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Bibliometric analysis for advancing chrysanthemum research in India

Vidya Nargundkar, Ajai Kumar Tiwari*, Ratna Prabha, Ritu Jain, Babita Singh, Shreekant, Pruthvi M.S. and Gunjeet Kumar

Division of Floriculture and Landscaping, ICAR-Indian Agricultural Research Institute, New Delhi 110012

ABSTRACT

Chrysanthemum, a genetically heterogeneous and economically pivotal ornamental species, has garnered substantial scientific attention due to its agronomic, medicinal, and ecological significance. This study employs an AI-driven bibliometric analysis of 421 chrysanthemum-related publications from 2000 to 2023, systematically delineating global research trajectories. Leveraging advanced machine learning algorithms on Scopus-indexed data, we elucidate publication dynamics, prolific authorship networks, institutional research hubs, and emergent thematic frontiers. Our findings underscore China's predominant scholarly contributions, followed by India and South Korea. Transcriptomics, functional genomics, and abiotic stress physiology emerge as critical research domains, providing deeper insights into the molecular and adaptive mechanisms underpinning chrysanthemum's phenotypic plasticity. By integrating bibliographic network modeling with evolutionary computation paradigms, this study constructs a multidimensional representation of chrysanthemum research, revealing intricate interdisciplinary synergies. The AI-powered analytical framework fosters data-driven knowledge discovery, accelerating floral biotechnology innovations and advancing precision horticulture strategies.

Key words: AI-Driven bibliometrics, machine learning, co-occurence analysis, publication output.

INTRODUCTION

AI-driven bibliometrics has emerged as a crucial tool for evaluating research trends and patterns across various scientific domains, offering invaluable insights into the evolving landscapes of academic and industrial research. This approach leverages artificial intelligence and machine learning techniques to analyze vast datasets, identify key themes, and predict future research trajectories. In agriculture, the integration of AI and IoT (Internet of Things) technologies has garnered significant attention, facilitating advancements in sustainable practices and resource management. Bibliometric analyses in this field have elucidated the rapid growth and emerging hotspots of research activity, providing a roadmap for future investigations.

(Rejeb *et al.*, 12) conducted a comprehensive bibliometric analysis of 827 publications from the Web of Science, focusing on the interplay between IoT and agriculture. Their study highlighted substantial growth in IoT-related research post-2015 and emphasized the need for further exploration of IoT integration with other technologies to enhance sustainable resource management. Similarly, (Jusoh *et al*., 7) examined 656 research documents on IoT and irrigation, identifying India as the leading contributor, followed by China, Indonesia, and Malaysia. This underscores the importance of continuing research in underexplored areas of IoT applications in agriculture. (Bhagat *et al.*, 5) reviewed 465 articles on AI-assisted sustainable agriculture published between 2000 and 2021, revealing varying growth phases and identifying China, the USA, India, Iran, and France as major research hotspots. Coulibaly *et al. (*10) analyzed 1406 documents on deep learning for precision agriculture, finding convolutional neural networks (CNN) to be the most frequently used approach. They also highlighted publicly available image datasets such as ImageNet, MS COCO, and Pascal VOC for evaluating deep learning models.

Chrysanthemum (*Chrysanthemum morifolium* Ramat), often eulogized as the "Queen of the East" or "Autumn Queen" belongs to the Asteraceae family, specifically within the tribe Anthemidae, encompassing over 40 species. Named by Carolus Linnaeus, the genus name derives from the Greek words “chryos” (golden) and “anthemon” (flower). Chrysanthemums are native to the Northern Hemisphere, particularly Europe and Asia, although some scholars argue that they originated in China, where they have been cultivated for at least 3000 years. Renowned for their ornamental value, chrysanthemums are the second most popular flower crop globally. Their extensive uses include cut flowers, loose flowers, potted flowering plants, and perennial garden plants. The unique position of chrysanthemums is attributed to their remarkable phenotypic variation and adaptability to diverse agro-ecological conditions. All cultivated

*Corresponding author: drajaitiwari@gmail.com

chrysanthemums are allohexaploid (2n = 6x = 54) with a base chromosome number of x = 9, and somatic chromosome numbers ranging from 2n = 47-63 (Dowrick, 12).

