Research Article

BIBLIOMETRIC ANALYSIS OF WORLDWIDE RESEARCH TRENDS ON RICE

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ABSTRACT

Rice is the world's second most significant and extensively farmed grain crop and serves as the nutritional foundation of humanity. Thus, this agricultural plant is critical for world food security. A bibliometric study of rice-related scientific publications and patents using several databases was carried out. The number of documents produced each year, the subject categories, publishing journals, document types, and languages were all metricated. The primary keywords used in research articles on this crop were also examined globally and organized into subject categories. Distinct papers were analyzed independently while searching for terms relating to genetics and transgenic rice. A comparison of rice data revealed several noteworthy differences, the causes for which are explained further. The total number of documents with the term "rice" in 11 databases and over 1980-2023 is 8,009,800. There are 25 different languages in which documents are published; the biggest share belongs to the English language in Springerlink data. China ranks first in the number of publications on rice. The expanding amount of papers and patents indicates a continued interest and investment in improving rice-related knowledge and applications, offering valuable insights that contribute to further improvements in rice crop production.

Keywords: Rice, Grain Crop, Articles, Genetics, Transgenic Rice, Bibliometric

INTRODUCTION

Rice (*Oryza sativa L.*) is the world's second most important and widely grown grain crop [1]. It is a vital energy source and a staple meal for more than 3.5 billion people globally, primarily in Asia. It is also regarded as a model plant species for molecular biology and genomic research due to its genetic diversity, small genome size, quantity of high-quality sequences, and effective transformation procedures. With the world's population anticipated to reach 9.6 billion by 2050, increasing rice production is urgently needed to fulfil rising food demand [2].

The rice genome includes 12 chromosomes (2n = 24) with a total length of 430 Mb (megabase, a nucleotide length of 1000 000 base pairs), equivalent to about 1500 cm (centiMorgan, a genetic unit of length assessed by the frequency of crossing-over in genetic recombinations at meiosis) [3].

Rice arose 9,000 years ago in the Yangtze Valley and evolved into temperate and tropical areas where japonica rice was cultivated during a global cold event 4,000 years ago. It is one of the world's most frequently produced grain products, with many genetic variants. Certain characteristics, such as texture, shape, and colour differentiate these variations. Machine vision systems, deep learning techniques, and support vector machines can be used to categorize and evaluate seed quality based on the traits that distinguish rice types. Machine learning algorithms provide quick and dependable examination of vast amounts of data. Using these approaches in rice production is critical for improving end-product quality while satisfying food safety regulations in an automated, cost-effective, efficient, and non-destructive manner. There are four types of rice: indica, japonica, aromatic, and glutinous [4].

Rice can be boiled or crushed to make flour. It is eaten independently and in various soups, side dishes, and main meals in Asian, Middle Eastern, and other cuisines. Rice is also found in morning cereals, noodles, and alcoholic beverages like Japanese sake. It is a key staple food contributing to vitamin A deficiency, a critical public health concern in at least 26 nations [5]. Rice bran includes protein, lipids,

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dietary fibre, minerals, and antioxidants, making it a possible functional element for treating life-threatening conditions [6]. Because of their increased functionality, hydrolyzed rice proteins are used to make hypoallergenic baby formulae and may be used in various dietary systems [7]. Traditional Chinese medicine uses pigmented rice, such as black, brown, purple, red and yellow, to increase kidney function, treat anaemia, promote blood circulation, remove blood stasis, treat diabetes, and improve sight [8]. Rice is used in traditional medicine to treat inflammation, gastrointestinal problems, hypercholesterolemia, diabetes, and skin illnesses, and its ingredients have several medicinal effects [9]. Increased phosphorus usage efficiency is critical to the agricultural sustainability of rice crops [10]. Transgenic rice has the potential to improve nutritional properties, increase grain output, and function as a biofactory for the synthesis of medicinal and industrial chemicals [11].

Rice serves an important nutritional function in humans by delivering energy, protein, vitamins, minerals, and dietary fibres, with different forms having differing health advantages and dangers. Introducing barley genes for phytosiderophore production into rice grains can boost iron and zinc levels, potentially addressing human nutritional issues [12]. Rice embryos also contain proteins comparable to endosperm glutelins and globulins, which play an important role in human nutrition [13]. Including micronutrients such as calcium, phosphorus, and selenium in rice fertilizer can minimize arsenic pollution, improve animal and human nutrition, and avoid sickness [14].

Developing rice cultivars with better yield potential and more yield stability is critical to meeting rising rice demand by 2030, using less land, water, labour, and pesticides [15]. China can expand rice output by 20% by 2030 using hybrid rice technology and research initiatives, despite constraints such as shrinking arable land, water scarcity, climate change, and labour shortages [16]. Improvements in breeding, production procedures, harvesting, drying, storage, and milling have made it possible to produce more high-quality rice for the world's population [17]. Advances in molecular biology and genomics, along with traditional breeding, can produce designer rice varieties capable of meeting global rice demand and food security issues in the twenty-first century [18].

Recent advances in bibliometrics, scientometrics [19] and informatics [20] have made examining scientific trends in specific domains possible. These analytical tools are critical for assessing the present status of research and comprehending the contributions of researchers and countries across several disciplines of knowledge. Furthermore, because of the significant resources invested in them, bibliometric indicators that measure scientific production in a particular field by a country or organization may also be used as economic and social indicators. Previously, 4170 publications were examined from 1990 to 2022, including 86 highly cited and three hot papers using the Web of Science database [21]. Furthermore, 1319 research and review articles about rice and irrigation were examined between 1965 and 2018 [22]. Two thousand six hundred eighty papers on rice remote sensing were published from 1980 to 2021 [23].

Thus, this study aimed to compare the past and present patterns of research on rice and its variants using a retrospective and descriptive bibliometric analysis of worldwide scientific production connected to this key crop. Furthermore, several research publications were examined using various databases to perform a bibliometric analysis. Therefore, databases i.e. PubMed, ScienceDirect, JSTOR, Mendeley, Google Scholar, Scite, Semantic Scholar, Wiley, Springer, MDPI, and Zendy were chosen. Given the potential for extensive information retrieval from these databases, they are valuable for conducting bibliometric studies.

MATERIALS AND METHODS

The research materials and patents analyzed in this study were obtained from eleven databases i.e. PubMed, ScienceDirect, JSTOR, Mendeley, Google Scholar, Scite, Semantic Scholar, Wiley, Springer, MDPI, and Zendy using search keywords such as TITLE-ABS-KEY(Rice), TITLE-ABS-KEY (Indica Rice), TITLE-ABS-KEY (Japonica Rice), TITLE-ABS-KEY (Aromatic Rice), and TITLE-ABS-KEY (Glutinous Rice) until December 31, 2023. These searches were used to identify scholarly publications and patents with "rice"-related phrases in the title, abstract, and keywords. The papers found during the search were appraised and classified based on various criteria, including the number of documents each year, document type and language, distribution by topic areas and journals, and affiliation by nation and institution. The resultant records were analyzed and graphed to provide a more user-friendly presentation of the findings.

The list of the most common terms in the papers obtained by the databases following any search was further examined subjectively and statistically. The list generated by the original search (i.e., primary keywords considering all scientific articles dated up to December 31, 2023) was used to analyze keywords connected to cereals-and-model-plants and human. Word clouds were made with the free software WordArt (https://wordart.com/) and combined with all of the keyword sets and clusters. Sankey plots were made through online free available website (https://sankeymatic.com/). The font size of a given

keyword in these clouds indicates how many times it appears in literary sources. However, national rice production, export, and import statistics were obtained from the World Food and Agriculture Statistical Yearbook 2023.

RESULTS AND DISCUSSION

Evolution of Scientific Output in Databases and Distribution by Languages and Subjects

The terms "rice", "indica rice", "japonica rice", "aromatic rice" and "glutinous rice" have been detected in the title, abstract or keywords of a total of 11 databases over the varying periods. The term "rice" has been detected in a total of 8,009,800 documents in 11 databases over the period 1980–2023, while "indica rice" has been identified in 1,456,278 articles, "japonica rice" has been identified in 900,597 articles, "aromatic rice" has been identified in 2,211,356 articles, and "glutinous rice" has been identified in 706,984 articles. The term "rice" has been detected highly in the google scholar (4,700,000) (Figure 1). The term "indica rice" has been detected highly in the google scholar (645,000). The term "japonica rice" has been detected highly in the semantic scholar (574,000). The term "aromatic rice" has been detected highly in the google scholar (1050000). The term "glutinous rice" has been detected highly in the semantic scholar (528,000) (Figure 2).

