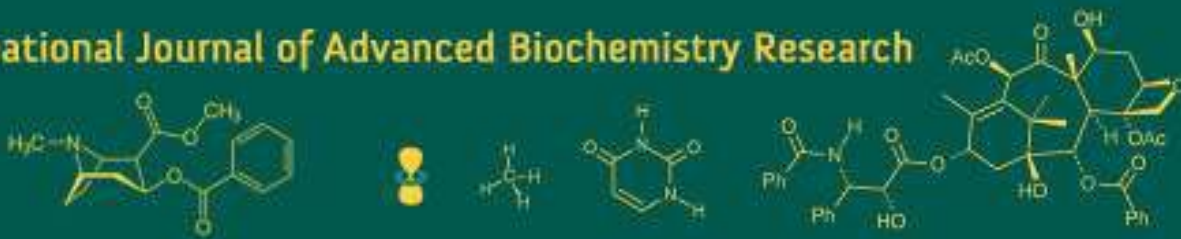


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
 ISSN Online: 2617-4707
 NAAS Rating (2025): 5.29
 IJABR 2025; SP-9(12): 1703-1710
www.biochemjournal.com
 Received: 03-10-2025
 Accepted: 07-11-2025

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Global research trends in finger millet (*Eleusine coracana* L.) research: A scopus-based bibliometric analysis

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DOI: <https://www.doi.org/10.33545/26174693.2025.v9.i12St.7125>

Abstract

Finger millet (*Eleusine coracana* L.), a climate-resilient cereal crop is vital for food and nutritional security in arid and semi-arid regions of Africa and Asia. In recent years, the sustainability of agriculture and climate change situations have caused further developments regarding this underutilized crop and the scientific interest to go on. The current research is based on a comprehensive bibliometric assessment of the global research trends in finger millet research which progressed through the Scopus database and the period from 1990 to 2024. The systematic search strategy was deployed to extract relevant publications, and a total of 2,412 documents including research articles, review papers, and conference proceedings were analyzed by means of standard bibliometric indicators. Research output has shown to grow steadily and consistently over the last thirty years, with a dramatic upsurge post-2010 which indicates that the world is gradually paying more attention to finger millet. Publications comprising mainly of research articles have been the stronghold of the domain reflecting the dominance of original research in this area. On the basis of country analysis, India was identified as the chief contributor, with the US and some African countries following, which indicated both the regions of the crop's traditional cultivation and the cross-over of growing global importance. The majority of the contributions came from agricultural faculties and national research institutes. When the research landscape covered by subject areas was analyzed, it was found that the agricultural and biological sciences once more occupied the dominant position with the help of biochemistry, genetics, and molecular biology contributing to the trend of shifting toward the molecular studies for improving nutrition rather than the traditional methods.

Keywords: Finger millet, *Eleusine coracana*, research, bibliometric analysis, climate resilient crop

Introduction

Finger millet (*Eleusine coracana* L.) is a major and extensively grown small millet in the semi-arid and rainfed regions of Asia and Africa with India being the major (Upadhyaya *et al.*, 2006; Gupta *et al.*, 2017) ^[20, 15] producer and consumer. It is the most important among the pulses mainly due to its great mineral and vitamin content, especially the high calcium, iron, fiber, and amino acids, thus, making it an integral part of the human diet and consequently, one of the major contributors to food and nutrition security of the underprivileged populations (Saleh *et al.*, 2013; Devi *et al.*, 2014; Chandra *et al.*, 2016) ^[19, 10, 9]. Furthermore, finger millet is extremely tolerant to drought, poor soil fertility, and marginal growing conditions, thus, it can significantly contribute to the development of sustainable and climate-resilient agricultural systems (Dida *et al.*, 2007) ^[11]. Concerns about climate change, land degradation, and malnutrition have sparked worldwide interest in the past and current use of resilient crops such as finger millet (Padulosi *et al.*, 2015; FAO, 2018) ^[16, 13]. Consequently, the research on finger millet has been considerably widened to cover a variety of topics like genetic enhancement, cultivation, tolerating abiotic and biotic stress, improving nutrition, and food technology (Ceasar *et al.*, 2018; Goron and Raizada, 2015) ^[18, 14]. A systematic appraisal of the scientific literature on finger millet has not yet occurred despite the abundant scientific literature.

