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A bibliometric study of Indian medicinal plant research: An analysis of quality research papers based on the web of science

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Abstract Many published resources on the topic can trace the research community's increasing interest in medicinal plant research. However, there is no systematic bibliometric review in the field of medicinal plants. This research's primary purpose was to analyze research output on the medicinal plant by the Indian researcher from 1977 to 2020 through a bibliometric perspective. To analyze and present the results based on bibliometrics indicators, namely yearly research trends, relevant journals, productive organization, prolific authors, authorship pattern, country collaboration level, and funding agencies. A total of 3911 quality research papers have been downloaded from the web of science. Data was analyzed with Microsoft excel, bibliometrics, and scientometric software, namely Bibexcel, VOSviewer, and Biblioshiny (RStudio). The study reveals that the year 2020 has the highest

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number of research papers (NP=376) in the medicinal plant, Journal of Ethnopharmacology (NP=125) found the leading contributed sources in the medicinal plant. Kumar A was the prolific author among Indian authors. Most of the researchers published their papers in the form of articles (89.70%), CSIR (NP=143) was the highest contributed organization in the field, and University Grants Commission India (NP=421) was the most influential funding agency on medicinal plant research in India. This bibliometrics analysis not providing the researchers' direction, but it extends helps to the policymaker and funding agencies.

Keywords: Medicinal Plant; Research Assessment: Research Productivity; Scientometric analysis; Bibliometrics; India

1. Introduction

Since prehistoric times, medicinal plants or medicinal herbs have been identified and employed in traditional medicine practices. Plants synthesize hundreds of chemical compounds for defense against insects, fungi, and other illnesses. Numerous phytochemicals have been found as having biological activity, either potential or established. However, the consequences of taking a complete plant as medication are unknown since a single plant has a vast range of phytochemicals. Due to the lack of rigorous scientific investigation, the phytochemical content and pharmacological effects of many medicinal remain unidentified to determine the efficacy and safety.

Plant-derived compounds have consistently been a rich source of components for pharmaceuticals and undoubtedly continue to be so. Plants are being used for primary health care and various precautions by humans. For medicinal, spiritual, and physiological care, approximately 70,000 plant species have been used. The Babylonians, Egyptians, Assyrians, and herbaceous were familiar with the uses and properties of many medicinal plants. Hippocrates (460 B.C.) started the system, followed by Theophrastus (370 B.C.). 'Materia Medica' of Hippocrates tested 400 medicinal plants as a pioneer for modern pharmacy. Galen (130-200AD) developed 100 recipes and formulations with medicinal plants. The ancient literature in medicine, the Rigveda (4500-1600BC), mentions medicinal plants from the Indian subcontinent in Asia. The earliest known Chinese pharmacopeia, the Pen Tsao discovered the therapeutic use of many plants. The Doctrine of Signatures, or a related concept devised by Paracelsus (1490-1541 AD), a Swiss alchemist and physician, guided the use of therapeutic herbs in Europe in the 13th and 14th centuries.

According to doctrine, all plants possessed some sign, given by the creator, which indicated the illness, symptoms, or diseased organ they intended. The best example may be Panax Gingseng (Michael T. Murray 1994). The Arabian physician Muslim by Sinims lilce Al-Razi and Sina (9 to 12 Century AD) brought about a revolution in the history of medicine by bringing new drugs of plants and mineral origin into general use. Enriching the original Greek system

Al-kunun of Sina laid down modern Western medicine (Mia and Ghani 1990). The Ayurvedic system (date back 5000 BC) and Unani, Siddha, and the Tibetan system remain important sources of everyday health and livelihood for tens of millions of people (Switzer, Switzer, and Switzer 2003). Modem allopathic medicine also uses extracts of many medicinal plants. It is estimated that 25 percent of plant drugs come from the USA. In India, nearly 80 plant supplies of medicinal plants come from the wild.

In the compilation of Atharva Veda, the traditional Indian medical system evolved into something like its survival. The Ayurveda came from Charaka, and Susruta did not eliminate the socio-megico religious concepts of medicine. It is known as 'Ayurveda,' the science of age (living to a ripe). In the early ages, Indian medicine reached its classical form. Plants have long been employed in traditional medicine.

Eighty percent of the world's population used alternative medicine. The Indian subcontinent is an extensive repository of medicinal plants used in the traditional therapeutic system. They are designed from herbs, minerals, and organic materials, while only medicinal plants are used for herbal drugs. In India, 7500 medicinal plants and the Indian Himalayan Region (IHR), 1748 medicinal plants, and 701 recorded from Uttarakhand. Medicinal plants and their consumption cause the people to seek more concern on these plants with sustainable use, development, and conservation (Karki 2000).

2. Scientometric review of literature on medicinal plants

Sivasekaran, K, Stanley, Prabakar, Ashok Kumar, P.Sivankalai, Sivasamy, K, (2021) have analyzed research productivity of Curcuma longa (Medicinal plant) research: A scientometric assessment of global publications. The current study looks at the characteristics of Curcuma longa research publication records over twenty years, from 2000 to 2019. The selected scientometric indices, namely growth rate, global citation scores, distribution of publications by journals, conferences, and institutions; preferred media of communication; Hirsch index (H-index) and citation profile of top institutions, countries, and authors; contribution of funding agencies. A total of 6087 research papers have been downloaded from the web of science during 2000-2019. The majority of the papers, accounting for 97% of all publications, were in the form of journal articles, reviews, papers in conference proceedings, and meeting abstracts. English is, of course, the most common language, accounting for 98.8% of all publications. India (24.68%) was the leading contributed country followed by, the United States (17.7%), China (12.2%), and Iran (6.09%). The "Mashhad University of Medical Sciences" was the most important institution in the field, accounting for 1.8 %. Sahebkar A (73 papers) was the most productive author followed by, Aggarwal BB (67 papers), Nayak S (35 papers), and Kumar. The "Food chemistry" (N=720) was the most contributed source in the field of medicinal plants. The study also revealed that China's National Natural Science Foundation (NP=318) funded most research.