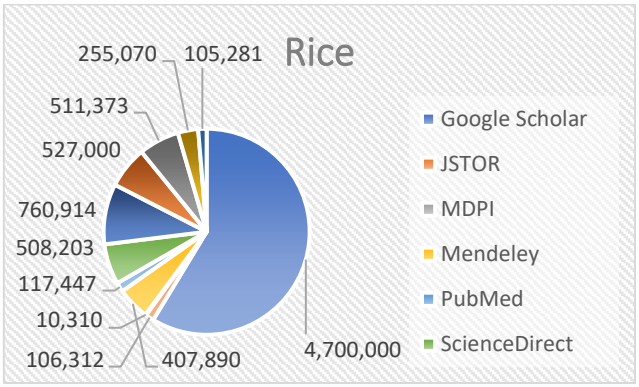

Figure 1. Trends in Publications on rice in different databases

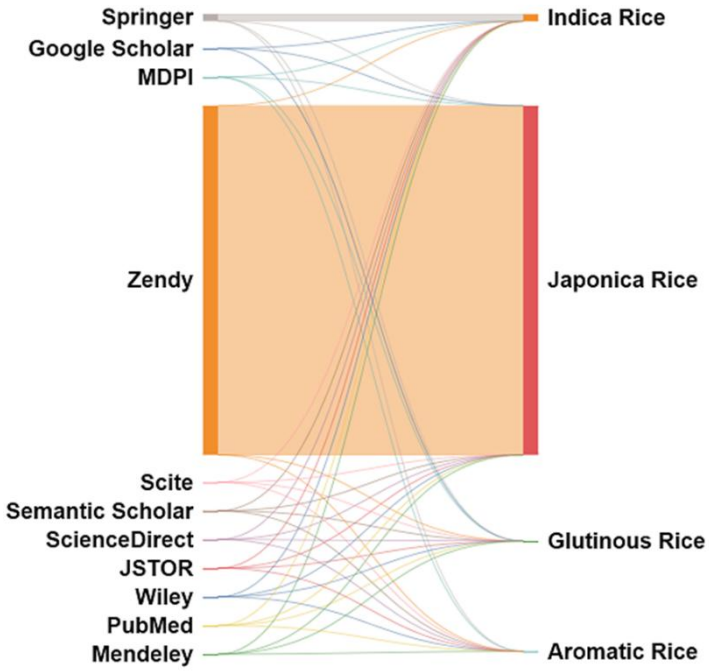

Figure 2. Trends in Publications on types of rice in different databases

Since its initial publication, the number of studies on "rice" and "types of rice" has steadily increased. And also, since the second part of the twentieth century, there has been a significant growth in publications on both study themes. (Figure 3, Figure 4, Figure 5).