Bibliometric analysis is a method that provides the ability carry out the quantitative assessment of research by using the statistical and mathematical approaches to characterize

the publications, authorship, alliances, and thematic trends in research area (Pritchard, 1969; Broadus, 1987; Donthu *et al.*, 2021) [18, 6, 12]. The availability of comprehensive and high-quality bibliographic records through databases like Scopus allows for a thorough appraisal of research at both global and regional levels, i.e., showing the connectivity of ideas across different scales (Bergman, 2012; Aghaei Chadeganet *et al.*, 2013; Afgan and Bing, 2021) [4, 1, 3]. In such a situation, the present study is aimed at investigating the global research trends in finger millet (*Eleusine coracana* L.) based on Scopus data and its bibliometric implications. The research covers areas such as the growth of publications, the types of documents, the main journals, the authors collaborating the most, the institutions, and the countries contributing the most, and the prevailing research themes. This analysis points out the progress of finger millet research and the identification of areas where future research and policy interventions for sustainable agriculture can take place.

Materials and Methods: The bibliometric data for the present study were retrieved from the Scopus database, which is recognized as one of the largest and most reliable abstract and citation databases covering peer-reviewed literature across scientific disciplines. Data were retrieved from the Scopus database using the search query: TITLE-ABS-KEY ("Finger millet" OR "Ragi" OR "Eleusine

coracana"). The search was conducted in June 2025 covering publications from 1990 to 2024. In total, two thousand six hundred and sixty eight (n=2,668) articles were found during the first phase of the search. Further screening was done by limiting the selection to include articles, reviews and conference papers n=2456. Then selection is limited to papers written in English language resulting in n = 2417 papers. After refinement, the final study database is comprised of 2412 research publications

3. Results and Discussion

3.1 Classification of documents

Figure 1 shows the breakdown of the publications into different document types. Research articles made up nearly 92% (2219) of the total publications, which indicates that the research conducted on finger millet is mainly based on original experimental and analytical studies. Review articles made up around 5-6% (135) of the total output, which means that there is consistently coming through the literature the periodic synthesis and consolidation of the advancements in the research field. Conference papers accounted for a smaller share around 2-3% (58), thus implying that there is a limited but upcoming dissemination of the research on finger millet through the conference platforms. The same pattern of publication has been reported in other similar agricultural bibliometric studies (Price, 1963; Donthu *et al.*, 2021) [17, 12].

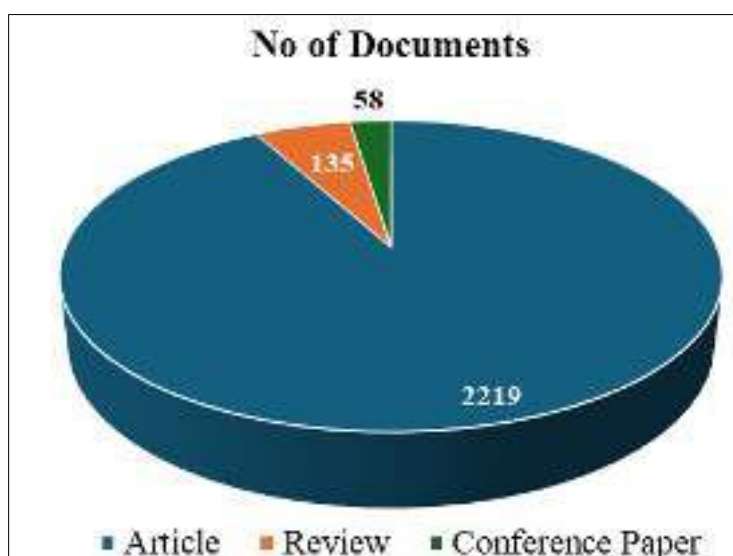


Fig 1: Classification of documents during the period of 1990-2024 based on document Type

3.2 Year-wise Growth of Publications

The year-wise increase in the number of scientific publications on the research of finger millet (*Eleusine coracana* L.) from 1990 to 2024 can be seen in the graph Figure 2. The output of research during the period of the study was increasing and it was steadily progressive, which is an indication of the growing worldwide interest in this particular crop. Initially (1990-2000), publications were very few, and the figure fluctuated from 13 to 30 documents per year. This era demonstrates scarce scientific interest, and the gradual growing pattern indicates that little finger millet was noticed or the crop was even neglected. The first decade of the 21st century saw a slow but steady rise in publication output. This period corresponds to the start of the acknowledgment of millets as resilient crops that can be grown in rainfed and harsh environments.