Salmerón-Manzano, Esther Garrido-Cardenas, Jose Antonio, Manzano-Agugliaro, Francisco (2020) have conducted global research trends on medicinal plants. The present study has analyzed a bibliometric analysis of 100,000 papers from the Scopus database up to 2019. On the one hand, the key countries, institutions, and authors researching this subject and their evolution over time have been established. On the other hand, identifying populations has been used to examine the connections between the writers, the countries, and the research topics. The study reveals that global research is increasingly focusing on discovering new medicines or active compounds rather than producing or domesticating plant species with demonstrated potential.

Dissanayake (2015) has conducted a scientometric analysis of medicinal plant research in Sri Lanka. The Scopus database used to investigate research contributed by the researcher of Sri Lanka on medicinal plants. The results were evaluated based on the different types of research, plant endemism, biological activities shown by different plants, international partnerships, publications by different institutions in Sri Lanka, and journals where many publications appeared. The publication production appeared in different years. The findings show that activity-related research is more common than general physicochemical research. Universities have produced more publications than research institutes and other organizations. The "Journal of Ethnopharmacology" was the most productive source. Scopus contains publications dating back to 1976, with the number of publications increasing over time. The year 2012 noted as the most effective.

Baskaran & Babu (2019) have explored the research productivity of 'Forensic Medicine' from 1989 to 2016. The study analyzed different metrics, including year-wise growth of publication, Relative growth rate and doubling time of research performance, collaboration pattern of the authors and collaborative co-efficient, etc. The result revealed that the publication's growth was 11 (0.26%) in 1989 while 447 (10.76%) in 2013. The year 2013 recorded the highest research productivity (447). The degree of collaboration ranges between 0.64 to 0.94, and the overall degree of collaboration is 23.08 from 1989 to 2016. The degree of collaboration increased, but research trends were decreasing during the study period.

Zhou et al. (2019) have analyzed research trends in disaster medicine publications from 2008 to 2016. Research data has been collected from the web of science database. It found that 564 research papers were indexed on disaster medicine from the year 2008 to 2016. The study showed that research publications increased from 2018 (55) to 2016 (83). Most of the research was published on disaster medicine and public health preparedness. Most of the articles published by the USA, Tohoku University, were highly productive, and the most prolific authors were F. Della Corte, M.D. Christian and P.L. Ingrassia. The study also analyzed the most research hotspots: emergency medicine, management, public health, natural disaster, and medicine. In contrast, the frontiers of disaster medicine research were Hurricane Katrina, Mechanical ventilation, Intensive care, and occupational medicine. The study revealed that

disaster medicine is closely associated with other medical fields, which will help the researcher and policymaker develop new research.

3. Research questions for Scientometric assessment of Medicinal Plant Publication

1) What are the publication trends of medicinal plants research in India during 1977-2020?
2) What are the commonly used author keywords or research trends of medicinal plants research in India?
3) Who are the most prolific, and what is the trend of authorship in medicinal plants research?
4) What are the most relevant journals of medicinal plants research?
5) What are India's most influential organizations and funding agencies regarding medicinal plants research in India between 1977 to 2020?
6) What are the most collaborative countries with India in the production of scientific literature of medicinal plants research?
7) What are the most cited documents and cited references in medicinal plants research?

4. Research methodology

Using statistical techniques to analyze any form of research publication such as books, conferences, journal articles, etc., is known as bibliometrics; it is a widely used library and information science method. Scientometric is the sub-field of bibliometrics that involves different scientometric approaches to study the quantitative means of investigation, scholarly publishing practices, publishing trends, trend topics, etc. This study, therefore, applies the scientometric method in medicinal plant research. The required literature in medicinal plants was retrieved from 'Web of Science (as of 20th February 2021), one of the most extensive peer-reviewed indexing and abstracting literature databases for data collection. The targeted data is searched in the advanced search box by selecting field tags (SU=Subject area).
The following search query is involved in the Web of Science database (Clarivate Analytics 2020)

- Topic search: TS= ("medicinal plant" OR "medicinal herb" OR "traditional plant")
- 1. Refined by: COUNTRIES/REGIONS: (INDIA)
- 2. Refined by [excluding] PUBLICATION YEARS: (2021)
- 3. Further refined by [excluding] DOCUMENT TYPES: (EARLY ACCESS OR NEWS ITEM OR NOTE OR CORRECTION OR DATA PAPER OR RETRACTION OR MEETING ABSTRACT)

- Timespan: All years. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI, CCR-EXPANDED, IC.

The initial search by topic retrieved 22817 published documents in the web of science, then the data refined by 'country,' which retrieved 4051 records, further refined by 'type of documents and retrieved 3911 records. The total items screened to achieve an accurate sample for data analysis are 18,906 records. Therefore, three thousand nine hundred eleven (3911) documents were considered for final analysis during 1977-2020. Researchers tried their best to retrieve and sampling the error-free, justified data for a biased free review of the literature published in medicinal plants in India (Refer to figure 1). It is also important since India has a significant role in this area of study. Research data downloaded in BibTeX, Tab-delimited, plain text, and analyzed with Microsoft excel and scientometric and bibliometric tools, namely Bibexcel, Biblioshiny, and VOSviewer.

5. Analysis and results

For the present analysis, 3911 publications were considered for the current study, published in 925 sources, written by 8978 authors. The results also revealed that 117005 references were consulted, average years from publication (7.84), average citations per document (13.72), and average citations per year per doc (1.405). The result also showed that 9316 author keywords in the 3911 publications during 1977-2020. The collaboration index was 2.34. (See table1).

5.1. Annual research trends on medicinal plants in India from 1977-2020

Table (2) shows India's annual research growth in medicinal plants research during 1977-2020. The first research paper on the medicinal plant was published in 1977 with 13 total citations. There was limited research before 1991 on medicinal plants in India. After 1991(NP=4), Indian medicinal plant research output gradually increased. The significant study involved 2005 (NP=83) to 2020 (NP=376), where 92.25 % of publications were published with 44656 citations. The year 2020 was the highest producer of research (NP=376) with 331 total citations. 2011 has received the maximum total citation (TC=4862) and H-index (36) for 232 publications. The year 2007 has the highest citation sum within h-core (2511) against 120 publications.

5. 2. Type of research on the medicinal plant in India during 1977-2020

Table (3) depicts the type of research publications on medicinal plants in India during 1977-2020. Article (89.70%) was the most preferred type of research among the researcher in medicinal plants, followed by review (7.85%) and Proceedings papers (2.74%). It reveals that less than 1% of research was

published in Editorial material (NP=10), Letter (NP=10), and Book chapters (NP=4).

