Bibliometric Review on Planters and Transplanters

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This bibliometric review article aims to analyze scientific publications on various types of planting equipment, focusing on technological advances and emerging research areas. Data was collected from academic databases. The analysis covered articles from 1993 to 2023, identifying citation patterns, key authors, institutions, and countries involved. Results indicate a significant rise in publications, especially precision equipment and sustainable technologies. China and the USA lead in publications, with India and Brazil following. Interdisciplinary collaboration between agricultural engineers and data scientists is raising and promoting advancements. In conclusion, research on planting equipment is rapidly evolving, driven by the need for increased efficiency and sustainability in agriculture.
Keywords: Planter. Transplanter. Yield. Performance. Agriculture.

Agricultural transplanter and planter machines are vital in modern agriculture. They enhance planting efficiency, productivity, and resource utilization. These machines improve planting precision and speed, reducing labor costs and manual effort and making large-scale agriculture more sustainable.

Recent studies estimate that the agricultural sector must increase food production between 100% and 110% to meet global demands until 2050 [1] while addressing climate change, soil degradation, and resource depletion. Advanced machinery is crucial for sustainable practices, improving planting efficiency, reducing waste, and optimizing plant growth conditions, which minimizes the usage of fertilizers, herbicides, and pesticides.

New procedures and advanced technologies, such as automation, sensors, and renewable energy sources, enhance equipment performance. Automation and precision agriculture improve planting accuracy, maximizing crop yields and minimizing resource use. Sensors and IoT enable real-time monitoring, allowing data-driven decisions that enhance efficiency and sustainability.

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The bibliometric review provides an overview of the research landscape and offers insights into the current state of research and development, highlighting influential studies, authors, and institutions. It reveals regional strengths and collaborations, guiding efforts to foster international cooperation and knowledge exchange and address global challenges in food security and sustainable agriculture.

In summary, this article provides a comprehensive understanding of the research landscape, highlighting key contributors to the evolution of agricultural machinery. It offers valuable insights for future research and development, promoting sustainable and efficient agricultural practices worldwide.

Materials and Methods

The study carried out in this work consists of a bibliometric review, which conducted a survey of articles published in the last 30 years (1993-2023) related to advances in agricultural planting machinery related to improvements in yield, performance, or efficiency. The search was conducted between May 29 and June 05, 2024, using the Scopus [2] and Web of Science [3] databases. The keywords used in the article were planter, transplanter, performance, efficiency, and yield.

After a preliminary analysis of the available publications, the search Booleans was defined for each interface, using the exact keywords and research fields. Still, in the interfaces themselves, filters were applied to remove articles unrelated to the area of interest from the results. The filter selection process removed 865 articles related to medicine, arts, pharmacology, and veterinary medicine (Table 1).

Next, the data were exported in "bibtex" file format, and pre-processing was carried out using the RStudio [4] software and its bibliometric review library Bibliometrix [5]. The two different datasets were merged into a single file, and duplicate information was removed, resulting in 1505 articles. After this initial process, the unified data were loaded into the Biblioshiny interface (a Bibliometrix development), and from there, graphs and maps were generated on quantitative and qualitative analyses to identify citation patterns, most frequent keywords, the timeline of the publication's evolution, relevant affiliations and authors, between other remarkable data.

Results and Discussion

The analysis of annual scientific production between 1993 and 2023 reveals a significant growth in the number of published articles, segmented into three distinct periods. From 1993 to 2004, stability was observed with moderate growth, with an average of approximately 11 annual articles, characterized by minimal variations and consolidation of research bases. From 2005 to 2014, there was accelerated growth (Figure 1), with the number of articles increasing from 14 in 2005 to 52 in 2014, possibly driven by technological advances, more significant investment in research and development, and expansion of scientific collaboration networks.

Between 2015 and 2023, scientific production has grown significantly, reaching 62 articles in 2015 and culminating in 160 articles in 2022, with a slight decrease to 150 in 2023. The analysis highlights the apparent growth trend in scientific production, reflecting advances in research and development and the importance of global scientific collaboration, which is essential for understanding the impact and direction of future scientific research.

