	4	0.68	10	1.42
10	1	0.17	9	1.28
11	2	0.34	7	0.99
13	1	0.17	6	0.85
15	1	0.17	5	0.71
18	1	0.17	4	0.57
20	1	0.17	3	0.42
21	1	0.17	2	0.28
23	1	0.17	2	0.28
32	1	0.17	1	0.14
34	1	0.17	1	0.14
37	2	0.34	1	0.14
39	1	0.17	1	0.14

CPRI published 365 articles through1370 authors during the period 2006-2019. Table.14. provides the observed value i.e.356 (60.54%) authors who made one article. 116 (19.72%) authors made two articles, 42 (7.14%) authors who made three articles, and so on. As per Lotka's law, there will be 117 (16.69%) authors made two articles, 61 (8.7%) authors made three articles, 39 (5.56%) authors made four articles. Here the study non-confirms Lotka's law of scientific productivity.

Lotka's law of scientific productivity of ICAR-NIANP

i.e., 1 * 284 = C (C = 284, number of authors contributing one papers)

When X= 2

$2^n * 97 = 284$ (C=284)

$2^n * 97 = 284$

$2^n = 284/97 = 2.92$ (by applying log)

n log 2 = log (2.92)

n = log (2.92) / log 2

n =0.465 / 0.301

n =1.5

Where, Y is the number of authors credited with X (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, and so on) papers, C are the number of authors contributing one article.

Table 15: Lotka's law of scientific productivity of ICAR-NIANP

No. of Articles	No. of Authors(Observed)	Observed	No. of Authors(Expected)	Expected
X	**527**	**%**	**633**	**%**
1	284	53.88	284	44.86
2	97	18.4	100	15.79
3	47	8.91	55	8.68
4	18	3.41	35	5.52
5	14	2.65	26	4.1
6	6	1.13	19	3
7	9	1.7	15	2.36
8	4	0.75	12	1.89
9	3	0.56	10	1.57

10	6	1.13	9	1.42
11	4	0.75	8	1.26
12	1	0.18	7	1.1
13	1	0.18	6	0.94
14	1	0.18	5	0.78
15	2	0.37	5	0.78
16	1	0.18	4	0.63
17	2	0.37	4	0.63
18	4	0.75	4	0.63
19	2	0.37	3	0.47
20	3	0.56	3	0.47
21	1	0.18	3	0.47
22	1	0.18	3	0.47
23	1	0.18	2	0.31
24	1	0.18	2	0.31
27	2	0.37	2	0.31
29	1	0.18	2	0.31
31	2	0.37	2	0.31
33	1	0.18	1	0.15
35	2	0.37	1	0.15
43	1	0.18	1	0.15
50	1	0.18	0	0
55	3	0.56	0	0
56	1	0.18	0	0

ICAR-NIANP published 382 articles by 1964 authors during the period 2006-2019. Table.15. provides the observed value i.e.284 (53.88%) authors who made one article. 97 (18.4%) authors who made two articles, 47 (8.91%) authors who made three articles, and so on. As per Lotka's law, there will be 100 (15.79%) authors who made two articles, 55 (8.68%) authors who made

three articles and 35 (5.52%) authors who made four articles. Here the study non-confirms Lotka's law of scientific productivity.

FINDINGS OF THE STUDY

The study analyzed the research output of selected research institutes AIISH, CPRI, and ICAR-NIANP during 2006-2019. The followings are the findings of the study,

- Totally 898 articles were analyzed during the period.
- AIISH published 151 articles, CPRI published 365 articles and ICAR-NIANP published 382 articles.
- Document type "Article" is highest for AIISH and ICAR-NIANP whereas "Proceedings Paper" is highest for CPRI.
- AIISH published 151 articles with 810 citations and the citation per paper was 5.36 and the H-index was 15.
- CPRI published 365 articles with 3049 citations and the citation per paper was 8.35 and the H-index was 27.
- ICAR-NIANP published 382 articles with 2827 citations and the citation per paper was 7.4 and the H-index was 26.
- AIISH cited articles were 99 (65.56%) and Un-cited articles were 52 (34.43%) and CPRI cited articles were 198 (54.24%) and Un-cited articles were 167 (45.75%) and ICAR-NIANP cited articles were 291 (74.61%) and Un-cited articles were 99 (25.38%).
- The highly productive authors table shows that the ICAR-NIANP authors have 1st position with more number of articles and followed by the CPRI authors have 2nd position and AIISH authors have 3rd position.
- The top ten ranks of highly cited papers of all the three institutes which prove that the CPRI articles have got 180 & 161 citations in 1st and 2nd rank and ICAR-NIANP have got 150 citations which stands 3rd rank and AIISH did not come within top ten ranks due to less number of citations.
- AIISH has mostly collaborated with England, USA, Australia, Peoples R China etc. CPRI has mostly collaborated with South Korea, USA, South Africa etc. ICAR-NIANP has mostly collaborated with Australia, USA, Brazil etc.
- Top institutions' collaboration shows that all three institutes mostly collaborated with Indian institutions.
- AIISH, CPRI and ICAR-NIANP institutes authors' productivity pattern non-confirms Lotka's law of scientific productivity.

CONCLUSION

The study was performed to analyze selected R & D's in three different research fields that come under different ministries. The data were compiled using the Web of Science database to calculate institutions' productivity, citations, h-index, impact factor etc. The study will be useful to policymakers, administrators of the institute to enhance its position. The researchers of the institute should work on collaborating project with foreign countries. Further, the study suggested

that higher authority should increase the faculty strength and introduce an incentive scheme to increase the publications of the institute.

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