5.3. Top ten most relevant journals on medicinal plants in India during 1977-2020

The top ten journals produce 728 papers with 9848 total citations (refer to table 4). *Journal of Ethnopharmacology* (JIF=3.69, Quartile=1, H-Index=35) published by Elsevier, Ireland nominated as the leading source with 125 publications with 3696 citations, followed by *International Journal of Pharmaceutical Sciences and Research* by Global research, India (Quartile=3) with 106 publications and 97 citations. *Industrial Crops and Products* by Elsevier, Netherland (JIF=4.24, Quartile=1) with 90 papers and 919 citations and *In Vitro Cellular & Developmental Biology-Plant* (JIF=1.81, Q2) with a 70 publication and 1081 citations are ranked 3rd and 4th respectively in the list.
Most of the sources belonged to India (5), Netherland (2), and Ireland, the USA, and Germany had one journal. The *Journal of Ethnopharmacology* has received the highest number of citations for 125 publications on the medicinal plant during 1977-2020, followed by *Current Science* with 1481 citations.

5.4. Top ten most prolific authors on medicinal plants in India during 1977-2020

Table (5) indicates the most prolific authors on medicinal plant research in India. The prolific author Kumar, A, affiliated with the CSIR - Institute of Himalayan Bioresource Technology (IHBT) has 91 publications (1156) citations, followed by Kumar S affiliated with Indian Council of Agricultural Research (ICAR) has 84 publications (1371 citations). Singh S, affiliated with CSIR - Academy of Scientific & Innovative Research, has 54 papers and 980 citations. Kumar R and Singh R have published 33 papers, each with 263 and 541 citations, respectively, and they identified as the least prolific authors in the list.
The table also revealed that Kumar S received the maximum number of citations (TC=1371) for 84 publications, followed by Kumar A (TC=1156) for 91 publications, Singh S (TC=980) for 54 research papers. Kumar S has the highest H-index (21), followed by Kumar A (19) and Sing S and Sing R (14) each.

5.5. Pattern of authorship

Figure (2) portrays the authorship pattern in Indian medicinal plants. For 3911 publications, there are 1-15 types of authorship patterns identified for the medicinal plants' research during 1977-2020. Three authored publications (NP=1025) have the maximum number of research papers, followed by two and Four authorship patterns, have an equal number of publications (NP=3794), five

authorship (NP=477), Six authorship (NP=316), and 15 authorship produced only one paper with six citations.
The figure 2 also shows the three-authorship received the maximum number of citations (TC=13814) for 1025 papers, followed by four authorship (TC=11415), two authorship (TC=9213). Fourteen and fifteen and authorship have at least 30 and 6 citations, respectively. This analysis is in agreement with (Rahaman et al. 2021).

5.6. Top 15 organizations on the medicinal plant research in India during 1977-2020

CSIR (NP=143, TC=1982) found as the leading organization in medicinal plant research in India, followed by Banaras Hindu University (NP=117, TC=2555) (refer to table 6). Aligarh Muslim Univ has (NP=71, TC1311), followed by Annamalai University (NP=63, TC1392), GB Pant Inst Himalayan Environment & Dev (NP=60, TC1195), and Univ Rajasthan produced least among the top 15 organizations.
Banaras Hindu Univ received the highest number of citations for the 117 publications, followed by CSIR (TC=1981) for 143 papers, Annamalai University (TC1311), and Aligarh Muslim University (TC=1311). Banaras Hindu University has emerged as 1st in H-index (29), followed by CSIR (H-index=24), and Annamalai University (H-index=22), etc.

5.7. Country collaboration on medicinal plant research during 1977-2020

Coincidently, India VS Saudi Arabia and India VS the USA are the top collaborating countries with106 collaborations (refer to figure 3), followed by India and Korea with 83 collaborations, India and China with 57 collaborations, India and Malaysia with 29 collaborations, and India and the United Kingdom with 26 research collaboration, etc. India and Germany (21 papers) are the least among the top ten collaborative countries.

5.8. Top influential funding agencies

Table (7) shows the top ten funding agencies to finance research in India's medicinal plants during 1977-2020. University Grants Commission, India, (421 papers) recognized as the most active funding agencies in the top ten list, financing almost 10.765% of 3911 research, followed by the Council of Scientific Industrial Research CSIR, India (8.31% of 3911 papers), Department of Science Technology India (7.083%), Department of Biotechnology DBT India (4.96%), Indian Council of Medical Research-ICMR (2.608%), Ministry of Science and Technology Government of India (0.614%), and Indian Council of Agricultural Research ICAR (0.563%). Science Engineering Research Board Serb India (14 papers) was the least among the top ten funding agencies.

5.9. Top ten most cited papers on the medicinal plant during 1977-2020

Table (8) shows the top ten most-cited research papers in medicinal plant. The article entitled 'Biological activities and medicinal properties of neem (Azadirachta indica)' by Biswas K (2002) appeared in *Current science* (TC=438) noted as the most cited paper (Biswas et al. 2002), followed by 'Hyperforin as a possible antidepressant component of hypericum extracts' by Chatterjee SS (1998), published in *Life Sci* with 375 total citations (Chatterjee et al. 1998). 'Indian herbs and herbal drugs used for the treatment of diabetes' by Modak M (2007) with 346 total citations (Modak et al. 2007), 'Rapid synthesis of silver nanoparticles using dried medicinal plant of basil' by Ahmad N (2010) with 313 total citations (Ahmad et al. 2010), and 'Impact of plant products on innate and adaptive immune system of cultured finfish and shellfish' by Harikrishnan R (2011) with 302 total citations (Harikrishnan, Balasundaram, and Heo 2011) is ranked 3rd,4th, and 5th respectively.
'Acclimatization of tissue-cultured plants' (Hazarika 2003) and 'Berberine: a potential phytochemical with multispectrum therapeutic activities' (Vuddanda, Chakraborty, and Singh 2010) noted as least cited papers in the list, received 193 and 192, respectively.