Following the initial data evaluation, the publications in the period grouped by the country of production of the article were analyzed (Figure 2). In this analysis, it is possible to perceive that the USA was the dominant country in the number of publications until mid-2015, when it was then surpassed by the current country with the most articles published per year, China, which showed a progressive increase in the publication rate from 2008, reaching the current number of 1210 articles published in 2023. In second place, we have the USA with 467 publications, followed by India with 377, Brazil with 226, and Turkey in fifth place with

Table 1. Search inputs and results.

#	Source	Boolean	Search Results	Search Results After Filters
1	Web of Science	(TS=(planter) OR TS=(transplanter)) AND (TS=(performance) OR TS=(yield) OR TS=(efficiency))	1,053	761
2	Scopus	((TITLE-ABS-KEY (planter) OR TITLE-ABS-KEY (transplanter)) AND (TITLE-ABS-KEY (performance) OR TITLE-ABS-KEY (yield) OR TITLE-ABS-KEY (efficiency)))	1,829	1,256

Figure 1. Annual scientific production.

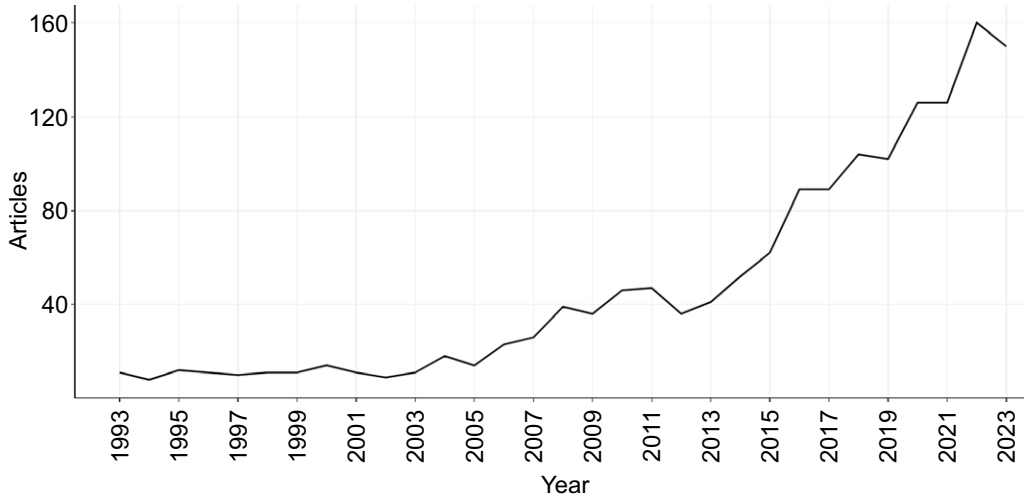
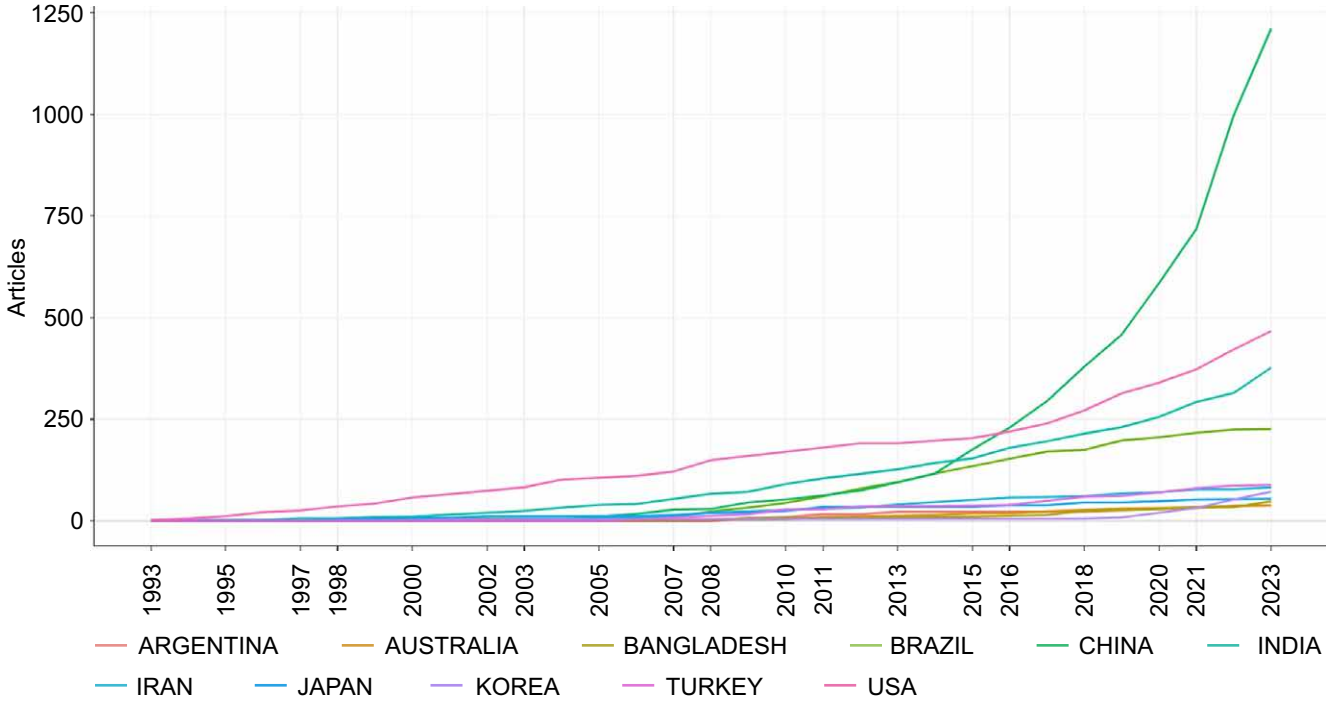