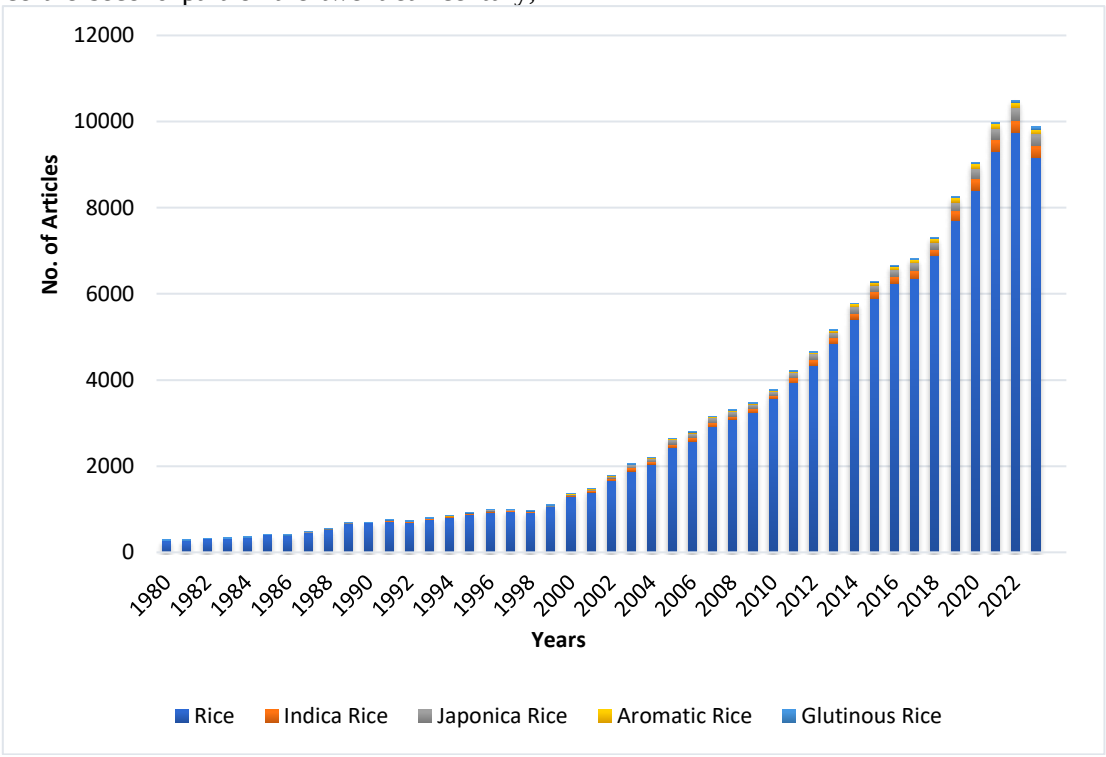

Figure 3. Trends in publications on rice and types of rice in PubMed

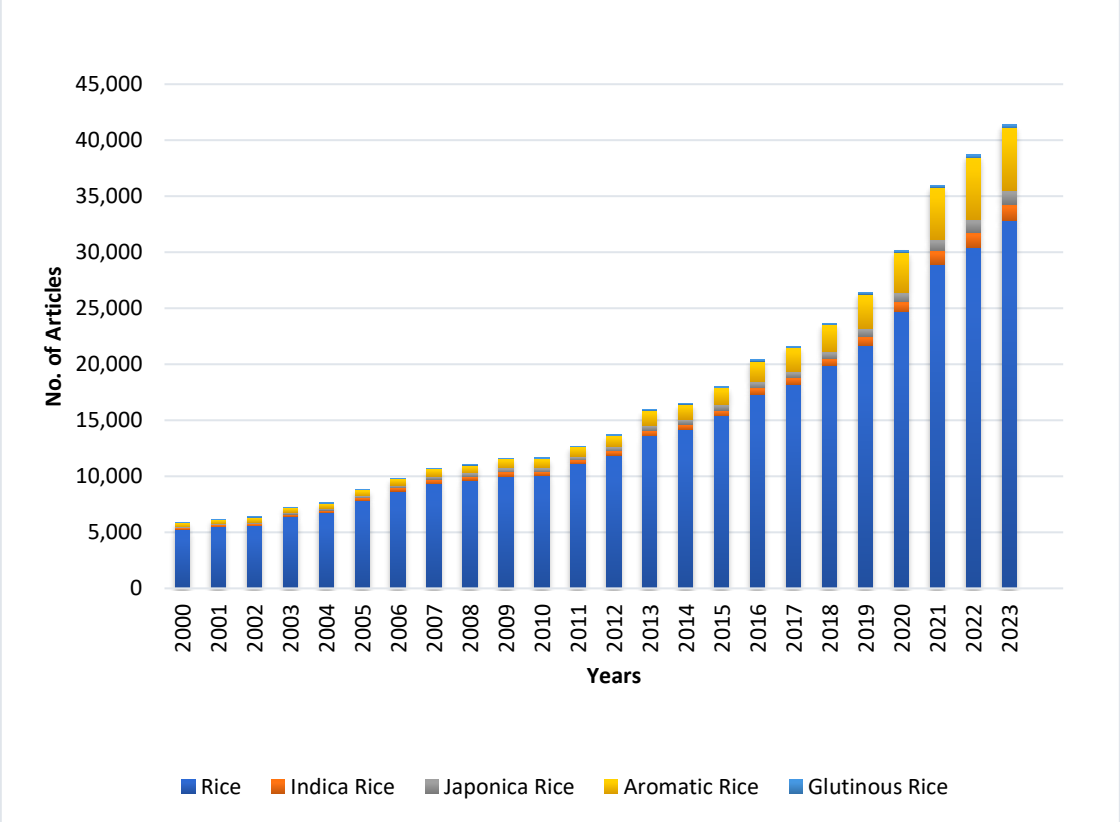

Figure 4. Trends in publications on rice and types of rice in ScienceDirect

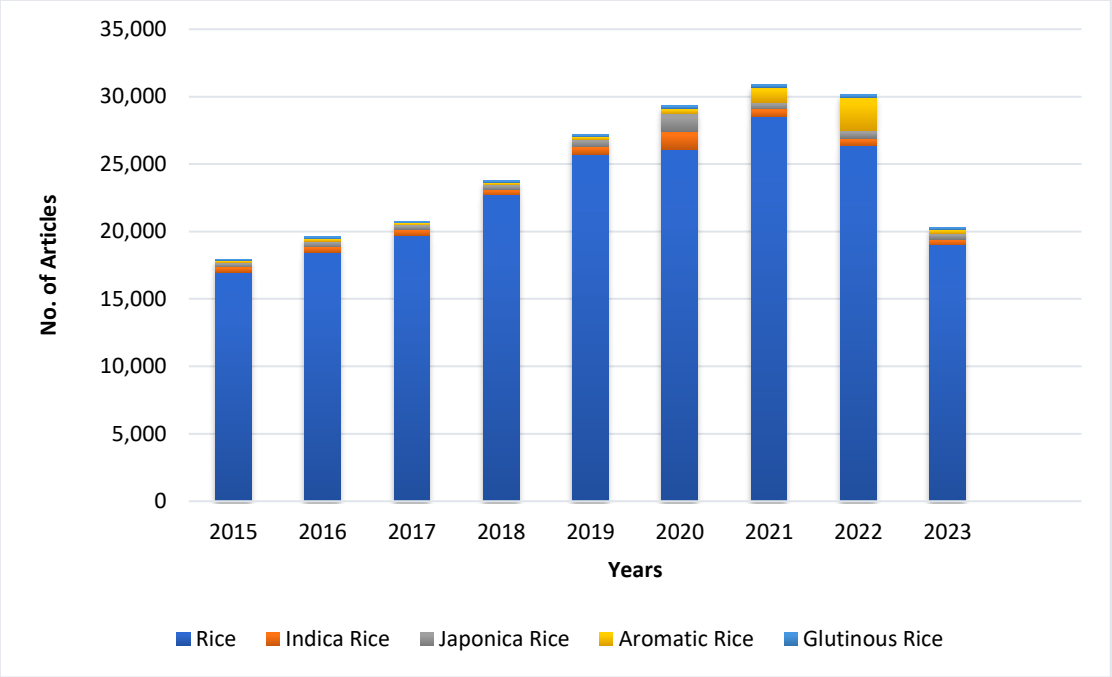

Figure 5. Trends in publications on rice and types of rice in Mendeley

Different trends have been observed in Google Scholar in search for research articles and review articles from 2020 to 2023. The number of publications has experienced a notable increase from 2020 to 2023 (Figure 6, Figure 7). This surge can be attributed to heightened research activities, increased funding opportunities, expanded collaboration within the academic community, and technological advancements facilitating easier dissemination of research findings.

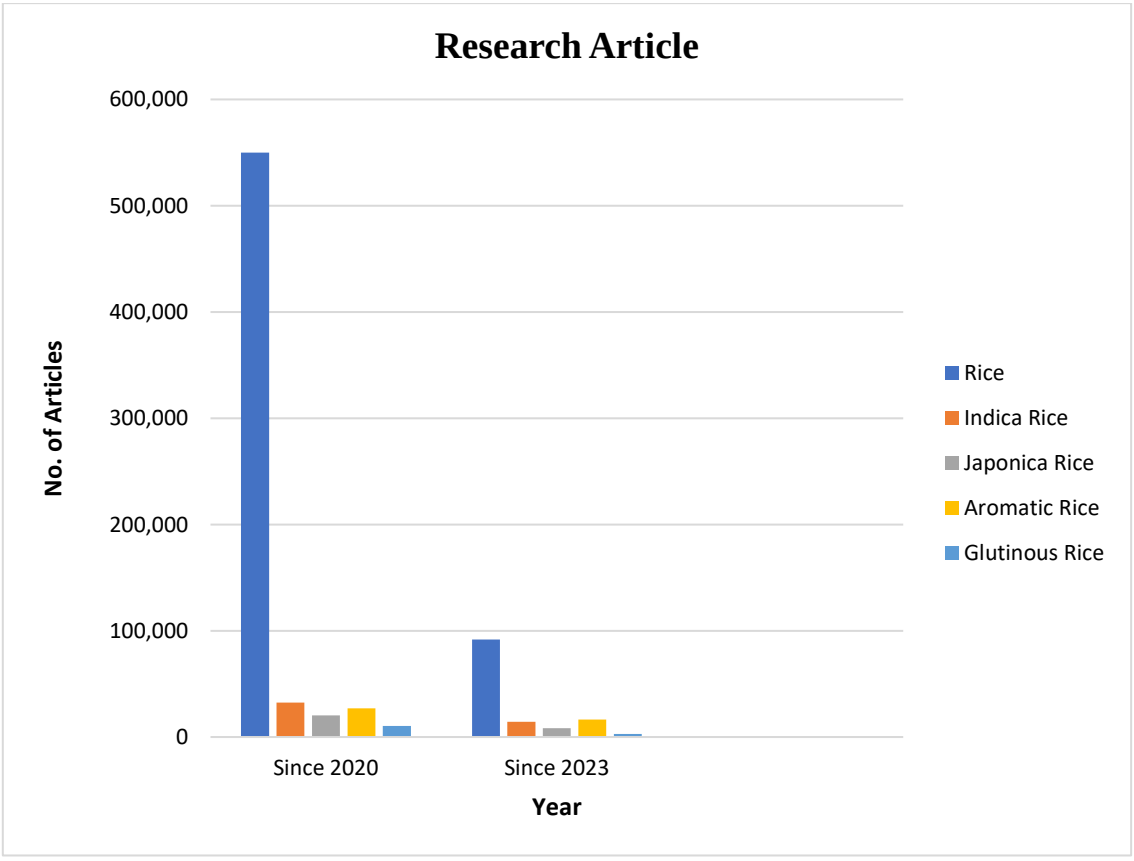

Figure 6. Trends in research articles published on rice and types of rice in Google Scholar

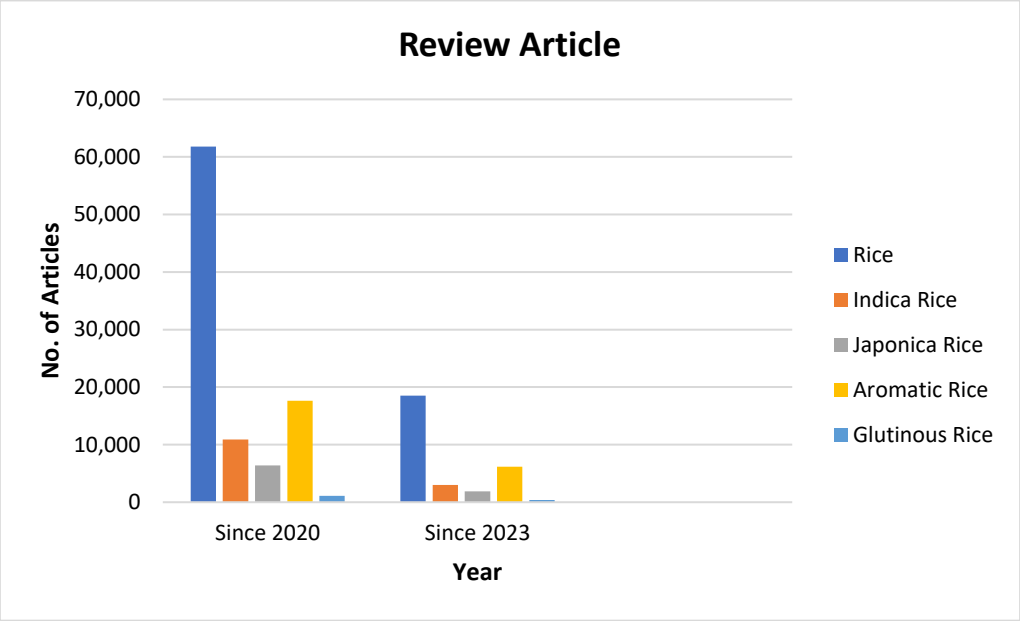

Figure 7. Trends in review articles published on rice and types of rice in Google Scholar

The highest number of open-access articles has been found in Mendeley (Figure 8), underscoring a deliberate emphasis on accessibility and knowledge dissemination. This preference for Mendeley can be attributed to its user-friendly interface, robust search functionalities, and commitment to fostering open science principles, making it a preferred platform for researchers and institutions dedicated to sharing their findings with a broader audience.