It is more likely that the scientific fields of crop enhancement, stable yields, and nutrition were the main drivers of this upward trend. Starting from 2011, on the whole, there was a very clear and sudden boost in research output, especially after 2016. The number of publications more than doubled, and a peak was reached in 2024. One of the main reasons for this rapid growth is increased global concern over the adaptation to climate change, climate-smart agriculture, food and nutrition security, and editing of cereal systems (Bornmann and Mutz, 2015; Varshney *et al.*, 2017) [5, 21]. Besides, policy support for millets in India and the development of technologies like molecular breeding, genomics, and value addition have been big contributors to research activity. The unprecedented rise in recent years serves as a marker for the transition of finger millet from an underutilized crop to one that is strategically significant for sustainable agriculture.

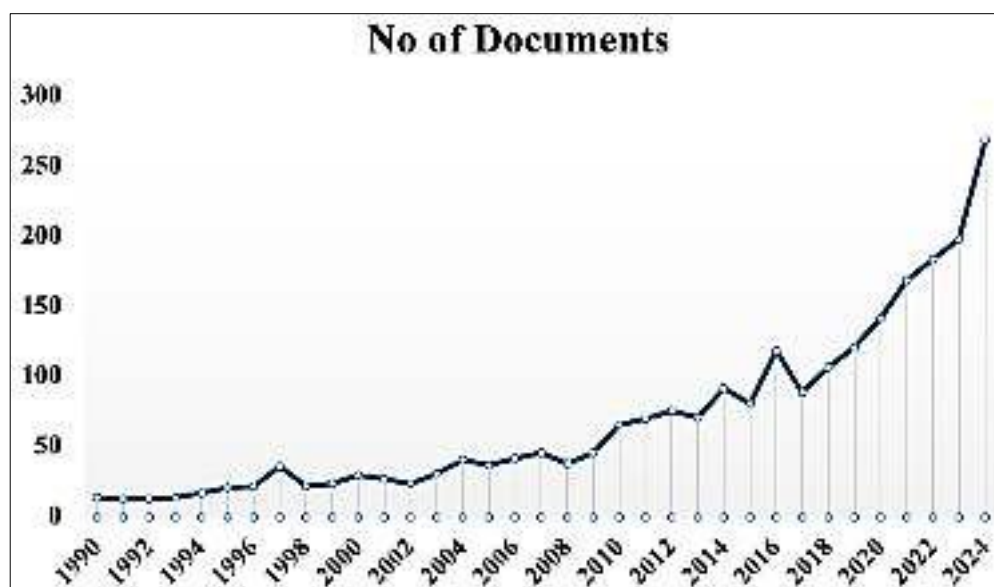


Fig 2: Year-wise growth of publications on finger millet (*Eleusine coracana* L.) research from 1990 to 2024.

3.3 Performance of Authors

The contribution of the most productive authors in the field of research on finger millet (*Eleusine coracana* L.) is shown in Figure 3. Among the leading authors, Kumar, A. came forth as the most prolific researcher with 63 publications which reflect the continuous and wide-ranging participation in researching finger millet. His research was mainly on crop improvement, genetics, and related areas thereby contributing significantly to the advancement of knowledge in this field. Among the most significant contributors are Malleshi, N.G. (34 documents) and Sood, S. (32 documents), who have greatly impacted research in nutrition, processing, and agriculture related to finger millet. Unproductive authors like Muralikrishna, G. (28 documents) and Ceasar, S.A. (20 documents) have their domain

specialties limited to molecular biology, stress tolerance, and value addition. Others, like Ignacimuthu, S., Bhatta, R., Chandra, T.S., Sunil, C.K. and Upadhyaya, H.D., corresponding between 14 and 17, have allied with research on germplasm conservation, crop diversity, and sustainable agriculture.

The noticed publication distribution hints a core group of researchers being responsible for the driving force of finger millet research, who are backed up by a wider net of contributors. A similar concentration of research output can be seen in other specific crop research areas and it illustrates the need for continue institutional support and collaborative networks. In a nutshell, the presence of highly productive authors is a sign of finger millet research having reached maturity and increased scientific depth globally.

