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RESEARCH NOTE

Bibliometric profile of global research on millets

R. S. BHAT

Publication Centre, University of Agricultural Sciences,
Dharwad - 580 005, Karnataka, India
E-mail: bhatrs@uasd.in

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Abstract : To commemorate the International Year of the Millet (IYOM 2023), an effort was made to study the bibliometric profile of global research on millets. A total of 5315 references of journal articles were downloaded from PubMed (NLM) using the common name and the scientific name of nine prominent millets as the keywords appearing in the title. The number of publications steadily increased over the years with the highest rate of increase during 2010-20. Sorghum followed by pearl millet and foxtail millet received the highest number of publications. Overall, the USA, India and China produced 1287, 1192 and 886 articles, respectively. Interestingly, almost all studies on "Browntop millet","Barnyard millet","Little millet" and "Kodo millet" were concentrated in India. Among the different areas of research, "Stress", "Nutrition" and "Breeding" were pursued in 971, 819 and 741 studies, respectively. These studies indicate a great future scope to employ both conventional and innovative next-generation breeding methods on a large germplasm accession pool available worldwide to overcome the challenges emerging from climate change and malnutrition.

Key words: Bibliometric profile, India's position, Key research areas, Millets, Year-wise and journal-wise distribution

The year 2023 is declared as the international year of millets (IYOM 2023) by the United Nations General Assembly (UNGA) in its 75th session in March 2021. This recognition for millets is worth celebrating to promote the sustainable production of millets and highlight their potential to provide new sustainable market opportunities for producers and consumers, apart from raising the awareness of nutritional and health benefits of millets. IYOM 2023 is also expected to draw policy attention to their suitability for cultivation under adverse and changing climatic conditions.

Global research on millets has seen unprecedented progress over the years. Bibliometric analyses have been conducted in several fields such as plant agronomic features (Gallegos-Cedillo *et al.*, 2021), soil nutrient research (Pan *et al.*, 2021), plant-microbial fuel cells (Prasad and Kalla, 2021) and endangered plants (Xu *et al.*, 2022). They indicate various world-wide historical trends in millet research, which could be useful in drawing the roadmap for the promotion of cultivation and consumption of millets for better health, especially on the eve of IYOM 2023.

The bibliometrics data were collected from Pub Med (NLM) on 12 January 2023. "Foxtail millet" or "*Setaria italica*", "Finger millet" or "*Eleusine coracana*", "Barnyard millet" or "*Echinochloa esculenta*", "Browntop millet" or "*Urochloa ramose*", "Little millet" or "*Panicum sumatrense*", "Kodo millet" or "Koda millet" or "*Paspalum scrobiculatum*", "Pearl millet" or "*Pennisetum glaucum*", "Proso millet" or "*Panicum miliaceum*", and "Sorghum" or "*Sorghum bicolor*" were used as the keywords (case insensitive) in the title of the references to search and retrieve the literature (only journal references) from 1857 to 2023. Such references were stored in End Note X9. These records were analysed using the various packages and functions of R programming.

In total, 5315 journal article references were downloaded, and they were published between 1857 and 2023 (12 Jan 2023) for millets globally. In comparison, 40147, 33210, 20227 and 10487 articles were published on rice, wheat, maize and barley, respectively, indicating a greater scope for the research on millets. The number of publications increased over the years with the highest number of articles published during 2010-20 (2408). A similar trend was also observed in India where the highest number of articles were published during 2010-20 (635) (Fig. 1). Parallelly, the productivity of millets also increased during this period (Sathish Kumar *et al.*, 2022). Sorghum (3801) followed by pearl millet (634) and foxtail millet (424) received the highest number of publications globally (Fig. 2). Similar