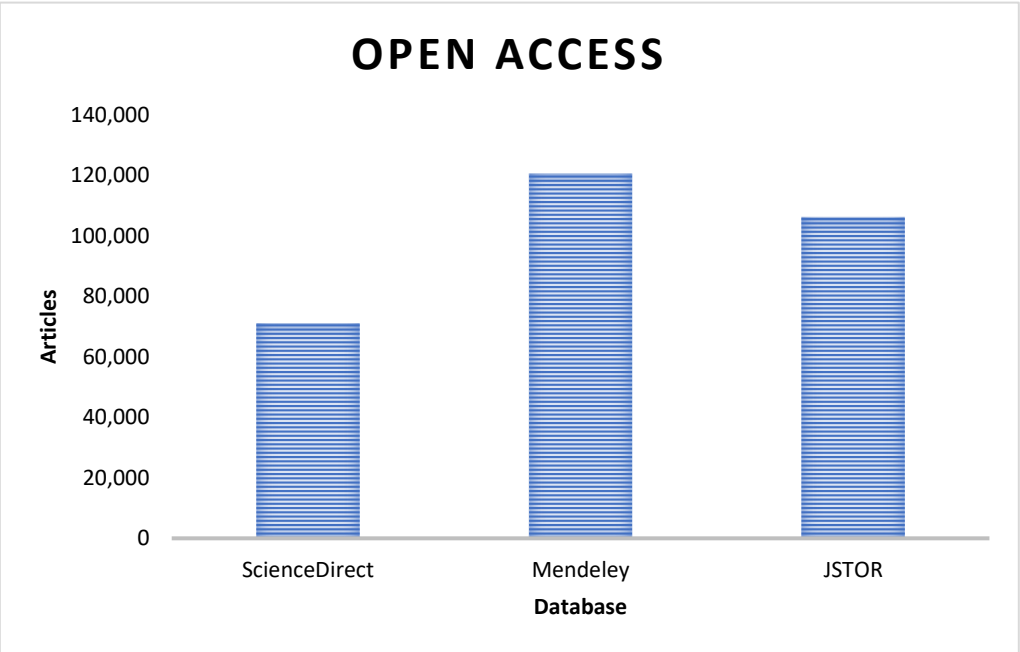

Figure 8. Trends in open access publications in various databases

The noticeable increase in academic reports on rice and its various types in recent years may reflect a general growth in scientific publications rather than a genuine surge in the scientific community's interest in these crops. An additional analysis was conducted to explore this possibility further, specifically focusing on documents published in different languages. Consequently, the ratio of documents published up to

1980 and from 2000 to 2023 was calculated for overall publications and for those incorporating terms like rice, indica rice, japonica rice, aromatic rice, or glutinous rice in the title, abstract, and/or keywords. The findings indicate that the rise in publications related to rice is indeed more significant than those specifically addressing the different types of rice. Research studies on rice have been published in 25 different languages across various databases. As anticipated, English, being the international language of science and technology, emerged as the predominant language for publishing rice-related content. Specifically, in Springerlink, there were 504,082 reports, constituting 98.575% of the publications in English language (Figure 9).

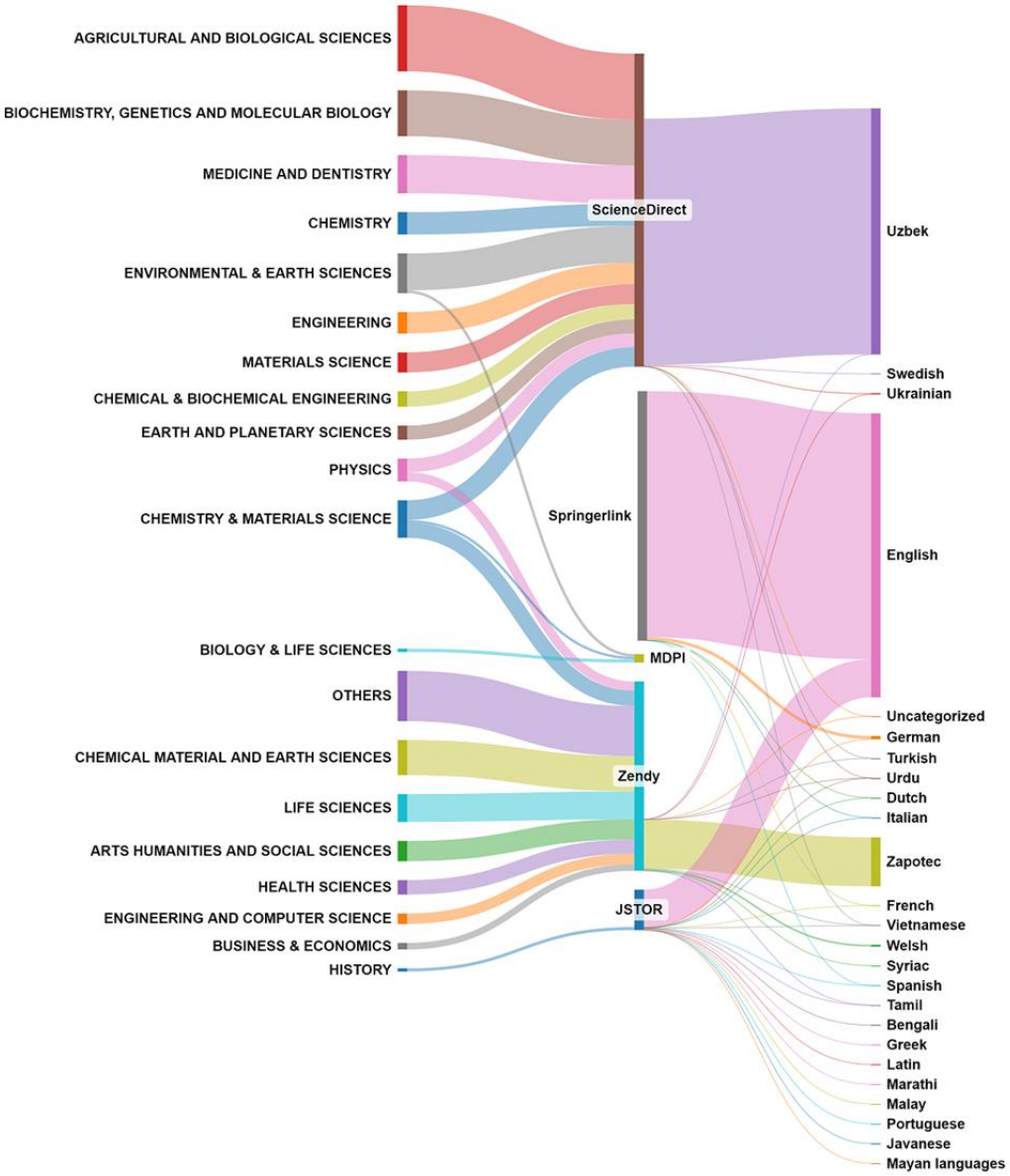

Figure 9. Distribution of scientific output in the rice research area by Subjects and Languages in various databases

Uzbek and Zapotec also contribute substantially, with 504,294 and 100,400 reports, respectively. Other languages such as Mayan, Latin, Javanese, Portuguese, Malay, Marathi, Tamil, Turkish and Syriac contribute to the overall body of literature, albeit with smaller numbers (Figure 9). Publications on rice research are distributed across 37 subject areas according to the database classification (Figure 9). Agricultural And Biological Sciences is the leading subject area for rice-related publications, with 135,305 reports. This indicates a strong focus on rice within the realm of agricultural and biological research. The subject area of Biochemistry, Genetics, and Molecular Biology is also prominently featured, with 93,904

publications. This suggests a substantial body of work exploring rice's molecular aspects and genetic characteristics. The data showcases a diverse coverage of subject areas, indicating that rice research extends across multiple scientific disciplines. The subject area of Environmental and Earth Science registers many publications (75,557), highlighting the intersection of rice research with environmental considerations and possibly related to sustainable agricultural practices. Engineering and Materials Science contribute substantially to the body of literature, with 43,850 and 40,776 publications, respectively. This suggests a focus on the engineering aspects and material properties relevant to rice-related studies. Medicine and Dentistry also feature prominently with 77,949 publications, indicating the relevance of rice in medical and dental research, potentially related to nutritional and health aspects (Figure 9).

