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RESEARCH PAPER

Trends in different global research fronts on maize: A Scopus-based scientometric study

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Abstract: Maize, the world's third most vital food crop, plays a crucial role in providing over 30% of calories to over 4.5 billion people. Global demand and fluctuating production levels have impacted its market sustainability, leading to rising global prices. With a focus on Sustainable Development Goals 1 and 2, maize gains significance for its nutritional value. This study employs bibliometric analysis to explore prominent publications on maize, offering a guide to identify key works and influential nations in the field. The analysis reveals that the USA, China, India, and Mexico lead research with a transdisciplinary approach, emphasizing nutritional aspects. Strategic investment in the maize industry is crucial for addressing underlying issues and realizing its full economic potential. Aligning research priorities and policies in the next decade will contribute significantly to achieving food and nutritional security.

Keywords: Food security · bibliometric analysis · nutrition · economy · maize

Introduction

Maize (*Zea mays* L.) is one of the most important agricultural crops worldwide, serving as a staple food, livestock feed, and industrial raw material (Troyer, 2006). It is well-known as the 'queen of cereals' due to its several uses in different fields. Among the cereal crops, it holds the status of the highest production and stands third in the area after wheat and rice (FAOSTAT, 2019). It is cultivated in around 190 million ha area globally under a wide range of environmental conditions and altitudes (Dowswell *et al.,* 1996).

Maize plays an important role in ensuring food security, as it is a significant component in human and animal diets worldwide (Cavane, 2016). Apart from providing nutrients, maize serves as a raw material for the production of oil, starch, protein, bio-fuel beverages, sweeteners, and biofuel (FAO, 2019). Its diversified uses also contribute indirectly to income generation and poverty reduction where the product is sold for non-food purposes. Nowadays, the use of maize for direct human consumption is declining, but its relevance in the feed industry and milling industry is increasing at a faster pace than our anticipation (Tariq and Iqbal, 2010; Gianessi and Williams, 2012). Moreover, due to high population growth and changing dietary habits, it is anticipated that the demand for maize will increase two-fold by 2050 (CIMMYT, 2012).

Materials and methods

In the current study, the Scopus database was used as a tool to retrieve the relevant documents. Several advantages exist for Scopus like more search options, export data creation in excel, and data available for use in other software like VOSviewer for further analysis and mapping, Network analysis has been carried out using the VOSviewer software. Moreover, Scopus is larger and has more non-English scientific journals than Web of Science (Falagas *et al.,* 2008). The major processes involved in

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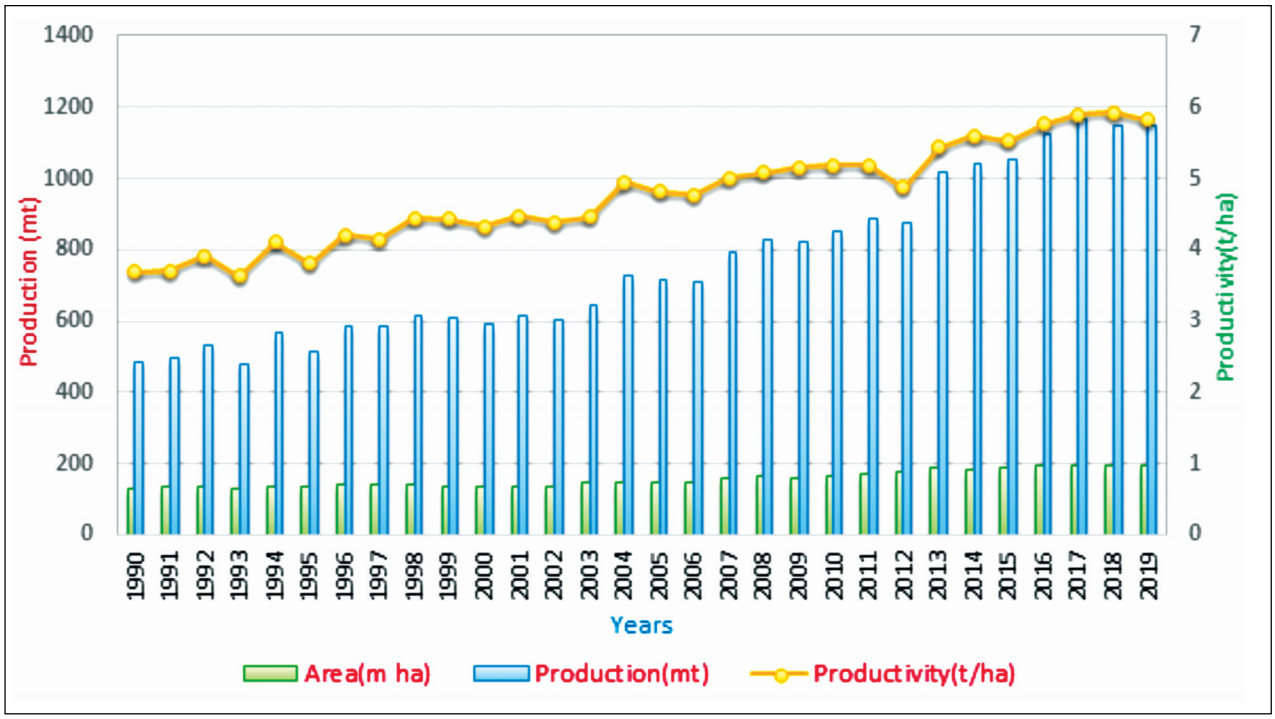