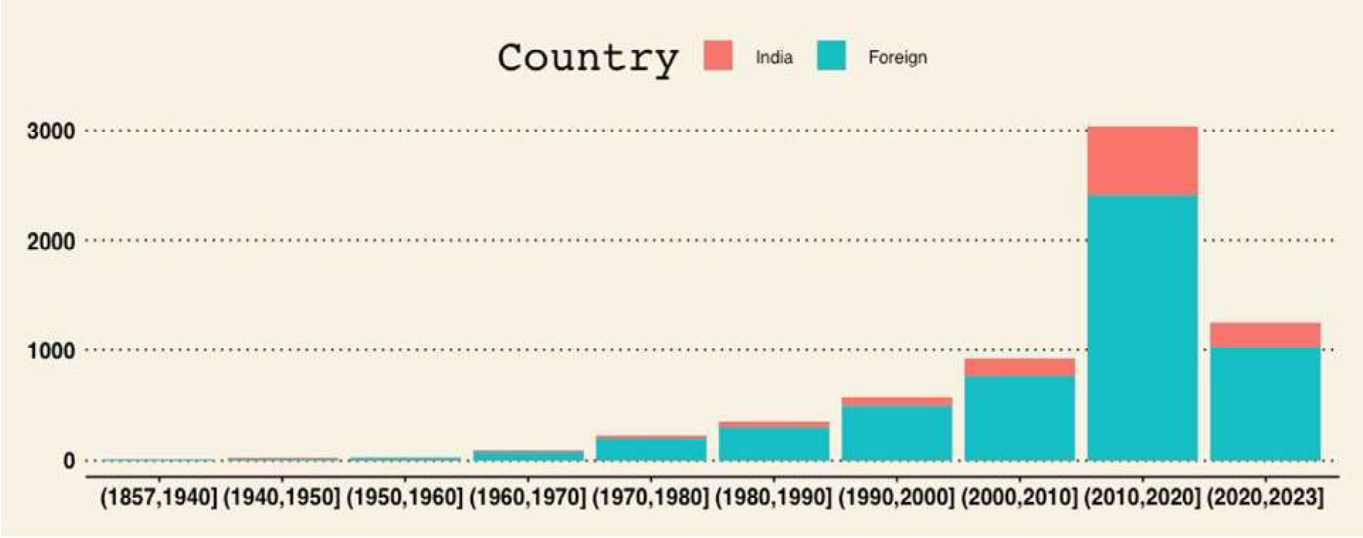

Fig 1. Research articles published on millets worldwide over the years

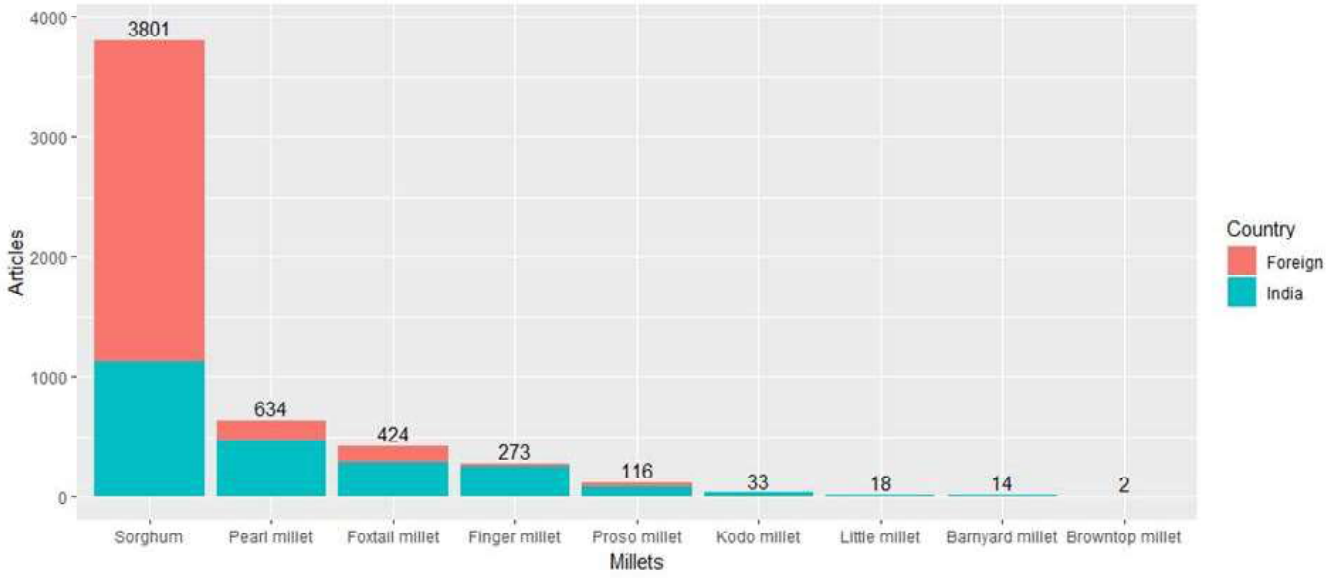

Fig 2. Research articles published on various millet crops worldwide

trend was also observed in India where sorghum (1130) followed by pearl millet (168) and foxtail millet (144) received the highest number of publications. These data indicate the future scope for research on other millets which might help expand area, production, productivity and market availability.

Overall, the USA, India and China produced 1287, 1192 and 886 articles, respectively (Fig. 3). Interestingly, all the articles on "Browntop millet","Barnyard millet","Little millet" and "Kodo millet" were connected to India either through affiliation or any other fields. Globally, the highest number of articles were published in Theoretical and Applied Genetics(234) followed by Frontiers in Plant Science (213) and Plant Physiology(163). From India, the highest number of articles were published in the Journal of Food Science and Technology (104) followed by Theoretical and Applied Genetics (73) and Frontiers in Plant Science (65). Journal of Food Science and Technology had an impact factor of 2.7 when compared to the impact factor of 4.4 for Theoretical and Applied Genetics.