5.10. Mapping co-citation of cited references

Co-occurrence considered for the analysis, minimum 30 number of citations selected, out of 116745 cited references, only 51 meet the thresholds. The total strength of the co-citation links with the other cited references was calculated for each 51 cited references. Therefore, for 51 cited references, 6 clusters, 435 links, and (2039) total link strength were observed. Different colors then visualize the 6 clusters. 1st cluster (red color) represents 13 cited references, followed by 2nd cluster (Green color) and 3rd cluster (blue color) consist of 10 cited references, 4th cluster (Blue color) contains eight cited references, 5th cluster, and 6th cluster represent five cited references each (See figure 4).
Table (9) show top ten co-citations of cited reference on the medicinal plant in India during 1977-2020. The paper entitled 'A Revised Medium for Rapid Growth and Bio Assays with Tobacco Tissue Cultures′ has a maximum total citation (TC=647) (Toshio Murashige 1962), followed by 'Protein measurement with the Folin phenol reagent (TC=188) (LOWRY et al. 1951). 'Assay for lipid peroxides in animal tissues by thiobarbituric acid reaction (TC=110) (Ohkawa, Ohishi, and Yagi 1979), 'A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding' (TC=107)(Bradford 1976), and 'Chloroplast DNA Phylogenetic Affinities of Newly Described Species in Glycine (Leguminosae: Phaseoleae)' (TC=76) (Doyle, Doyle, and Brown 1990) are ranked 3rd, 4th, 5th in the list.

5.11. Mapping co-occurrence of all Keywords in medicinal plant research

For mapping the keywords, co-occurrences of keywords considered, minimum of 50 occurrences considered, out of 14121 keywords, only 70 meet the thresholds. The total strength of the co-occurrence links with the other keywords was calculated for 70 keywords. Total item found (67) keywords, cluster (4), links (1635), and total link strength (11022). These 67 keywords are then grouped into 4 clusters and represented with different colors (See figure 5).
Cluster 1 (red color) represents 36 keywords. (*Accumulation, Acid, Activation, Alkaloids, Anticancer, Antioxidant, Antioxidant Activity, Antioxidants, Apoptosis, Assay, Cancer, Cells, Constituents, Cytotoxicity, Essential Oils, Expression, Extracts, Flavonoids, Gc-Ms, Glutathione, Inhibition, Leaves, Lipid-Peroxidation, Mechanisms, Metabolism, Natural-Products, Oxidative Stress, Phytochemicals, Plants, Rats, Resistance, Roots, Secondary Metabolites, Stress, Toxicity, and Withania Somnifera*).
Cluster 2 (Green color) consists of 16 keywords (*Callus, Cultures, Explants, Growth, In Vitro, In-Vitro Propagation, Induction, Leaf Medicinal Plants, Micropropagation, Multiplication, Organogenesis, Plant-Regeneration, Propagation, Regeneration, and Somatic Embryogenesis*). Cluster 3 (Blue color) comprises eight keywords. (*Conservation, Diversity, Genetic Diversity, High-Performance Liquid Chromatography, Identification, Issr, Medicinal Herb, and Rapd*) and,
Cluster 4 (Yelloshish) represents seven keywords (*Antibacterial, Antimicrobial Activity, Aqueous Extract, Biosynthesis, Green Synthesis, Leaf Extract, and Silver Nanoparticles).*
The figure (5) also shows the top ten most occurred keywords in medicinal plant research were medicinal plants (n=870), Extracts (n=368), Plants (n=342), Growth (n=304), in vitro (n=297), micro propagation (n=295), Antioxidant (n=285), Regeneration (n=209), Cultures (n=205) and Antibacterial (n=203).

5.12. Trends topic by author keywords on the medicinal plant during 1977-2020

Figure (6) portrays the top 20 trending topics from authors' keywords in medicinal plant research. The most trending topic by authors' distinguished as 'Medicinal plant' occurred 386 times since 2011, followed by 'Antioxidant' (n=180), 'Medicinal Plants' (n=169), 'Micropropagation' (n=149), 'Conservation' (n=90), 'Withania Somnifera' (n=75), 'Antioxidants' (n=70), 'Phytochemicals' (n=63), 'Oxidative Stress' (n=61), 'HPLC' (n=58). The author keywords *Antioxidant Activity* and *Gc-Ms* (n-49) among the top 20 have least occurred trending medicinal plant research topics.

Discussion

The use of bibliometric analysis to review patterns and development in various fields and areas of study is becoming more common. The current data analysis reflects multiple aspects of Indian medicinal plant analysis, including the top researchers, organizations, and journals contributing to the field. 2020 was the highest producer of research (NP=376) with 331 total citations, while 2011 has received the maximum total citation (TC=4862) and H-index (36) for 232 publications. Article (89.70%) was the most preferred type of research among the researcher in medicinal plants. Journal of Ethnopharmacology (JIF=3.69, Quartile=1, H-Index=35) published by Elsevier, Ireland was the leading source with 125 publications with 3696 citations. Among the top ten sources, five belonged to India, followed by Netherland (2 sources). The author *Kumar A* was the most prolific author affiliated with the CSIR - Institute of Himalayan Bioresource Technology (IHBT) had 91 publications with 1156 citations. Affiliated with the Indian Council of Agricultural Research (ICAR), Kumar S received the maximum citation (TC=1371) for 84 publications. There were 1-15 types of authorship patterns on the medicinal plant during 1977-2020. The pattern of three-authorship publications (NP=1025) has the maximum number of research papers. CSIR (NP=143, TC=1982) was the leading organization in medicinal plant research in India, followed by Banaras Hindu Univ (NP=117, TC=2555). Banaras Hindu University received the highest number of citations (TC=2555) for the 117 publications, followed by CSIR (TC=1981) for 143 papers. India VS Saudi Arabia and India VS the USA are the top collaborating countries with 106 collaborations, followed by India and Korea with 83 collaborations. University Grants Commission, India (421 papers) was the most active funding agency in the top ten list and produced almost 10.765% of 3911 research papers alone. The Council of Scientific Industrial Research CSIR, India (8.31% of 3911 papers) was the 2nd highest funding agency in medicinal plant research. The title entitled "*Biological activities and medicinal properties of neem (Azadirachta indica)"* by Biswas K (2002) appeared in current science (TC=438) was the most cited paper in medicinal plants. The co-citation of cited reference for the paper entitled "*A Revised Medium for Rapid Growth and Bioassays with Tobacco Tissue Cultures"* has a maximum total citation (TC=647). The most occurred keywords in medicinal plant research were "medicinal plants" (n=870) in medicinal plant research in India during the study period. The most author trending topic was "medicinal plant," which occurred 386 times since 2011, followed by Antioxidant (n=180).