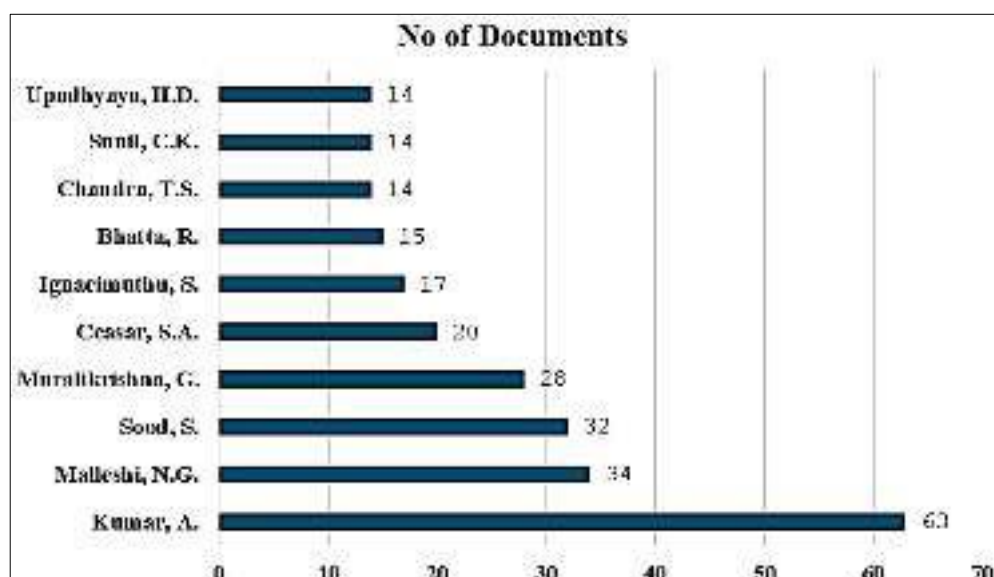


Fig 3: Most prolific authors contributing to finger millet (*Eleusine coracana* L.) research based on Scopus data

3.4 Country-wise Distribution of Publications

India was the foremost contributor with 1711 publications taking a lion's share of the worldwide research output (Table 1). This very much is the case since India is the main center of growing, eating, and producing the most diverse types of finger millet genetically. The strong research output is a sign

of national agricultural research systems, universities, and international collaborations focusing on crop improvement, nutrition, climate resilience, and value addition investing over a long period of time. The United States came second with 175 publications, even though finger millet is not a major crop in the country. The present work is mostly a

result of collaboration between millet-growing countries in nutrition, food science, genomics, and global food security. Ethiopia (90 documents) and Kenya (89 documents) are listed as the third and fourth most productive countries, respectively, which indicates the significance of finger millet in the diet of East Africa and the capacity of the region in agronomy and crop adaptation research is growing. The increasing involvement of African nations points to the escalating acknowledgment of finger millet in food security and climate change adaptation tactics (FAO, 2018) [13].

The United Kingdom (79 documents) and Japan (77 documents) were also leading to the forefront, mainly by their excellent research in plant science, food technology, and biotechnology accompanied by strong global partnerships. The contributions from South Africa, China, Canada, and Germany are also indicative of the growing global interest in finger millet, particularly in terms of climate-smart agriculture and functional foods. The analysis of countries clearly shows that the millet research is predominantly supported by those countries that have direct agricultural and nutritional relevance with this crop, while the research-intensive nations provide advanced scientific methods. The strengthening of South-South and North-South collaborations could further magnify the global impact of research and facilitate the development of better finger millet varieties for sustainable agriculture.

Table 1: Country-wise distribution of publications on finger millet (*Eleusine coracana* L.) research based on Scopus data.

S. No	Country	No of Documents
1	India	1711
2	United States	175
3	Ethiopia	90
4	Kenya	89
5	United Kingdom	79
6	Japan	77
7	South Africa	60
8	China	57
9	Canada	53
10	Germany	50

3.5 Institution-wise Contribution to Finger Millet Research: In Table 2, the institutions leading the way in releasing the results of finger millet (*Eleusine coracana* L.) research are listed. The results point out the indispensable

participation of the agricultural universities and research institutes of the nations in the area of finger millet research, that the whole world can take advantage of. University of Agricultural Sciences, Bangalore has been the most prolific educational institute with a total of 163 publications, which corroborates its research-centricity in millet breeding, agronomy, and crop improvement. The impressive figure also serves the purpose of ensuring the status of research institutions that are located in the primary millet growing areas. The second most productive was the Central Food Technological Research Institute (CFTRI), India, generating 126 publications thus indicating the necessity of the contributions of food scientists and nutritionists in such areas as value addition, processing, and functional food of finger millet.