Among the different areas of research, "Stress", "Nutrition" and "Breeding" were pursued in 971, 819 and 741 studies, respectively.Various biotic (Das and Padmaja, 2016) and abiotic (Saleem *et al.*, 2021) stresses are known to adversely affect the productivity of millets, and efforts are in progress to manage the stresses. Surprisingly, only three articles had "value addition" in the keywords, which indicates a large scope for the research on this area.

Considerable efforts are in progress on breeding (Sumit and Wali, 2016), crop management (Manjunath and Salakinkop, 2017), processing (Patil *et al.*, 2018), value addition (Kulkarni and Naik, 2000) *etc* in millets. With 395 studies connected to genomics, it appears that innovative breeding methods can be initiated in millets. Genome-editing was reported from sorghum and foxtail millet. As high as 47 articles reported the cloning and expression of candidate genes from millets in rice, Arabidopsis, tobacco etc to confer tolerance to abiotic stresses. The paper "International Year of Millets 2023: The article "Opportunity for Enhancing the Use of Indian Millets Germplasm" by Elangovan *et al.* (2022) reported the conservation of almost one lakh accessions of millets germplasm in India. They can be of great use in identifying and developing improved millet cultivars, which can offer a great opportunity to overcome the challenges such as climate change and malnutrition owing to their climate resilience and high nutritional value. Both conventional and genomics-assisted innovative breeding methods can be employed as they have advanced in millets.

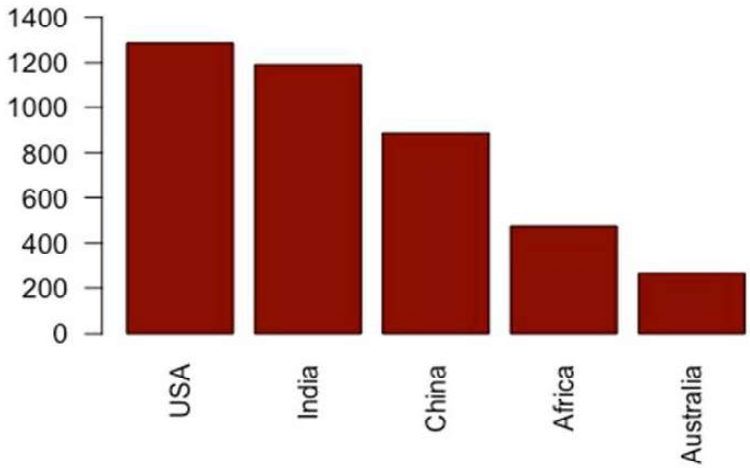

Fig 3. Research articles published by selected countries

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