Figure 1. Global maize area, production, and yield
Source: FAOSTAT

designing a bibliometric analysis of the nutrition aspects of maize are:

- Database Selection.
- Tuning the Search Strategy
- Proper refining of the retrieved documents
- Data export and analysis.
- Fixing the bibliometric indicators.

For bibliometric analysis, we used a different combination of search words related to maize and nutrition to track the published documents between 1990 and 2020. The professional citation indexing database Scopus was utilized to identify the papers in the subject of maize nutrition. After the quantity of articles stabilized, the keywords were eventually determined in order to guarantee the depth and pertinence of the search scope. The final set of search phrases includes the following: "nutrition in maize, biofortification, maize research papers in different subjects, maize research collaborations, research priorities in maize," which were contained in the title, abstract, or topic.

Results and discussion

Over time, maize's nutritional value has been enhanced, and this has led to a rise in interest and significance in this area of research (Kar *et al.,* 2023). To ensure the nutritional security of growing economies overall, many nutrients are incorporated into the crop. Scopus database was used to retrieve the documents and VOSviewer was used for further analysis and mapping. The countries selected had at least 50 documents with a minimum of 10 citations per document. The different countries working on enriching the nutrients level in maize are given below:

Table 1. Top 15 countries working on the Maize Nutrition

Countries	No. of documents/ country	No of citations	Citations per paper
Nigeria	51	320	12
Kenya	57	984	11
South Africa	65	481	13
Australia	65	1279	17
Italy	67	1061	12
Canada	69	1187	13
United Kingdom	74	1427	17
Pakistan	76	1065	11
France	78	1342	15
Mexico	87	1371	12
Germany	101	1894	16
India	129	1901	13
Brazil	170	1264	10
United States	380	8773	25
China	426	4530	13

Source: Scopus Database

From Table 1 it is clearly evident that China is leading the research with the highest number of publications, followed by the USA and Brazil. The results of the citation analysis revealed that the USA is having the highest number of citations, followed by China and India. The citation per paper indicates that USA stands first followed by UK and Australia.

International research collaboration

Countries with a minimum contribution of 50 documents were visualized to assess the international research collaboration among active countries (Figure 2). For research collaboration, the strongest linkage was between the USA and Mexico (link strength = 70), followed by the USA and United Kingdom (link strength = 34). India has the highest research collaboration with the USA in the aspect of maize nutrition (link strength=20). The link strength was less than 10 for most countries implying inadequate international research collaboration. The thickness of the connecting lines represents the strength of research collaboration between any two countries. The connecting line between the USA and Mexico represents the strongest research collaboration due to its thickness relative to other lines. The North American food system recognizes corn as their staple source of food and research on different landraces has been going on for decades. Moreover, the US universities is leading research in maize globally for increasing its productivity and integrate it into different cropping systems. The presence of CIMMYT in this region and its high collaboration with the US universities and USDA has further promoted the research on maize in different aspects.

Global research trend analysis

Maize is an important crop useful in food, fodder, feed, and other industries for its utilities in different sectors. Global research in maize increased with the inclusion of tryptophan and lysine in maize kernels with the advent of QPM in the market.

Using the Scopus database (1990-2020), the global research trends in maize were analyzed. Research on maize is mainly done in the subject domain (from highest to lowest) of Agriculture and Biological sciences, followed by Biochemistry, Genetics and Molecular Biology, Environment Science, Immunology and Microbiology, Social Sciences, and Multidisciplinary sciences (Figure 3).