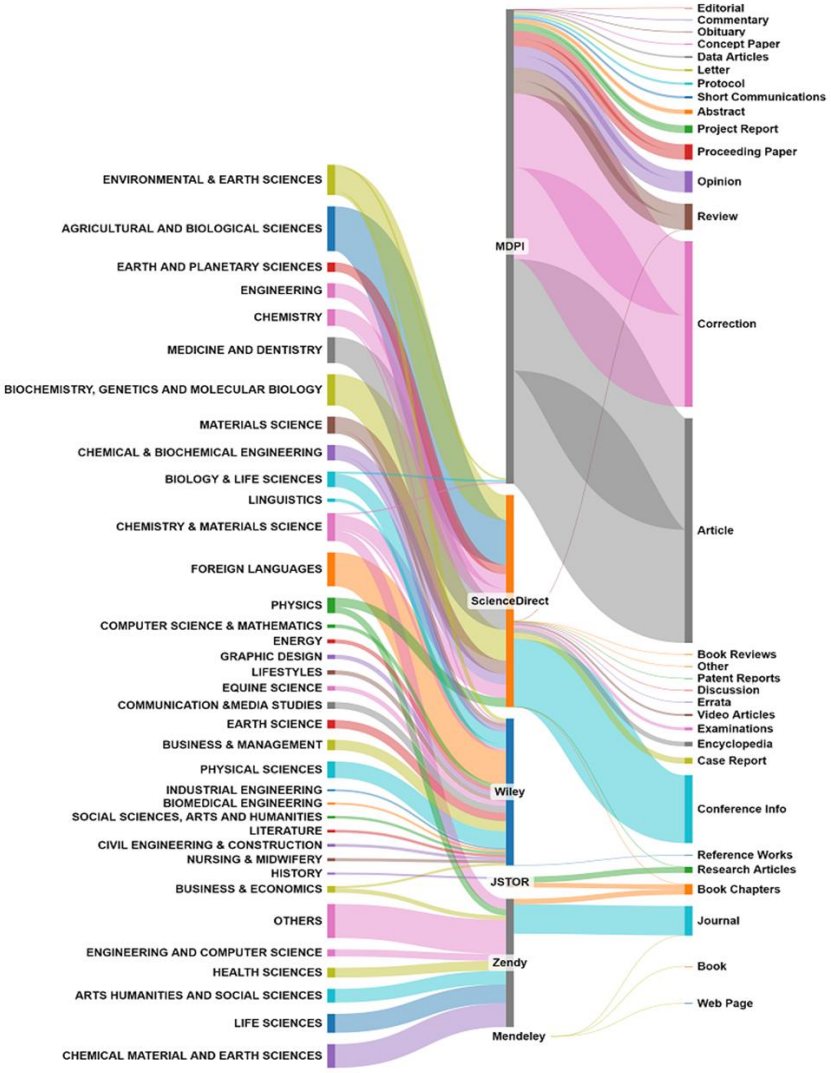

Figure 10. Distribution of Subjects and document types for research on rice.

Subject Areas, Article Types and Journals

Regarding the number of publications by source, research articles are the most prevalent category, with a substantial count of 679,444 records, showcasing the primary focus on in-depth research within the given dataset. Book chapters are significant, indicating contributions to collective volumes or edited works (31,702 records). Review articles follow, emphasizing the importance of comprehensive reviews in summarizing existing literature (78,994 records). Conference abstracts (205,550 records) and short communications (7,073 records) highlight the participation and dissemination of research findings at conferences and through brief communications. The data diversity across these categories underscores the multifaceted nature of scholarly communication within the given dataset, covering many document types and formats (Figure 10).

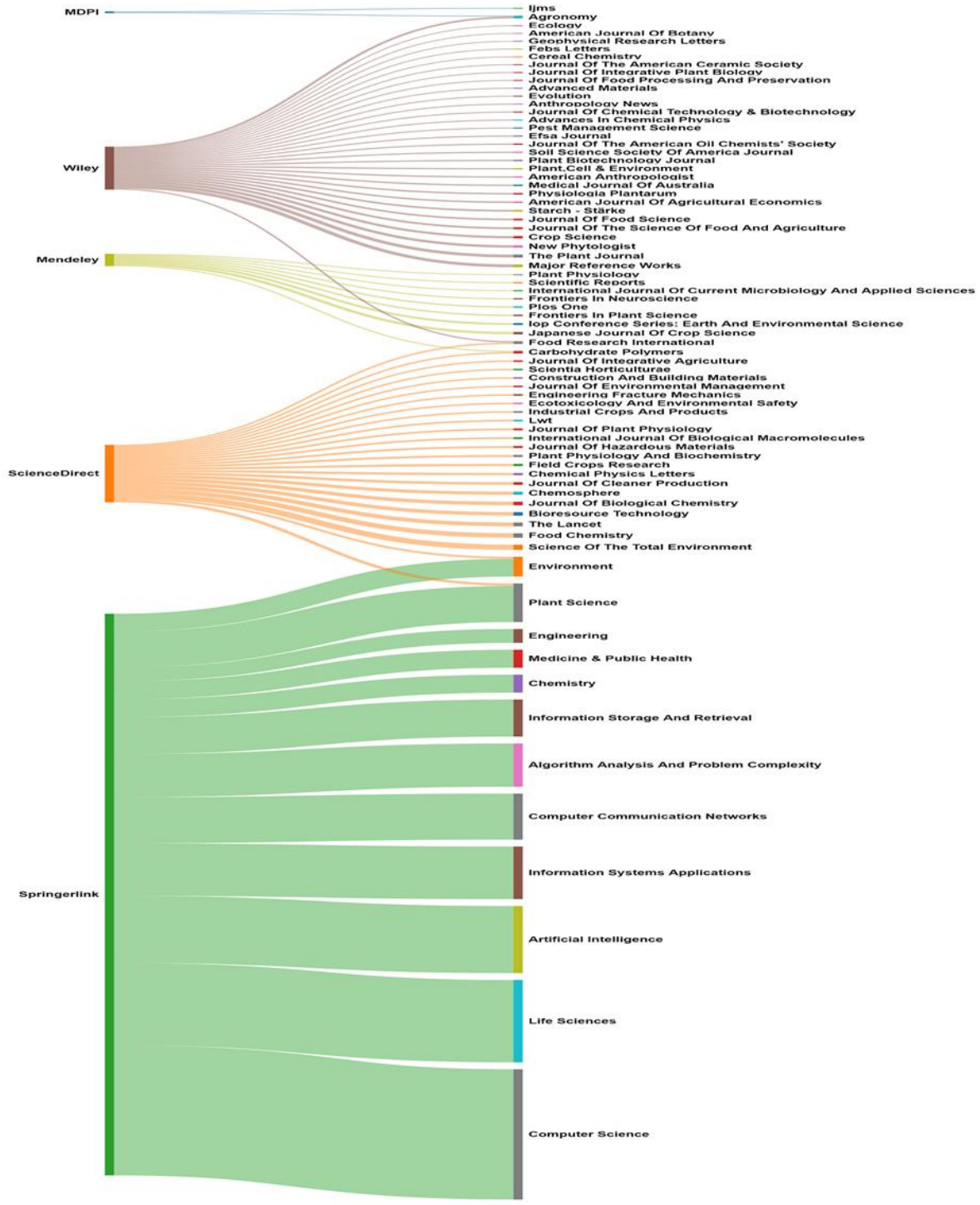

Figure 11. Journals in which rice research findings have been published

The dataset presents publication counts for various journals. Journal of Life Sciences (113,358) has the highest publication count in the dataset, indicating a substantial volume of research related to crop science originating from China. Frontiers in Plant Science (49,635) has a notable publication count, emphasizing its significance in the dataset and suggesting a focus on advancements and research in plant science (Figure 11).