Govind Ballabh Pant University of Agriculture and Technology (118 publications) and the Indian Council of Agricultural Research (111 publications) are other organizations which yield a considerable amount of research output and thus prove the active involvement of academic institutions and the national agricultural research systems in areas like a finger millet plant breeding and its use in various forms. Research output from Tamil Nadu Agricultural University (95 publications) emphasizes the importance of finger millet in Southern India and the engagement of state agricultural universities in generating applied research. The coming of ICRISAT, International Crops Research Institute for the Semi-Arid Tropics among the top contributors, signifies its mandate of breeding climate-resilient crops for dryland farming. Contributions by ICAR-Indian Agricultural Research Institute (IARI), New Delhi, and ICAR-National Institute of Animal Nutrition and Physiology, Bengaluru, are suggestive of interdisciplinary studies that are dealing with the genetics of the crops, nutrition, and livestock feed applications.

Outside of India, Addis Ababa University is the African representative in the finger millet research, pointing out the crop's role in the different aspects of Ethiopia's agricultural and food security thus supporting scientific collaborations in the millet growing areas (Wagner and Leydesdorff, 2005; Adams, 2013) [22, 2]. Moreover, the institution-wise variation shows that research on finger millet is mainly supported by public-sector research institutions, revealing their indispensable position in fostering eco-friendly and climate-smart farming practices.

Table 2: Leading institutions contributing to finger millet (*Eleusine coracana* L.) research based on Scopus data.

Institutions	No of Documents
University of Agricultural Sciences, Bangalore	163
Central Food Technological Research Institute India	126
Govind Ballabh Pant University of Agriculture and Technology	118
Indian Council of Agricultural Research	111
Tamil Nadu Agricultural University	95
International Crops Research Institute for the Semi-Arid Tropics	65
ICAR - Indian Agricultural Research Institute, New Delhi	51
ICAR - National Institute of Animal Nutrition and Physiology, Bengaluru	46
Acharya N.G. Ranga Agricultural University	39
Addis Ababa University	31

3.6 Subject Area-wise Distribution of Publications

The way the research on finger millet (*Eleusine coracana* L.) is distributed among various subjects is given in Table 3. The result shows a very high disciplinary concentration with the contributions coming from agricultural sciences, life

sciences, environmental studies, and other allied interdisciplinary domains. The area of Agricultural and Biological Sciences produced the largest number of research output with 1643 publications, which is also the largest share of all the documents. The Research done in areas of

crop improvement, agronomy, breeding, stress physiology, and management practices has reflected the stronghold of the research on finger millet. The enhancement of this field of study points to the crop being a major player in sustainable agriculture and food security.

The second most important area in the subject was the Biochemistry, Genetics, and Molecular Biology with 601 documents. The molecular tools, genetic analysis, genomics, and biotechnology among others have all been used to a large extent in the research of finger millet as revealed by the big contribution. The studies on nutritional genomics, mechanisms of stress tolerance, and molecular breeding strategies have been the main reasons for the considerable growth of research in this area. Environmental Science with 249 documents was the third area producing the most and that confirms the rising interest in finger millet being a crop resilient to climate hence perfect for poor and stressed soils. A great deal of the work in Chemistry (210 documents) and Chemical Engineering (135 documents) has dealt with grain quality analysis, bioactive compounds, food processing, and value addition.

Among the other fields, Medicine (188 documents) and Immunology and Microbiology (157 documents) are the areas where the increased acknowledgment of finger millet's health benefits, like its involvement in the treatment of lifestyle disorders, maintenance of good digestive health, and development of functional foods, is being reflected the most. Furthermore, the mention of Engineering, Social Sciences and Multidisciplinary research indicates a gradual transition to holistic and system-based methods that comprise technology adoption, socio-economic studies, and policy dialogues. Subject-wise assessment, in general, has shown that the research on finger millet has gradually shifted from a mainly agronomic aspect to a multidisciplinary area comprising genetics, nutrition, environmental sustainability, and human health which eventually reaffirms its role in the development of climate-smart and sustainable agriculture. The consistent expansion of molecular and genomic studies demonstrates the progress made in the area of crop improvement and biofortification research (Dida *et al.*, 2007; Ceasar *et al.*, 2018; Varshney *et al.*, 2017) [11, 8, 21].