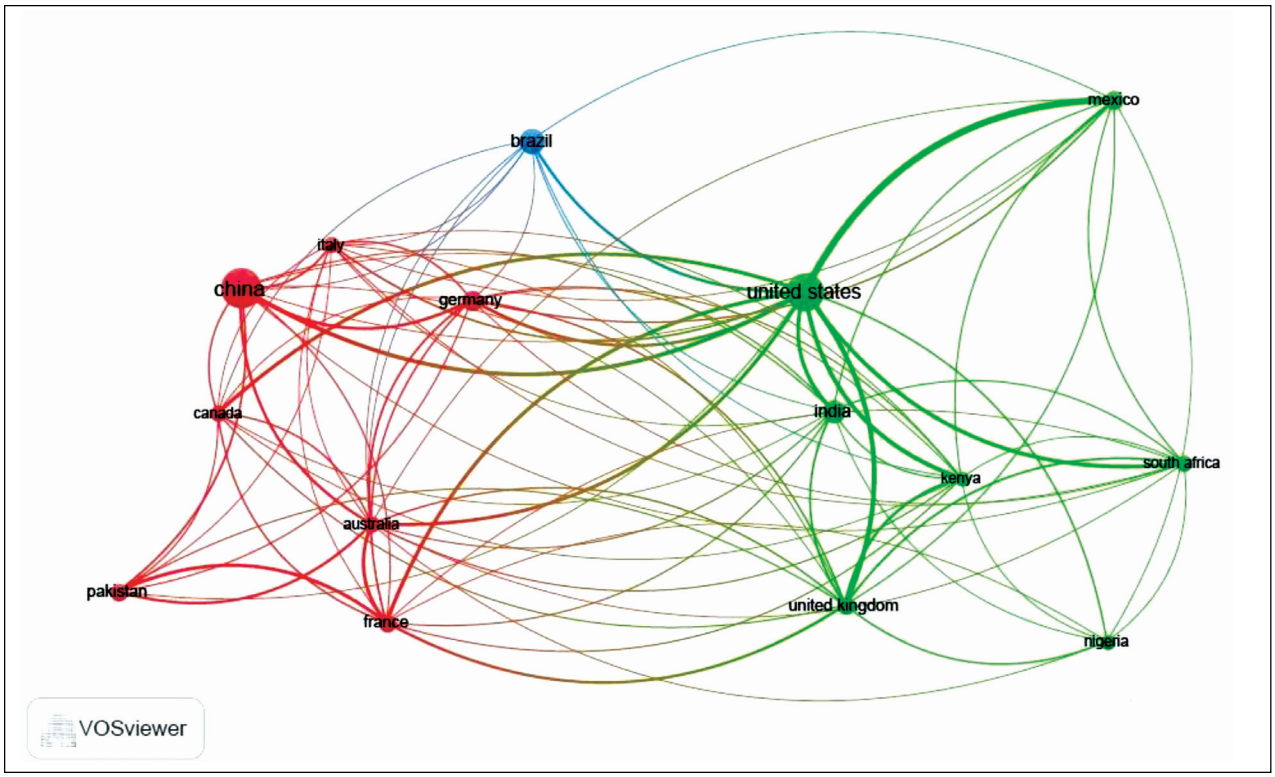

Figure 2. Network visualization map of international research collaboration
Source: Scopus Database, 2021