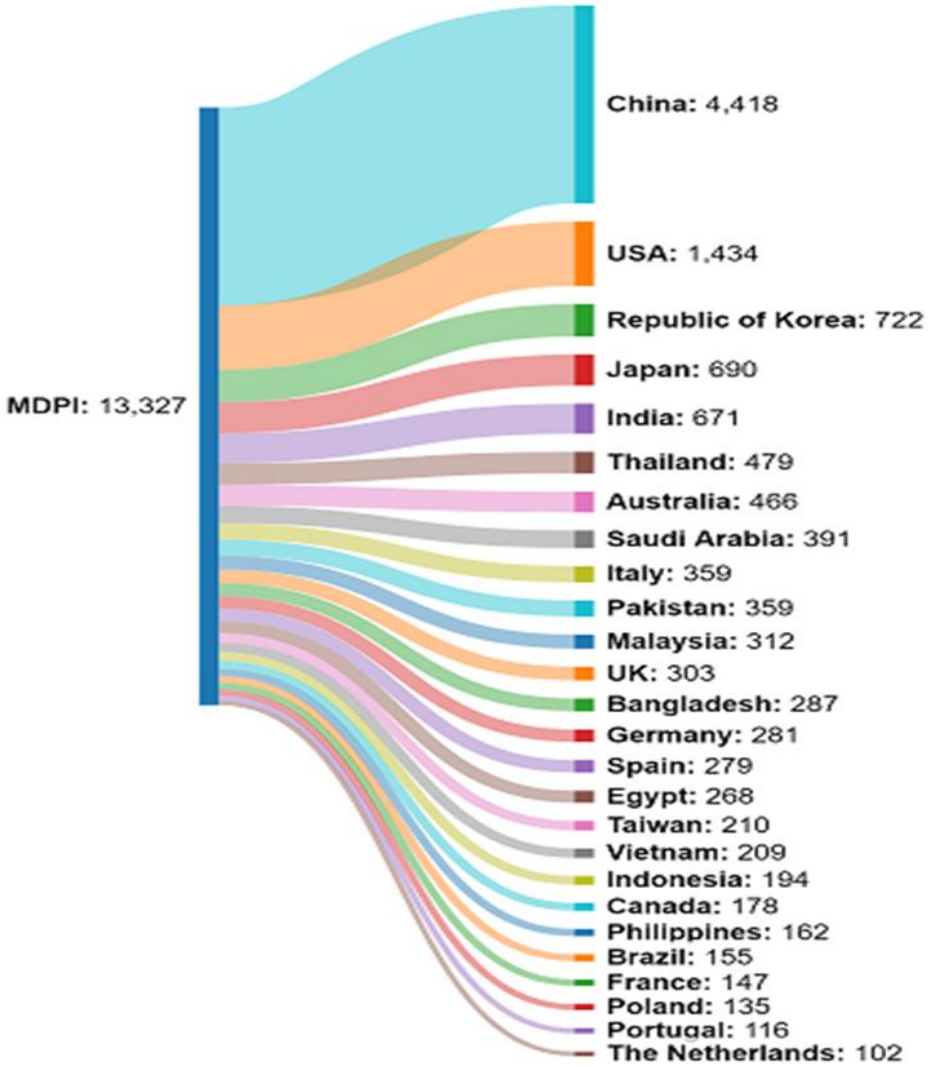

Figure 12. Country wise distribution of articles on rice

China has the most publications (4418) on rice, showing a considerable commitment to rice research (Figure 12). This reflects China's position as one of the world's greatest producers and consumers of rice, as well as its substantial research into rice breeding, growing techniques, and agricultural practices. The United States is another important contributor to rice research, having published 1434 publications. Research from the United States frequently focuses on rice genetics, biotechnology, and the development of sustainable agricultural techniques.

South Korea, commonly known as the Republic of Korea, is strongly dedicated to rice research, as indicated by the many publications (722). South Korean research frequently emphasizes technical advances in rice growing, quality enhancement, and disease management. Japan has a long history of rice farming and study, as evidenced by many rice-related publications (690). Japanese researchers frequently investigate traditional rice varietals, precision agriculture techniques, and improvements in rice processing and utilization (Figure 12).

India (671), one of the world's top rice producers, significantly contributes to rice research. Indian research frequently focuses on rice breeding for increased production and resilience and the development of climate-smart agricultural strategies to address issues like water shortages and climate change. Thailand (479), known for its high-quality rice varieties, engages in research to improve rice yield and quality. Thai research frequently focuses on sustainable agricultural techniques, post-harvest technology, and market-oriented approaches to rice production.

Australia has contributed 466 publications to rice research, with an emphasis on temperate rice growing, water management measures, and precision agricultural advances. An Australian study also looks on the environmental impact of rice growing on wetland ecosystems and biodiversity conservation. Saudi Arabia (391) invests in rice research to boost agricultural production in dry climates. Research efforts frequently focus on water-efficient irrigation techniques, salinity control, and cultivating drought-tolerant rice cultivars suited for the region's climate.
Italy's (359) rice research focuses mostly on producing risotto variations, sustainable rice farming techniques in paddy ecosystems, and the nutritional value of Italian rice varieties. Italian experts also look at rice's culinary and cultural relevance in Italian cuisine. Pakistan's contributions to rice research (359) include breeding programmes for high-yielding and disease-resistant rice varieties and research into water management, soil health, and post-harvest technology. Pakistani study also covers socioeconomic factors affecting rice agricultural communities (Figure 12).
This sheds light on the various contributions of different countries to the global body of knowledge on rice, highlighting the importance of rice as a staple food crop and the collaborative efforts of researchers worldwide to improve its production, quality, and sustainability.

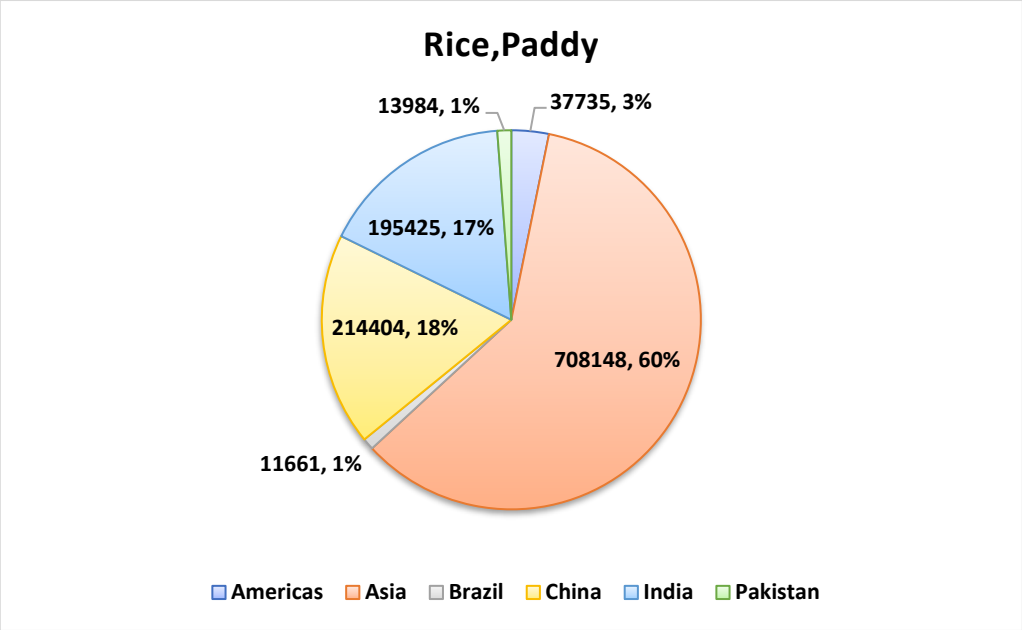

Figure 13. Distribution of production of rice by country

Evolution of Scientific Output by Worldwide Production of Rice

The worldwide distribution of paddy rice output, emphasizes regional and national contributions (Figure 13). Asia accounts for 60% of overall output, underscoring its pivotal position in the world rice supply. China (18%) and India (17%) are the main producers, together representing 35% of overall output. The Americas account for 3%, with Brazil and Pakistan both holding a negligible 1% portion. These findings highlight the dependence on Asian agriculture for rice production, indicating its agro-climatic compatibility and extensive growing strategies (Table 1).

Table 1. Production of primary crops country wise.

Country	Maize	Rice,Paddy	Wheat
Americas	592356	37735	99666
Asia	378856	708148	340462

Brazil	88462	11661	7875
China	272762	214404	136952
India	31650	195425	109590
Pakistan	10635	13984	27464