In 2022, the leading exporters of chrysanthemums were the Netherlands ($ 411 M), Colombia ($ 180 M), Malaysia ($ 83.6 M), Vietnam ($ 53.9 M), and China ($ 39.5 M), while the top importers included the United Kingdom ($ 137 M), the United States ($ 125 M), Russia ($ 122 M), Japan ($ 110 M), and Germany ($ 67.9 M) (Anonymous, 2). In India, chrysanthemums were cultivated over an area of 24.02 thousand hectares, producing 456.11 thousand metric tonnes of loose flowers and 15.74 thousand metric tonnes of cut flowers during 2020-21 (Anon., 1). The Netherlands remains the predominant importer of chrysanthemum cut flowers, serving as a global distribution hub. In contrast, India's chrysanthemum cultivation exhibits a dichotomy: large-flowered varieties are primarily cultivated for cut flowers, while small-flowered cultivars are used in garlands, wreaths, religious offerings, bedding, and potting purposes (Kumar *et al.*, 21).

Chrysanthemums are extensively utilized in traditional medicine for their anti-inflammatory properties, treating conditions such as bruises, sprains, snake and centipede bites, rhinitis, diphtheria, cholera, and malaria. Additionally, they possess antipyretic and antihypertensive properties. Chrysanthemum petals are used to treat fever and wind-heat syndrome (Eisa *et al.*, 13). Chrysanthemum tea is a popular summer beverage in southern China. Beyond their ornamental use, *C. cinerarifolium* is cultivated for pyrethrum, a vital insecticide. *C. morifolium* Ramat is notable for pot culture and is acclaimed for its air-purifying capabilities, effectively removing pollutants such as trichloroethylene, benzene, formaldehyde, and ammonia, as evidenced by NASA studies.

MATERIALS AND METHODS

The data utilized in this study was retrieved from the Scopus database in Feb, 2024. Scopus, known for its extensive coverage and reliability, indexes 481 major journals across various scientific disciplines. The primary source for bibliographic data retrieval was the Web of Science (WoS) Core Collection, which is highly regarded for its authenticity and citation frequency. The Science Citation Index (SCI)-indexed data spans the period from 2000 to 2023. Additionally, the WoS, Scopus, IEEE Xplore, and Google Scholar databases are recognized as essential repositories, each offering varying levels of generalist and specialized content. Scopus is particularly noted for its broad journal coverage, facilitating comprehensive keyword searching and citation analysis.

The data collection process involved utilizing the search field utility, with restrictions set to "Title" (TS), "Abstract" (ABS), and "Authors' Keywords" (KEY). Queries were generated using the terms TITLE-ABS-KEY ("Chrysanthemum" AND ("pot mums" OR "vertical gardening" OR "growth medium" OR "germination medium" OR "variety" OR "indoor gardening" OR "genomics" OR "transcriptomics" OR "proteomics" OR "metabolomics" OR "genome-wide association" OR "plant physiology")) AND PUBYEAR > 1999 AND PUBYEAR < 2024 AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (LANGUAGE, "English")). This initial search yielded a total of 482 publications. After filtering, 421 publications were finally considered for subsequent bibliometric analysis.

RESULTS AND DISCUSSION

A total of 482 documents related to “Review of Chrysanthemum Research in the 21st Century” were collected (access date: February 7, 2024). Of these, 421 publications were categorized as follows: articles (388), review articles (28), erratum (2), conference papers (1), and editorial notes (2), as displayed in Fig. 1. These publications were used for further analysis. The annual publications from 2000 to 2023 are presented chronologically in Fig. 1. The publication rate (articles per year) saw a significant increase after 2010, rising from an average of 4.0 (2000-2010) to 29.0 (2011-2023), indicating a growing prominence of chrysanthemum research in the last decade.

The present study aimed to identify the most prominent research areas in the field of chrysanthemum for the 21st century through AI-driven bibliometric analysis. The documents were categorized into various scientific disciplines: Agricultural and Biological Sciences (270 documents, 37%), Biochemistry (182 publications, 25.2%), Medicine (50 publications, 6.9%), Chemistry(50 publications, 4%), Pharmacology (29 publications, 6%), Environmental Science (28 publications, 3.9%), Chemical Engineering (25 publications, 3.5%), Computer Science (23 publications, 3.2%), Multidisciplinary (17 publications, 2.4%), Engineering (12 publications, 1.7%), and others (6%), as illustrated in Fig. 2.