Table 3: Subject area-wise distribution of publications on finger millet (*Eleusine coracana* L.) research based on Scopus data.

Subject area	No. of Documents
Agricultural and Biological Sciences	1643
Biochemistry, Genetics and Molecular Biology	601
Environmental Science	249
Chemistry	210
Medicine	188
Immunology and Microbiology	157
Chemical Engineering	135
Engineering	123
Social Sciences	103
Multidisciplinary	92
Other	78

3.7 Source-wise Distribution of Publications

The leading journals where finger millet (*Eleusine coracana* L.) research is published are listed in Table 4. The findings suggest that research on finger millet is published in a wide variety of journals which cuts across agricultural, food science, plant breeding and interdisciplinary fields. The Journal of Food Science and Technology was the leading source of research (86 publications) which indicates the great interest in finger millet's nutritional quality, food processing, value addition, and development of functional

foods. The above findings suggest that the health-promoting and nutraceutical aspects of millet are becoming more and more popular. The second position was taken by Food Chemistry which had 36 publications, and it also helped to draw attention to the importance of the composition, bioactive compounds, antioxidant properties, and nutritional profile of finger millet. The hierarchy of the food science journals among the main sources shows that research on finger millet has moved from crop production to human health through the use of the crop traits.

Table 4: Leading journals publishing research on finger millet (*Eleusine coracana* L.) based on Scopus data.

Source	No. of Articles
Journal of Food Science and Technology	86
Food Chemistry	36
Indian Journal of Agronomy	35
Electronic Journal of Plant Breeding	30
Indian Journal of Agricultural Sciences	27
Frontiers in Plant Science	26
Indian Journal of Animal Sciences	26
Lwt	24
Plos One	23
Journal of Agricultural and Food Chemistry	20

The Indian Journal of Agronomy (35 documents), Indian Journal of Agricultural Sciences (27 documents), and the Electronic Journal of Plant Breeding (30 documents) are among the agriculture-focused journals that bring to light the continuous and lasting research efforts in the areas of

crop improvement, agronomic practices, and varietal development. Such journals are essential for the distribution of applied research and farming methods that are specific to millets and their regions of growth. International and interdisciplinary journals like Frontiers in Plant Science (26

publications) and PLOS ONE (23 publications) are some of the reflections of the ever-increasing global visibility of finger millet research. Studies published in these journals are primarily concerned with molecular biology, stress physiology, genomics, and systems-level analyses. On the other side, LWT (24 documents) and the Journal of Agricultural and Food Chemistry (20 documents) indicate the increasing interest in food quality, processing methods, and biochemical characterization.

3.8 Keyword Frequency and Research Focus

A keyword analysis offers a comprehensive view of the main research themes, areas of focus, and the conceptual framework of the scientific literature. The most frequently used keywords in the study of finger millet (*Eleusine coracana* L.) are presented in Table 6. The most frequently used keyword "Finger millet" occurred 842 times, followed by "Eleusine coracana" with 740 occurrences, which are almost the same. This implies the publications had both the common and scientific names appearing simultaneously. It also indicates that there was a common ground in the identification of the crop which consequently led to the consistency in subject matter of literature. The mention of related terms such as "Finger millets" and "Millet" even more confirms that research on this crop is in the core of the millets research area.

The occurrences "Eleusine" (370) and "Eleusine coracana subsp. coracana" (155) indicate that taxonomical and botanical studies are in the spotlight and point to the

ongoing interest in germplasm characterization, diversity analysis, and evolutionary aspects of finger millet. The high frequency of "India" (165 occurrences) again refers to India's leading role in the area of finger millet research, which is in agreement with the country-wise publication trends observed previously. Methodological and indexing terms like "Article" (467 occurrences), "Controlled study" (224 occurrences), and "Nonhuman" (332 occurrences) reflect the classification practices within the Scopus database. The terms suggest that a large proportion of the studies consist of experiments and research with no clinical implications, and that they are mainly devoted to plant studies rather than human trials.