Conclusion

This research is being examined for a broad analysis and detailed review of 'web of science' published medicinal plant research in India from 1977 to 2020. This bibliometric analysis reveals that medicinal plant research has increasingly risen, with India collaborating closely with Saudi Arabia and the United States.

The CSIR conducts the most research, and the University Grants Commission funds the majority of it. This research demonstrated that Indian academics are very interested in medicinal plant research, and the visualization of data provides many more avenues in which to perform the research. With the use of the analysis and conclusions of this study, researchers, both new and established, can identify the lacking gaps.

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Appendices

Tables

Table (1): The primary information on Indian medical plant research for 1977-2020

Description	Results
Timespan	1977:2020
Sources (Journals, Books, etc.)	925
Documents	3911
Average years from publication	7.84
Average citations per document	13.72
Average citations per year per doc	1.405
References	117005
DOCUMENT CONTENTS	
Keywords Plus (ID)	6664
Author's Keywords (DE)	9316
AUTHORS	
Authors	8978
Author Appearances	15531
Authors of single-authored documents	76
Authors of multi-authored documents	8902
AUTHORS COLLABORATION	
Single-authored documents	101
Documents per Author	0.436
Authors per Document	2.3
Co-Authors per Documents	3.97
Collaboration Index	2.34

Table (2): Literature growth in Indian medicinal plant research during 1977-2020

Year	NP	% of 3911	TC	Citation sum within h-core	h-index

1977	1	0.03	13	13	1
1980	2	0.05	2	1	1
1981	1	0.03	0	0	0
1984	1	0.03	49	49	1
1989	1	0.03	58	58	1
1990	1	0.03	48	48	1
1991	4	0.10	92	91	3
1992	7	0.18	117	116	6
1993	7	0.18	92	86	3
1994	7	0.18	157	157	7
1995	8	0.21	127	121	4
1996	11	0.28	366	358	9
1997	15	0.38	352	330	10
1998	28	0.72	852	737	13
1999	29	0.74	539	450	14
2000	32	0.82	1216	1126	20
2001	27	0.69	852	769	14
2002	35	0.90	1248	1105	17
2003	45	1.15	1518	1248	20
2004	41	1.05	1303	1138	20
2005	83	2.12	2433	1779	29
2006	95	2.43	2843	1966	33
2007	120	3.07	3689	2511	33
2008	135	3.45	2973	1730	30
2009	170	4.35	3683	2173	31
2010	159	4.07	3461	2219	31
2011	232	5.93	4862	2616	36
2012	209	5.34	3804	1690	31
2013	213	5.45	3451	1660	29
2014	232	5.93	3292	1343	29
2015	316	8.08	2957	1061	26
2016	308	7.88	2324	718	23
2017	325	8.31	2054	612	18
2018	329	8.41	1449	520	16
2019	306	7.82	1050	325	13
2020	376	9.61	331	75	7

***NP=Number of publications, **TC=Total citations**

Table (3): Type of research papers

Rank	Document Types	Records	% of 3911	TC
1	Article	3508	89.70	46797
2	Review	307	7.85	6333

3	Proceedings Paper	107	2.74	94
4	Editorial Material	10	0.26	288
5	Letter	10	0.26	38
6	Book Chapter	4	0.10	113

***Records=Number of publications, **TC=Total citations**

Table (4): Top ten most relevant journals

Rank	**Source**	**NP**	**TC**	**JIF**	**Q**	**Publisher & Country**	**h_index**	**g_index**	**m_index**	**PY_start**
1	Journal of Ethnopharmacology	125	3696	3.69	Q1	Elsevier, Ireland	35	55	0.92	1984
2	International Journal of Pharmaceutical Sciences and Research	106	97	0	Q3	Global Research, India	4	5	0.57	2015
3	Industrial Crops and Products	90	919	4.24	Q1	Elsevier, Netherland	18	25	1	2004
4	In Vitro Cellular & Developmental Biology-Plant	70	1027	1.81	Q2	Springer, USA	17	26	0.68	1997
5	Current Science	69	1481	0.72	Q4	Indian Acad Sci, India	17	37	0.68	1997
6	Indian Journal of Traditional Knowledge	66	433	0.73	Q4	NISCAIR, India	11	16	0.73	2007
7	Plant Cell Tissue and Organ Culture	58	1270	2.19	Q3	Springer, Netherland	22	33	0.73	1992
8	Research Journal of Biotechnology	51	40	0.23	Q4	Research Journal Biotechnology, India	3	4	0.2	2007
9	Acta Physiologiae Plantarum	50	665	1.76	Q2	Springer, Germany	16	22	0.76	2001

10	Indian Journal of Biotechnology	43	220	0.41	Q4	NISCAIR, India	7	12	0.5	2008

***NP=Number of publications, **TC=Total citations, ***JIF=Journal impact factor, ****Q=Quartile**

Table (5): Prolific authors

Rank	Author	Affiliations	NP	TC	h_index	g_index	m_index	PY_start
1	Kumar A	CSIR - Institute of Himalayan Bioresource Technology (IHBT)	91	1156	19	31	0.679	1994
2	Kumar S	Indian Council of Agricultural Research (ICAR)	84	1371	21	34	0.7	1992
3	Singh S	CSIR - Academy of Scientific & Innovative Research	54	980	14	30	0.875	2006
4	Sharma S	Banaras Hindu University	41	701	11	26	0.367	1992
5	Kumar V	Lovely Professional University	39	480	12	21	0.706	2005
6	Sharma A	Council of Scientific & Industrial Research (CSIR)	37	283	10	15	0.323	1991
7	Sharma N	CSIR - Indian Institute of Integrative Medicine (IIIM)	34	365	12	18	0.387	1991
8	Singh A	Central University of Punjab	34	254	8	14	0.364	2000
9	Kumar R	CSIR - Institute of Himalayan Bioresource Technology (IHBT)	33	263	10	15	0.769	2009
10	Singh R	CAR - Directorate of Medicinal & Aromatic Plants Research	33	541	14	22	0.824	2005