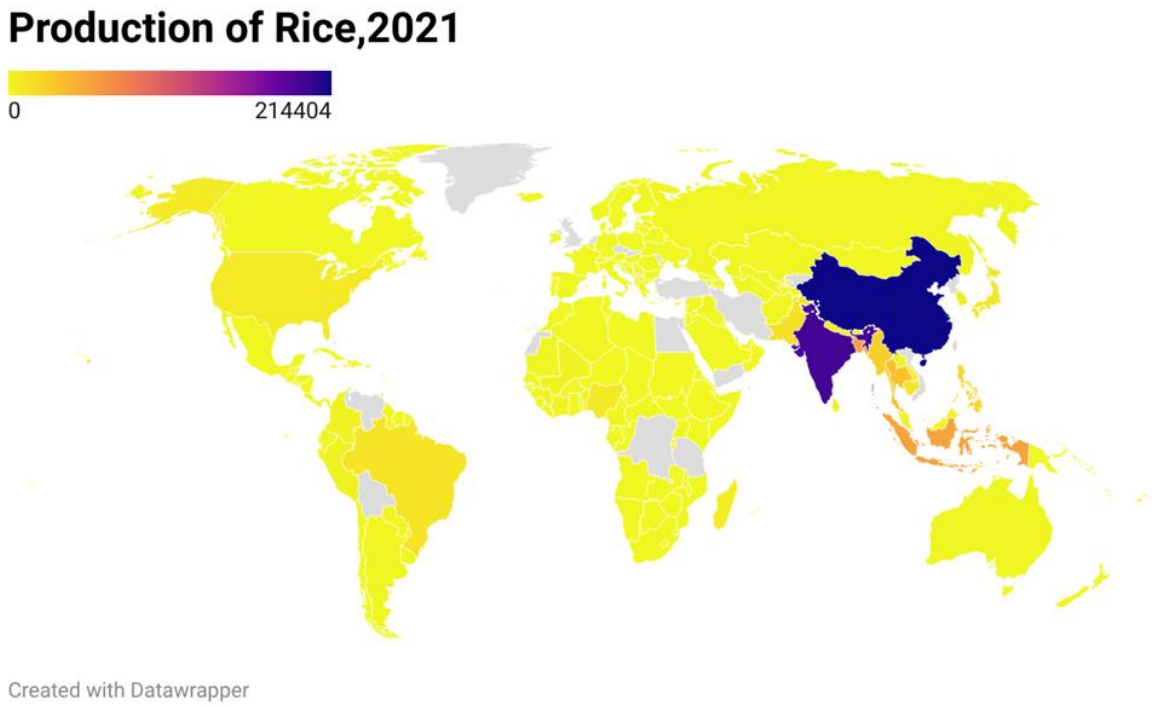

Figure 14. Map for production of rice worldwide

Keywords Used in Rice-Related Publication

The keywords provided in a particular article describe the main study subjects. Thus, studying the keywords in scientific publications enables the identification of research trends in a certain topic. Figure 15 illustrates a word cloud generated from the keywords discovered in multiple databases for the rice-related articles examined in this work. The shape of the word cloud demonstrates that rice is the world's second most important crop. As expected, the most often used phrase in rice papers is "*Oryza sativa L.*", the scientific classification for rice, the most significant rice crop species.

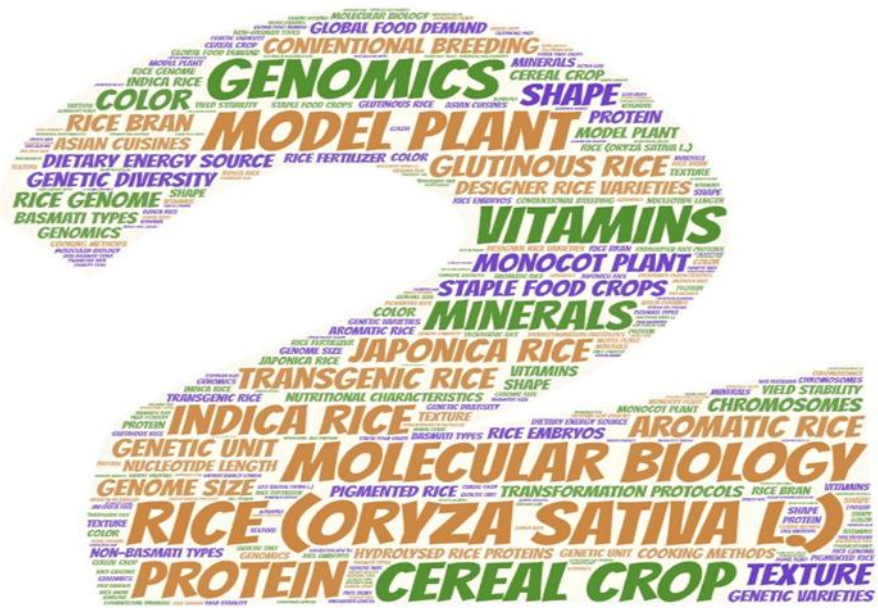

Figure 15. Word cloud based on the main keywords related to rice, second most cultivated crop

However, the phrases "rice bran", "pigmented rice", "indica rice", "japonica rice", "aromatic rice", and "glutinous rice" appear often in rice-related writings. "Genetics" appears to be the most relevant scientific subject, emphasizing the importance of heredity and plant characteristic variation in agricultural research. "Transgenic rice" is another major discipline that may reflect the many challenges in rice farming, offering potential solutions to improve crop productivity, nutritional content, and resilience to environmental pressures. However, its execution is subject to stringent requirements to ensure agricultural safety, sustainability, and ethical standards.

When the plant species keywords were metricized, the results indicated that rice records had a wider range of plant species. Rice is largely associated with other "cereals," such as "maize," "barley," "wheat," "oats," "millet," etc. (Figure 16a), but rice is also associated with several model species, including "*Arabidopsis thaliana*," "*Brachypodium distachyon*," and "*Oryza sativa*." (Fig. 16b). Rice is associated with a variety of terms related to human nutrition and health, including "diet," "gluten," "glucose," "dietary fibre," "protein," "fats," "minerals," "antioxidants," "rice bran," and so on (Figure 16c). These data demonstrate that rice farming is primarily intended for human consumption.

Figure 16. Word cloud based on the main keywords related to cereals (a), model plants (b) and human (c) in rice research documents

Patent In Rice Research Domain

The sheer volume of documents released on a certain research topic demonstrates its scientific importance. In contrast, patent metrics allow for evaluating industry interest in a certain topic. The number of patents for rice has followed a similar trend (Figure 17).

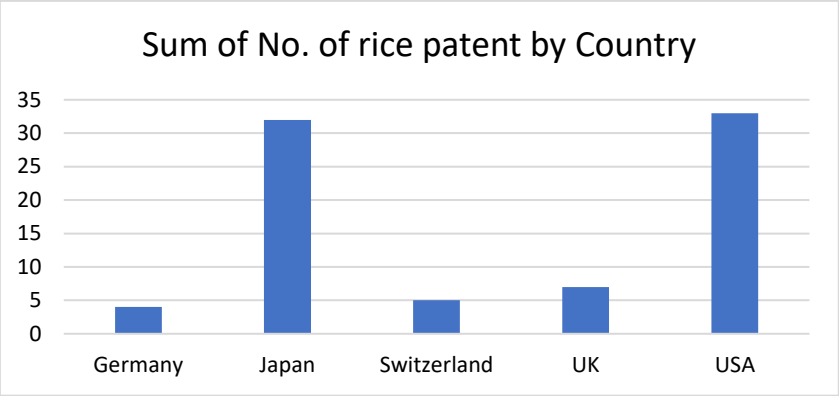

Figure 17. Patent trends in rice research domains

The data depict the distribution of rice-related patents across various nations, with the United States and Japan having far more than the other countries listed. This shows that, although the scientific community continues to focus on rice, industrial interest in rice has risen dramatically.

All the data recovered for this study was processed using hand identification, sorting, and deduplication methods. After the superfluous documents were eliminated, the gathered papers were loaded into the excel sheet for analysis. The literature measuring indicators in this study comprised the number of records, either research or review articles in different databases, categorization by language and subjects, keywords, research hot areas, etc. Rice is among the most extensively farmed crops, serving as the primary diet for more than half of the global population. However, rice, a crucial crop for food security, plays an important role in alleviating the strain on the food demand resulting from population expansion and sustaining social stability [24, 25]. Thus, real-time monitoring of rice growth and sustainable rice production management provides significant scientific value. Historically, rice acreage and production information was derived from field surveys, which were time-consuming, expensive, labour intensive and challenging for large-scale monitoring. As research and technology advance, remote sensing, characterized by extensive coverage and dynamic tracking, has increasingly been applied in agriculture [23]. Bibliometric analysis possesses robust quantitative capabilities, characterized by elements of computer science, mathematics, and statistics, hence offering a thorough and systematic statistical evaluation of publications. Bibliometric analysis not only intuitively illustrates the developments of research institutions, scholars, and research teams but also delineates significant research themes and developing hotspots, aiding readers in deepening their comprehension of a certain topic [26,27]. Bibliometric analysis has been extensively utilized in the scientific and social sciences [28]. Similar investigations have been undertaken in rice research, including rice genome [29], rice diseases [30], rice salt stress [31], rice intercropping [32], rice and climate change [21], rice physiology [33], rice farming [34], rice and greenhouse gases [35] and so on. Similarly, to assess the present research state in rice remote sensing, a bibliometric analysis was conducted using 2680 publications published between 1980 and 2021 from the core collection of the Web of Science database [23,36].

CONCLUSION

A complete bibliometric study is used to investigate historical and present trends in rice research, exposing the evolution of scientific contributions across several platforms and languages. According to the report, rice research encompasses various fields, including agriculture, biology, environmental science, engineering, and medicine. This demonstrates that researching rice requires an interdisciplinary approach. Rice research is extremely significant, as seen by the numerous publications, including research papers, book chapters, review articles, conference proceedings, and journals. These papers are critical for communicating research findings. The worldwide trade patterns of cereals, particularly wheat, maize, and rice, demonstrate the commodities' importance in the global market.