Based on AI-driven bibliometric analysis, the top 10 countries leading advanced research in the field of Chrysanthemum are predominantly Asian, collectively contributing approximately 90.75% of the entire research publications. China emerges as the foremost contributor with 194 publications, followed by India and South Korea with 60 and 32 publications, respectively. This dominance can be attributed to the

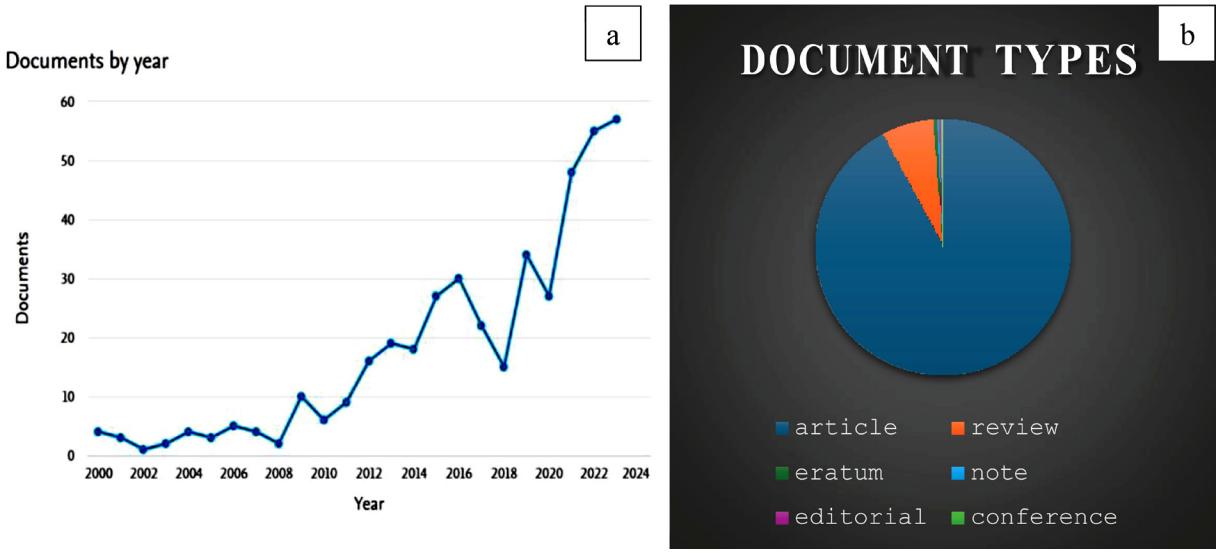

Fig. 1. Document trend (a) and types (b) of publication.

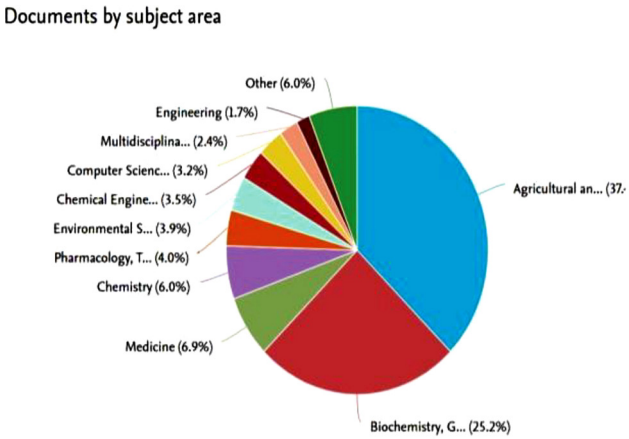

Fig. 2. Percentage contribution of documents in specific subject area.

significant importance of agriculture in these countries and the challenges faced by traditional farming systems, which have prompted a greater openness toward technologically assisted farming methods.

The top five countries with the highest publication counts were classified as leading nations due to their dominant positions, early initiation in chrysanthemum research, and robust collaborations with other countries. This classification is likely influenced by the fact that China, India, the USA, and Australia are among the largest agricultural producers globally. Moreover, their respective governments have implemented flagship schemes that provide substantial funding to institutions and universities engaged in agricultural research, thereby fostering significant advancements in the field as illustrated in Fig. 3.

Table 1 presents the top ten impactful publications in the field of chrysanthemum research based on the Web of Science database from 2000 to 2023. These publications have been cited between 95 times (Choi *et al*., 9) and 315 times (Ahloowalia and Maluszynski, 3), highlighting their significance and influence within the field. The publication titled "Induced Mutations - A New Paradigm in Plant Breeding" (Ahloowalia and Maluszynski, 3) is particularly noteworthy, with 315 citations, demonstrating its substantial impact on chrysanthemum research.