Table (6): Productive organization

Rank	Organization	NP	TC	Citation sum within h-core	h-index
1	CSIR	143	1982	1131	24
2	Banaras Hindu University	117	2555	1880	29
3	Aligarh Muslim University	71	1311	893	21
4	Annamalai University	63	1392	1008	22
5	GB Pant Inst Himalayan Environment & Dev	60	1195	896	20
6	University of Delhi	56	1050	869	21
7	Cent Inst Med & Aromat Plants	53	937	687	18
8	Bharathidasan University	52	1188	983	17
9	Natl Bot Res Inst	51	1200	1064	20
10	Bharathiar University	51	661	475	15
11	University Calcutta	50	878	704	17
12	University Madras	48	1128	909	19
13	University Mysore	42	470	373	12
14	Alagappa University	40	422	312	12
15	University Rajasthan	39	401	302	12

Table (7): Funding agencies

Rank	Funding Agencies	NP	% of 3911
1	University Grants Commission India	421	10.765
2	Council of Scientific Industrial Research CSIR India	325	8.31
3	Department of Science Technology India	277	7.083
4	Department of Biotechnology DBT India	194	4.96

5	Indian Council of Medical Research-ICMR	102	2.608
6	Ministry of Science and Technology Government of India	24	0.614
7	Indian Council of Agricultural Research ICAR	22	0.563
8	DST-Purse Laboratory, Mangalore	16	0.409
9	Defense Research Development Organization DRDO	15	0.384
10	Science Engineering Research Board Serb India	14	0.358

Table (8): Most cited research papers

Rank	**Title**	**Author & Year**	**Source**	**TC**	**TCPY**	**NTC**
1	Biological activities and medicinal properties of neem (Azadirachta indica) (Biswas et al. 2002)	Biswas K, 2002	Current Sci	438	21.90	12.28
2	Hyperforin as a possible antidepressant component of hypericum extracts (Chatterjee et al. 1998)	Chatterjee SS, 1998	Life Sci	375	15.63	12.32
3	Indian herbs and herbal drugs used for the treatment of diabetes (Modak et al. 2007)	Modak M, 2007	J Clin Biochem Nutr	346	23.07	11.26
4	Rapid synthesis of silver nanoparticles using dried medicinal plant of basil (Ahmad et al. 2010)	Ahmad N, 2010	Colloid Surf B-Biointerfaces	313	26.08	14.38
5	Impact of plant products on innate and adaptive immune system of cultured finfish and shellfish (Harikrishnan, Balasundaram, and Heo 2011)	Harikrishnan R, 2011	Aquaculture	302	27.45	14.41
6	Antimalarials from nature (Kaur et al. 2009)	Kaur K, 2009	Bioorg Med Chem	246	18.92	11.35
7	Cadmium accumulation and its influence on lipid	Singh S, 2006	Chemosphere	241	15.06	8.05

	peroxidation and antioxidative system in an aquatic plant, bacopa monnieri l.(Singh, Eapen, and D'Souza 2006)					
8	Density functional study on the structural conformations and intramolecular charge transfer from the vibrational spectra of the anticancer drug combretastatin-a2 (L. Padmaja, C. Ravikumar, D. Sajan, I. Hubert Joe, V. S. Jayakumar, G. R. Pettit 2009)	Padmaja L, 2009	J Raman Spectrosc	193	14.85	8.91
9	Acclimatization of tissue-cultured plants(Hazarika 2003)	Hazarika Bn, 2003	Current Sci	193	10.16	5.72
10	Berberine: a potential phytochemical with multispectrum therapeutic activities (Vuddanda, Chakraborty, and Singh 2010)	Vuddanda PR, 2010	Expert Opin Investig Drugs	192	16.00	8.82

Table (9): Top ten co-citation of cited references

Rank	Title	Author & Year	Source	TC
1	A Revised Medium for Rapid Growth and Bio Assays with Tobacco Tissue Cultures (Toshio Murashige 1962)	MURASHIGE T, 1962	PHYSIOL PLANTARUM	647
2	Protein measurement with the Folin phenol reagent (LOWRY et al. 1951)	LOWRY OH, 1951	J BIOL CHEM	188
3	Assay for lipid peroxides in animal tissues by thiobarbituric acid reaction (Ohkawa, Ohishi, and Yagi 1979)	OHKAWA H, 1979	ANAL BIOCHEM	110
4	A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding (Bradford 1976)	BRADFORD MM, 1976	ANAL BIOCHEM	107
5	Chloroplast DNA Phylogenetic Affinities of Newly Described Species in Glycine (Leguminosae: Phaseoleae) (Doyle, Doyle, and Brown 1990)	DOYLE J.J., 1990	FOCUS	76

6	DNA polymorphisms amplified by arbitrary primers are useful as genetic markers (Williams et al. 1990)	WILLIAMS JGK, 1990	NUCLEIC ACIDS RES	67
7	Tissue sulfhydryl groups (ELLMAN 1959)	ELLMAN GL, 1959	ARCH BIOCHEM BIOPHYS	66
8	Nutrient requirements of suspension cultures of soybean root cells (Gamborg, Miller, and Ojima 1968)	GAMBORG OL, 1968	EXP CELL RES	63
9	Rapid colorimetric assay for cellular growth and survival: Application to proliferation and cytotoxicity assays (Mosmann 1983)	MOSMANN T, 1983	J IMMUNOL METHODS	61
10	Catalase in vitro (Aebi 1984)	AEBI H, 1984	METHOD ENZYMOL	57