Furthermore, an examination of patents connected to rice highlights the industrial interest. Finally, rice's multidimensional character, from its genetic variety to its numerous uses in human health and industry, highlights its critical position in worldwide agriculture

and research. The expanding amount of papers and patents indicates a continued interest and investment in improving rice-related knowledge and applications, which provide answers to the issues of a growing global population.

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CONFLICT OF INTEREST

The writers have stated that they have no conflict of interests.

REFERENCES

1. Ehrlich PR, Ehrlich AH, Daily GC. Food security, population, and environment. *Popul Dev Rev*. 1993;19(1):1-32. doi:10.2307/2938383
2. Chen T, Shabala S, Niu Y, et al. Molecular mechanisms of salinity tolerance in rice. *Crop J*. 2021;9(3):506-520. doi:10.1016/j.cj.2021.03.005
3. Briefing B. Annalsbotany_90_427.Pdf. Published online 2002. doi:10.1093/mcf218
4. Koklu M, Cinar I, Taspinar YS. Classification of rice varieties with deep learning methods. *Comput Electron Agric*. 2021;187(June):106285. doi:10.1016/j.compag.2021.106285
5. Ye X, Beyer P. Engineering the provitamin A (β-carotene) biosynthetic pathway into (carotenoid-free) rice endosperm. *Science (80-)*. 2000;287(5451):303-305. doi:10.1126/science.287.5451.303
6. Sharif MK, Butt MS, Anjum FM, Khan SH. Rice Bran: A Novel Functional Ingredient. *Crit Rev Food Sci Nutr*. 2014;54(6):807-816. doi:10.1080/10408398.2011.608586
7. Deng GF, Xu XR, Zhang Y, Li D, Gan RY, Li H Bin. Phenolic Compounds and Bioactivities of Pigmented Rice. *Crit Rev Food Sci Nutr*. 2013;53(3):296-306. doi:10.1080/10408398.2010.529624
8. Amagliani L, O'Regan J, Kelly AL, O'Mahony JA. The composition, extraction, functionality and applications of rice proteins: A review. *Trends Food Sci Technol*. 2017;64:1-12. doi:10.1016/j.tifs.2017.01.008
9. Burlando B, Cornara L. Therapeutic properties of rice constituents and derivatives (Oryza sativa L.): A review update. *Trends Food Sci Technol*. 2014;40(1):82-98. doi:10.1016/j.tifs.2014.08.002
10. Wu P, Shou H, Xu G, Lian X. Improvement of phosphorus efficiency in rice on the basis of understanding phosphate signaling and homeostasis. *Curr Opin Plant Biol*. 2013;16(2):205-212. doi:10.1016/j.pbi.2013.03.002
11. Kathuria H, Giri J, Tyagi H, Tyagi AK. Advances in transgenic rice biotechnology. *CRC Crit Rev Plant Sci*. 2007;26(2):65-103. doi:10.1080/07352680701252809
12. Masuda H, Suzuki M, Morikawa KC, et al. Increase in Iron and zinc concentrations in rice grains via the introduction of barley genes involved in phytosiderophore synthesis. *Rice*. 2008;1(1):100-108. doi:10.1007/s12284-008-9007-6
13. Krishnan HB, White JA. Protein body formation and immunocytochemical localization of globulins and glutelins in developing rice (Oryza sativa L.) Embryos. *Crop Sci*. 1997;37(3):932-939. doi:10.2135/cropsci1997.0011183X003700030038x
14. Boorboori MR, Gao Y, Wang H, Fang C. Usage of si, p, se, and ca decrease arsenic concentration/toxicity in rice, a review. *Appl Sci*. 2021;11(17). doi:10.3390/app11178090
15. Khush GS. What it will take to Feed 5.0 Billion Rice consumers in 2030. *Plant Mol Biol*. 2005;59(1):1-6. doi:10.1007/s11103-005-2159-5
16. Peng S, Tang Q, Zou Y. Current status and challenges of rice production in China. *Plant Prod Sci*. 2009;12(1):3-8. doi:10.1626/pps.12.3
17. Bautista RC, Counce PA. An Overview of Rice and Rice Quality. *Cereal Foods World*. 2020;65(5). doi:10.1094/cfw-65-5-0052
18. Khush GS. Strategies for increasing the yield potential of cereals: Case of rice as an example. *Plant Breed*. 2013;132(5):433-436. doi:10.1111/pbr.1991
19. Santillán A, Vargas-Díaz AA, Flota- Bañuelos C, Fraire-Cordero S, Rosales-Martínez V, Bautista-Ortega J. Bibliometric analysis of scientific research about agroecological strategies. *Agro*

Product. Published online 2023:77-84. doi:10.32854/agrop.v16i8.2438
20. Rojas-Sola JI, Aguilera-García ÁI. Global bibliometric analysis of the mining & mineral processing subject category from the web of science (1997-2012). *Miner Process Extr Metall Rev*. 2015;36(6):349-369. doi:10.1080/08827508.2015.1019068
21. Yuan BZ, Sun J. Bibliometric analysis of rice and climate change publications based on Web of Science. *Theor Appl Climatol*. Published online 2022. doi:10.1007/s00704-022-04169-3
22. Sun J, Yuan BZ. A bibliometric analysis of research on rice and irrigation from the "Agronomy" category based on the Web of Science. *Curr Sci*. Published online 2020. doi:10.18520/cs/v119/i3/438-446
23. Xu T, Wang F, Yi Q, Xie L, Yao X. A Bibliometric and Visualized Analysis of Research Progress and Trends in Rice Remote Sensing over the Past 42 Years (1980–2021). *Remote Sens*. Published online 2022. doi:10.3390/rs14153607
24. Food W. *World Food and Agriculture – Statistical Pocketbook 2023*.; 2023. doi:10.4060/cc8165en
25. Matsumura KI, Hijmans RJ, Chemin Y, et al. Mapping the global supply and demand structure of rice. *Sustain Sci*. Published online 2009. doi:10.1007/s11625-009-0077-1
26. Zhang Y, Chen Y. Research trends and areas of focus on the Chinese Loess Plateau: A bibliometric analysis during 1991–2018. *Catena*. Published online 2020. doi:10.1016/j.catena.2020.104798
27. Zhong S, Geng Y, Liu W, Gao C, Chen W. A bibliometric review on natural resource accounting during 1995–2014. *J Clean Prod*. Published online 2016. doi:10.1016/j.jclepro.2016.08.039
28. Ye N, Kueh TB, Hou L, Liu Y, Yu H. A bibliometric analysis of corporate social responsibility in sustainable development. *J Clean Prod*. Published online 2020. doi:10.1016/j.jclepro.2020.122679
29. Liu B, Zhang L, Wang X. Scientometric profile of global rice research during 1985-2014. *Curr Sci*. Published online 2017. doi:10.18520/cs/v112/i05/1003-1011
30. Ashfaq MY, Da'na DA, Al-Ghouti MA. Application of MALDI-TOF MS for identification of environmental bacteria: A review. *J Environ Manage*. Published online 2022. doi:10.1016/j.jenvman.2021.114359
31. Zhang R, Hussain S, Yang S, et al. Research on Salt Stress in Rice from 2000 to 2021: A Bibliometric Analysis. *Sustain*. Published online 2023. doi:10.3390/su15054512
32. Shahidullah SM, Shirazy BJ, Rouf Sarkar MA, Quais MK. Four decades of research on rice intercropping: A bibliometric analysis. *J Agric Food Res*. Published online 2024. doi:10.1016/j.jafr.2024.100964
33. PENG S bing. Booming research on rice physiology and management in China: A bibliometric analysis based on three major agronomic journals. *J Integr Agric*. Published online 2017. doi:10.1016/S2095-3119(17)61804-5
34. Ali NIM, Aiyub K, Lam KC, Abas A. A bibliometric review on the inter-connection between climate change and rice farming. *Environ Sci Pollut Res*. Published online 2022. doi:10.1007/s11356-022-18880-1
35. Yuan BZ, Sun J. Research trend of rice and greenhouse gases based on Web of Science: a bibliometric analysis. *All Earth*. Published online 2023. doi:10.1080/27669645.2022.2164412
36. Li T, Cui L, Xu Z, et al. Quantitative analysis of the research trends and areas in grassland remote sensing: A scientometrics analysis of web of science from 1980 to 2020. *Remote Sens*. Published online 2021. doi:10.3390/rs13071279