All of these impactful publications were published in high-impact factor journals (as per the Journal Citation Report: 2022), with impact factors ranging from 1.9 (Euphytica) to 10.6 (IEEE Transactions on Image Processing). This trend suggests that research involving advanced technologies is more likely to be published in high-impact journals and attract a higher number of citations compared to those in journals

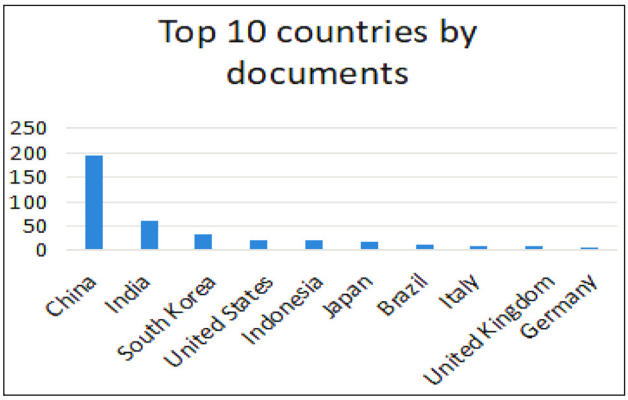

Fig. 3. Total publications with geographical distribution.

Table 1. Highly cited publications in the field of chrysanthemum during 21st century.

Publications	DOI	TC	ACPY
Ahloowalia and Maluszynski (2001)	10.1023/A:1004162323428	315	14.31
Leiss *et al.* (2009)	10.1104/pp.109.138131	240	17.14
Tanaka *et al.* (2010)	10.1269/jrr.09143	196	15.07
Aydogan and Montoya (2011)	10.1016/j.atmosenv.2011.02.062	136	11.33
Paek *et. al.* (2001)	10.1007/s11627-001-0027-9	121	5.5
Mokhtarian and Abbasi (2004)	10.1109/TIP.2004.826126	118	6.21
Su *et al.* (2019)	10.1038/s41438-019-0193-8	112	28
Curci *et al.* (2015)	10.1371/journal.pone.0120589	105	13.12
Xu *et al.* (2013)	10.1186/1471-2164-14-662	102	10.2
Choi *et al.* (2009)	10.1016/j.jep.2009.02.009	95	6.785

with lower impact factors (Calcagno *et al*., 6). It is important to note that citation counts may vary across different databases; for instance, Google Scholar includes citations from non-journal sources (Yang and Meho, 13), which could potentially influence the ranking of publications.

To identify the most prolific organizations in chrysanthemum research, we selected the top 10 institutions based on the highest number of publications from a total of 160 organizations. We also calculated the total strength of co-authorship links with other institutions. Organizations with the greatest total link strength were prioritized.

Among the top 10 institutions, China was prominently represented, occupying the top three positions. Nanjing Agricultural University, Nanjing, China, ranked first with 73 publications (17.33% of the total). The Ministry of Agriculture of the People's Republic of China followed in second place with 30 publications (7.12%), and Beijing Forestry University, Beijing, secured third place with 21 publications (4.98%). The ICAR - Indian Agricultural Research Institute, New Delhi, India, ranked fourth with 17 publications, accounting for 4.03% of the total. These findings underscore the leading role of Chinese institutions in chrysanthemum research, facilitated by extensive collaborative networks and significant contributions to the field (Table 2).

Table 3 delineates the characteristics of the primary journals that have published documents in the field of chrysanthemum research. Based on AI-driven bibliometric analysis, 160 reputable journals have collectively published 421 research articles in this domain. This table highlights the top ten journals that have published the most research from 2000 to 2023. The analysis revealed that "BioMed Central Genomics" secured the top position with 17 publications, followed by "Scientia Horticulturae" with 15 publications, and the "International Journal of Molecular Sciences" with 14 publications. Articles published in "BMC Genomics" are strongly associated with research on transcriptomics studies, whereas

Table 2. Contribution of top 10 institutes in chrysanthemum research.

Affiliation	No. of documents	% Contribution
Nanjing Agricultural University	73	17.33
Ministry of Agriculture of the People's Republic of China	30	7.12
Beijing Forestry University	21	4.98
ICAR - Indian Agricultural Research Institute, New Delhi	17	4.03
Ministry of Education of the People's Republic of China	14	3.32
Indian Council of Agricultural Research	11	2.61
Jiangsu Province Engineering Lab for Modern Facility Agriculture Technology and Equipment	10	2.37
Institute of Vegetable and Floriculture Science, NARO	10	2.37
Rural Development Administration	10	2.37
National Agriculture and Food Research Organization, NARO	9	2.13

Table 3. Major journals publishing sources.