Figures

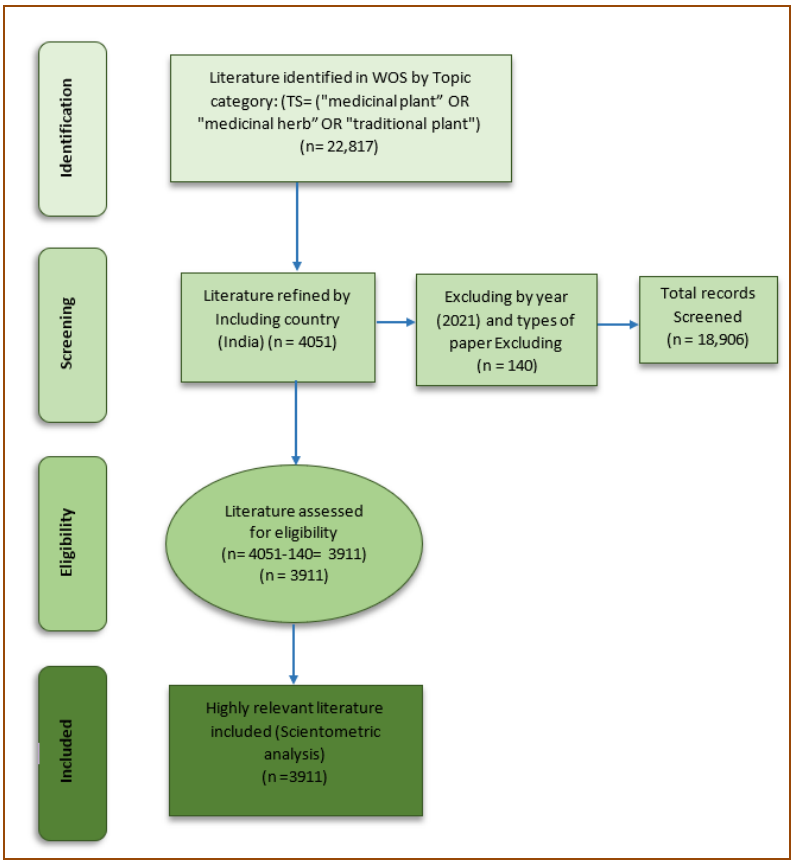


Figure (1): PRISMA flow diagram of data extraction and refined process

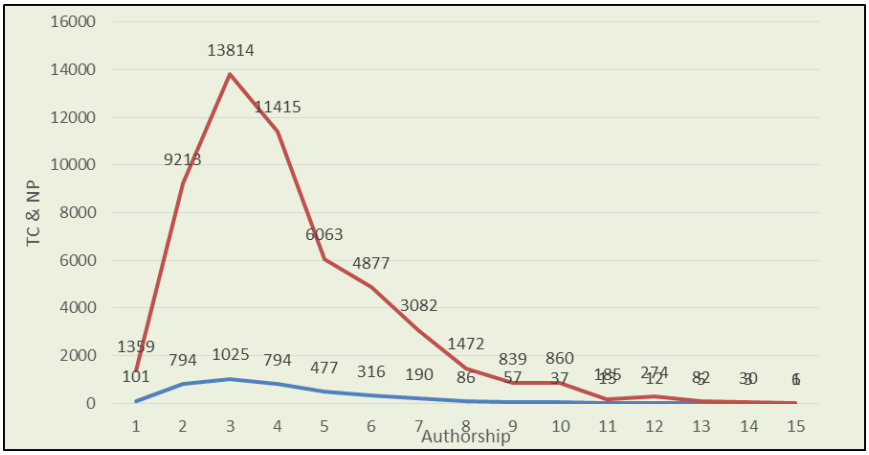
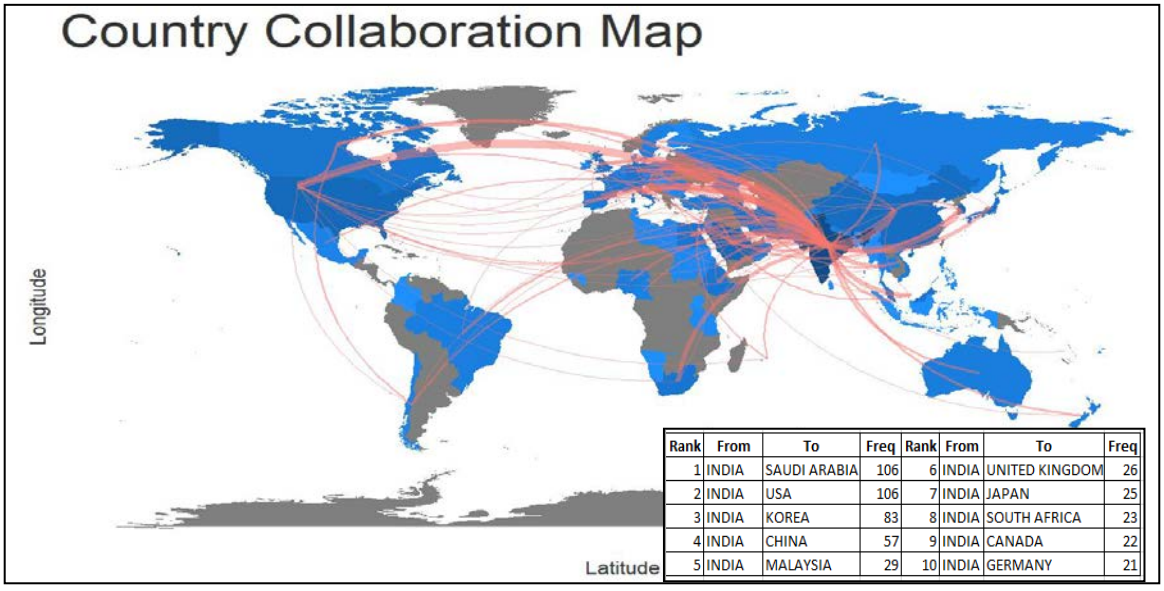


Figure (2): Pattern of authorship along with total citation



Rank	From	To	Freq	Rank	From	To	Freq
1	INDIA	SAUDI ARABIA	106	6	INDIA	UNITED KINGDOM	26
2	INDIA	USA	106	7	INDIA	JAPAN	25
3	INDIA	KOREA	83	8	INDIA	SOUTH AFRICA	23
4	INDIA	CHINA	57	9	INDIA	CANADA	22
5	INDIA	MALAYSIA	29	10	INDIA	GERMANY	21