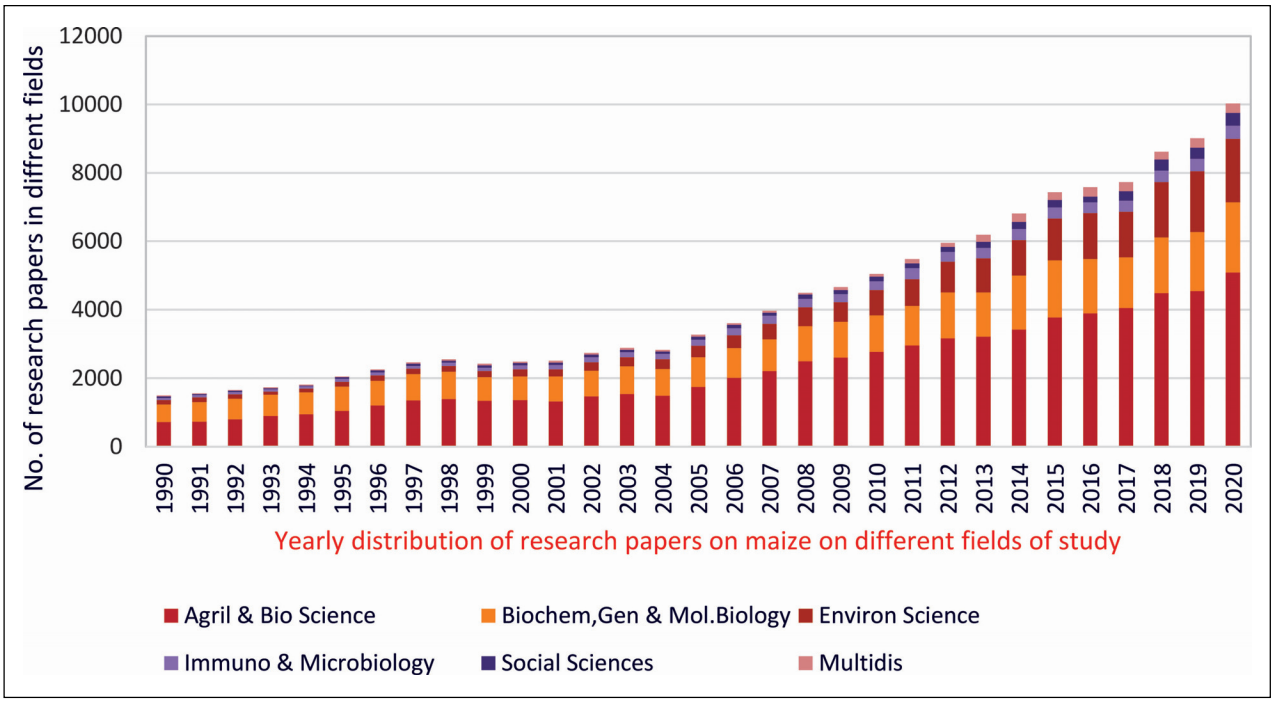

Figure 3. Global research trends in maize categorized by different subjects
Source: Scopus Database (1990-2020), Elsevier

Research priorities in maize

Maize is a popular crop among smallholder farming systems around the world because of its wider adaptability, high yields, and valuable byproducts. Considering its diverse use, maize demand is expected to increase at a faster pace in the coming decade. Exploration of basic mechanisms and adaptation to biotic-abiotic stresses are of immediate concern in maize (Vision 2050, IIMR). The popularization of superior single cross hybrids with diverse genetic bases significantly improves yield and stability (Singh and Srivastava, 2016). Devising suitable intercropping strategies will lead to the development of high-yielding, profitable, and climate-smart sustainable maize-based farming systems. Popularizing resource conservation technologies and providing innovation support to the maize value chain will strengthen the value-added aspects of maize (Singh and Srivastava, 2016). Research priorities should focus on developing the seed sector of maize for reaching the unreached to supply high-quality and affordable seeds to farmers (CIMMYT, 2020). Upgraded technology alteration according to the needs of farmers and linkage among farmers, government organizations, and industries should be established for better crop utilization (Cavane, 2016).

Table 2. Global Research Priorities on Mazie

Focused/ Identified Broad Areas	Research Sub-Areas
Maize/Corn Metabolism	Digestibility, mycotoxins, rheological properties, in-vitro, starch, bioavailability
Maize/ Corn Gene expression and QTL	Arabidopsis, evolution, diversity, resistance, selection, domestication
Maize as Energy Source	Biomass, corn stover, enzymatic-hydrolysis, ethanol production, fermentation, hydrolysis, bioethanol
Effect of Climate Change on Maize	Climate change management, food security, models, impact, adaptation, quality of grain
Abiotic Stress	Grain yield, abscisic acid, drought tolerance, oxidative stress, responses.
Cropping Systems	Biochar, organic matter, pyrolysis, carbon sequestration, adsorption, emissions, microbial biomass.

Authors own calculation: Source Scopus Database

Conclusion

Growing demand for maize requires holistic approaches to achieve the set target(s) by prioritizing technological interventions and innovations. Also, technological solutions need to be integrated with institutional platforms for addressing policy issues (Dube and Srivastava, 2016). Specific incentives aimed at the farming community to increase the adoption and adaptation of maize can play a new role in popularizing its benefits (Jiyawan *et al*., 2016). Maize can be converted as a potential export-oriented crop utilizing its diversified uses. Of them, bio-fortified maize varieties can pave the way to increase acreage in different non-traditional regions. But, for that consumer acceptance is a major factor, and trials are undertaken regarding consumer responses. In addition, varieties are also specifically developed targeting the nutritional requirement of feed and fodder. The bibliometric analysis uncovered that for research association, the most grounded linkage was found between the USA and Mexico, followed by the USA and the United Kingdom. Concerning the global research association, the USA, China, and India occupy prominent positions. Sustained and increased investment in the maize sector will address the hidden issues which are required to reap the actual economic benefits derived from the crop. Institutional linkages among the private sector for feed and industrial usage of maize will contribute to its sustainable growth. The nutritional importance of maize has paramount importance in alleviating the global malnutrition scenario. Limitations in accessing information, better seed systems, and weak market linkages are the major reasons for restricted growth in the maize sector. Future investments should be concentrated on upscaling institutional innovations. Linkages, especially multi-stakeholder partnerships, should be developed with respect to strengthening the value chain on specialty corns, feed usage, fodder usage, and other industrial usage. The multi-stakeholder partnerships enabling extension support with better input supplies and reduced transaction costs will increase the livelihood and welfare of the maize producers.

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Conflict of interest

The authors declare no conflict of interest.

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