Source	No. of documents
BMC Genomics	17
Scientia Horticulturae	15
International Journal of Molecular Sciences	14
Indian Journal of Agricultural Sciences	12
Horticulture Research	10
Frontiers In Plant Science	8
Plos One	8
Genes	6
Horticulture Environment and Biotechnology	6
Ornamental Horticulture	6

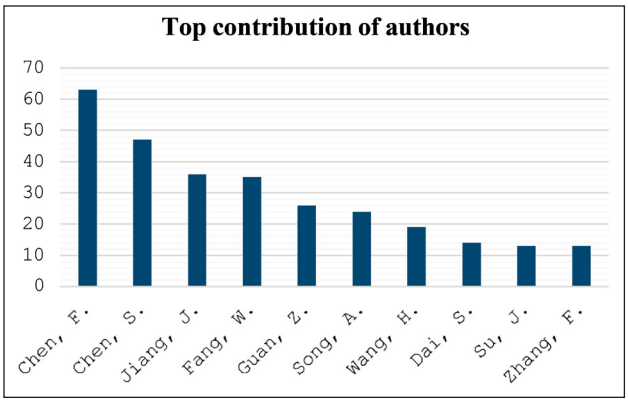

Fig. 4. Top contribution of authors in the field of chrysanthemum.

those in "Scientia Horticulturae" predominantly focus on gene expression and breeding for biotic and abiotic stresses in chrysanthemums. The impact factors of these journals vary significantly, reflecting a diverse range of influence within the scientific community. Trends in publishing within journals of varying impact factors have not been steady, indicating a dynamic research landscape. Notably, approximately 24.22% of the total publications are attributed to the top ten publishers (as illustrated in Table 3), underscoring the impact and relevance of chrysanthemum research within these leading journals.

Several prolific authors have significantly contributed to chrysanthemum-based research, resulting in 421 publications over the past two decades (2000-2023). Fig. 4 presents the top 10 authors who have published extensively in this field. Chen, F. leads with 63 publications, followed by Chen, S. with 47 publications, and Jiang, J. with 36 publications. These authors have played pivotal roles in advancing chrysanthemum research, reflecting their substantial impact and leadership in the scientific community.

This investigation employs bibliometric analysis to evaluate research trends on chrysanthemum for the 21st century. It examines research trends, impact, influential researchers and their connections, emerging countries, leading publishers, and the latest studies conducted on chrysanthemum. However, this study has certain limitations as we have only extracted data from the SCOPUS database, and hence documents from non- indexed plant journals have not been considered. The search was then restricted to publications containing the keywords TITLE-ABS-KEY ("Chrysanthemum" AND ("pot mums" OR "vertical gardening" OR "growth medium" OR "germination medium" OR "variety" OR "Indoor gardening" OR "genomics" OR "transcriptomics" OR "proteomics" OR "metabolomics" OR "genome wide association" OR "plant physiology")) AND PUBYEAR > 1999 AND PUBYEAR < 2024 AND [LIMIT-TO (SRCTYPE, "j")] AND [LIMIT-TO (LANGUAGE, "English")].

To the best of our knowledge and survey, this is the first study regarding chrysanthemum-based bibliometric analysis for the 21st century, providing a comprehensive and specific view of available research from the largest existing database. The study summarizes the current state of research in the chrysanthemum field, identifying gaps and future directions. It also highlights the increasing use of these technologies. Furthermore, it identifies influential authors, institutions and countries in the field aiding collaboration and partnerships for future research.

Chrysanthemum-based bibliometric analysis, integrating AI with traditional methods, offers significant potential for advancing research in this field. AI can enhance data processing by analyzing large volumes of scholarly data with greater efficiency and accuracy, while also identifying emerging trends and areas of interest in chrysanthemum studies. Through network analysis, AI can map research collaborations and pinpoint key influencers, fostering interdisciplinary cooperation. Predictive analytics could forecast future research trends, guiding resource allocation and prioritization. Customizing insights based on user needs would enhance relevance for diverse stakeholders, while interactive visualizations would offer intuitive ways to explore complex data. Ethical considerations, including data privacy and bias mitigation, must be prioritized, ensuring responsible AI use. Additionally, integrating AI with technologies like blockchain and natural language processing could further enhance the

transparency, accuracy, and depth of bibliometric analysis, promoting innovation and collaboration in the chrysanthemum research landscape.

AUTHORS' CONTRIBUTION

Conceptualization (VN, AKT, RP, S); Data curation (VN, AKT, RP, S); Writing-original draft (VN, PMS, S); Methodology (AKT, RP); Visualization (AKT, RP); Writing-review and editing (AKT, RP, RJ, BS, GK).

DECLARATION

The authors declare that there is no conflict of interest.

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