Figure (3): Country-wise collaboration

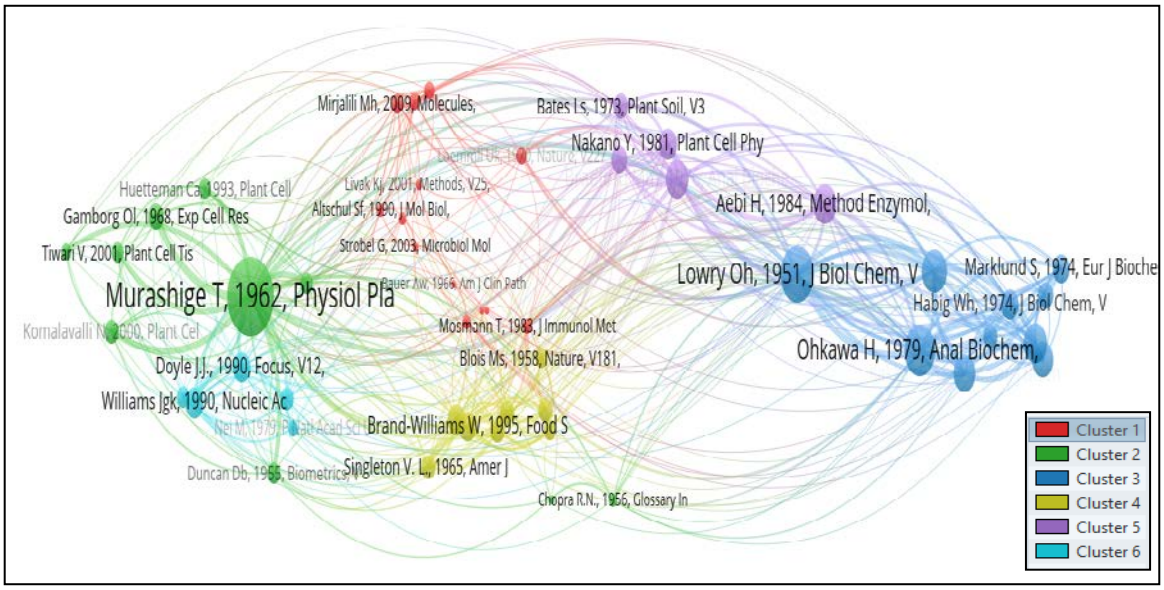


Figure (4): Mapping co-citation of cited references through VOSviewer

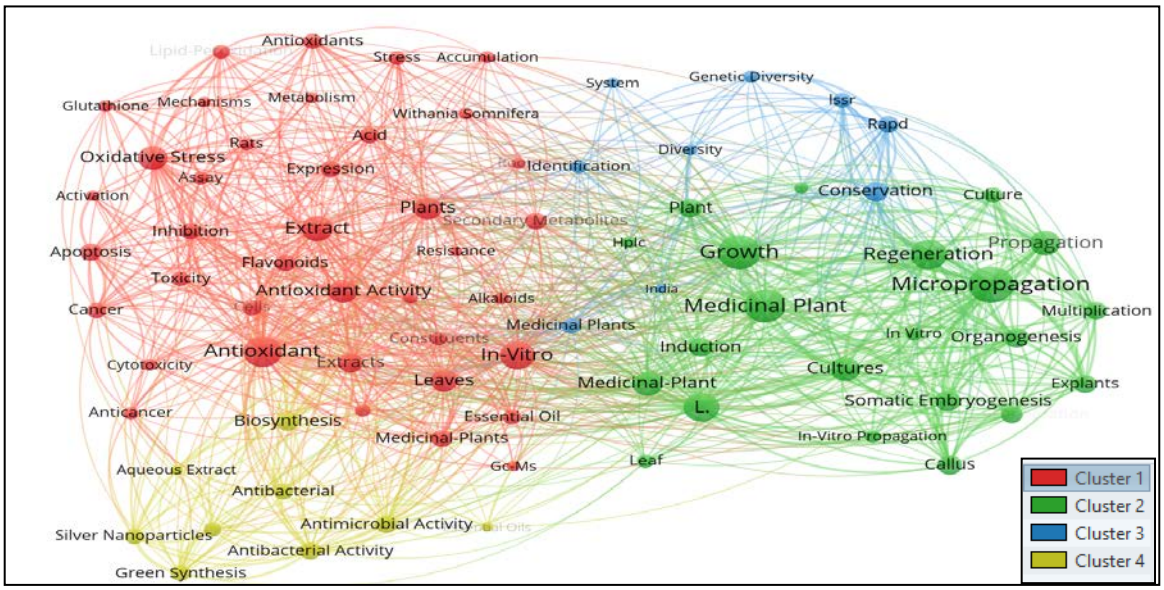


Figure (5): Mapping co-occurrence of all Keywords through VOSviewer

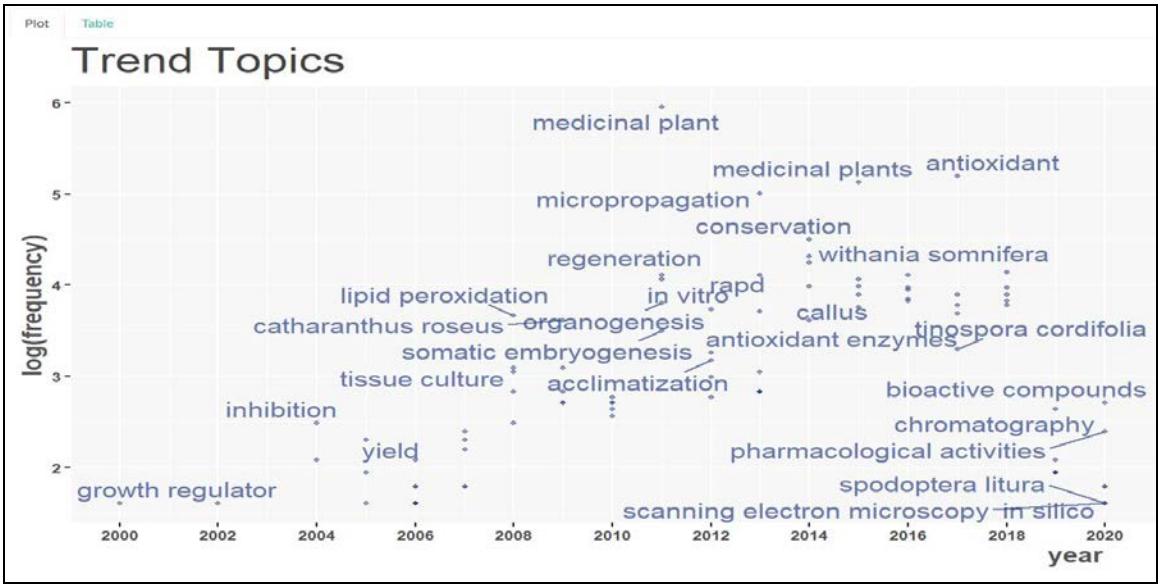


Figure (6): Trends topic by author keywords through Biblioshiny