The keyword frequency analysis in general indicates that the research of finger millet is mainly concentration on crop-based, experimental, and area-specific studies with strong focuses on taxonomy, cultivation, and applied agricultural research. The prevalence of crop- and location-specific terms, together with methodological descriptors, indicates that diversification of research themes is possible, especially in the areas of genomics, climate resilience, socio-economic analysis, and policy-oriented studies. Trending keywords concerning genomics, bioactive compounds, and climate resilience point to a gradual transition from conventional breeding to advanced breeding and functional food research (Callon *et al.*, 1991) [7]. The changing keyword pattern in this regard illustrates the gradual shifting of finger millet research from the original disciplinary boundary to becoming a globally relevant research area.

Table 5. The top ten keywords used in the study of finger millet

Keyword	Frequency
Finger Millet	842
Eleusine Coracana	740
Article	467
Eleusine	370
Nonhuman	332
Millet	267
Controlled Study	224
Finger Millets	184
India	165
Eleusine Coracana Subsp. Coracana	155

3.9 Emerging and Declining Research Themes

3.9.1 Emerging Research Themes

The bibliometric examination points out a number of new research areas in finger millet (*Eleusine coracana* L.) studies, the most impressive of which is the Genetics, Genomics and Molecular Breeding, where the impact of the area Biochemistry, Genetics and Molecular Biology has been quite large. The leading areas of study in the field have been genetic diversity analysis, marker-assisted selection, transcriptomics and researchers are working on stress-responsive genes to increase yield stability and resilience to changing climates.

The researchers have also pointed to another theme which is nutrition, functional foods, and health benefits as an emerging one. The extensive literature on food science journals such as Journal of Food Science and Technology, Food Chemistry, and LWT, plus the keywords that indicate biochemical and nutritional studies, show the increasing interest in the bioactive compounds, antioxidant properties, and the role of finger millet in tackling lifestyle-related disorders. The topics of climate resilience and environmental sustainability have also become more

important, which is also reflected by the growing contribution from Environmental Science. Research on drought tolerance, climate adaptation, low-input farming systems, and sustainable agriculture has placed finger millet as a climate-smart crop in less productive areas. Furthermore, value addition and food processing technologies are an emerging applied research area that is taking place because of the consumers' growing interest in millet-based products and the government's support for millets on a national and international scale.

3.9.2 Declining or Mature Research Themes

On the other hand, a few research themes seem to have grown already or are at least on the way downwards. Studies that relied on the traditional methods of basic agronomy, varietal evaluation, and conventional cultivation practices, which were the main focus during the early research phases (1990 - 2005), are now having slower growth when compared to other areas. However, these studies still have great importance; they have simply come to a point where there are no new questions to ask and no new approaches to apply in terms of methods. In the same way, descriptive

taxonomic and morphological studies, marked by earlier frequent use of generic botanical keywords, have lost their prominence with the adoption of molecular and genomic tools. Instead of being isolated research areas, these themes are increasingly incorporated into wider genetic and breeding frameworks.

4. Conclusion

The current Scopus-based bibliometric study has presented an extensive picture of the global research trends in finger millet (*Eleusine coracana* L.) from 1990 to 2024. The findings indicate a consistent and considerable rise in the amount of scientific output, especially after 2016, which is a sign of a revival of the global interest in finger millet as a climate-resilient and nutritionally rich crop. The prevalence of research articles shows that there was a strong focus on original experimental work, and the presence of review papers indicates that the knowledge in this field has been periodically consolidated. India was recognized as the foremost contributor in terms of publications, authors, and institutions, which indicates its crucial role in the areas of production, conservation, and research of finger millet. The significant contribution from African countries and those with intensive research are additional proofs of the increasing global significance of finger millet that is being acknowledged. The analyses that were conducted in terms of institutions and sources pointed out the essential participation of agrarian universities, national research institutions, and food science journals in releasing the research. The identification of the subject area and the keywords confirmed the multi-dimensionality of the research done on finger millet, which included agriculture, genetics, nutrition, environmental science, and human health.

The volume of research is increasing but, still, the future studies in this field should be concentrated on cutting-edge genomics, pre-breeding, and trait-based development strategies that would lead to yield stability and climate resilience. In total, this bibliometric analysis has revealed the scientific landscape of finger millet research that is changing and has provided a lot of information to researchers, policymakers, and funding agencies. The research, which is conducted in a way that it meets the goals of sustainability, nutrition, and climate adaptation, will further strengthen the position of finger millet in the development of resilient and sustainable agricultural systems.

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