Figure 2. Ten countries with the most articles published per year (1993 - 2023).



89 publications in the same year of 2023. These countries are leaders in agricultural production [6] and in the publication of scientific articles related to improvements in planting equipment, suggesting a strong correlation between academic research and agricultural production.

The analysis of the collected data revealed that the most prolific authors in research on improvements in agricultural planting machinery are predominantly Chinese, highlighting China's leadership in this field. The most productive author is LI H, with 57 publications and an H-index of 17, followed by Zhang X, with 51 articles and an H-index of 14. In third place, Wang X has 36 publications and an H-index of 11, while Wang Q, with 34 publications, also has an H-index of 17,

demonstrating the high quality of their research. Zhang Y completes the list of five authors with 33 articles and an H-index of 9 (Figure 3). These 5 authors with the most publications illustrate the trend that China, the country with the most publications, also has the authors with the most individual publications globally on improvements in agricultural planting machinery. These data not only indicate the significant amount of research carried out in China but also the high quality and impact of the same, as evidenced by the high H-indices of these authors.

Continuing with the study, the surveys indicate that the author, Taylor R., is the most globally cited, with 46 citations related to the theme of this study (Figure 4). An interesting point is to mention that this author has an H-index of 6 and 9 articles published in the period analyzed here. Another relevant aspect is the predominance of citations from Indian authors and the absence of Chinese authors, which can be indicative that agricultural machinery development in China is based on Indian information; also, it could be related to the similarity in the crop productions, such as rice and wheat and corn [7], at the top of the ranking of most cited authors (possibly due to the recent ramp up in Chinese publications).

Regarding the number of publications by affiliations, China Agricultural University leads with 138 articles, demonstrating China's predominance in this research field. Zhejiang Sci-Tech University, Jilin University, Nanjing Institute

Figure 3. Most relevant authors and index H.

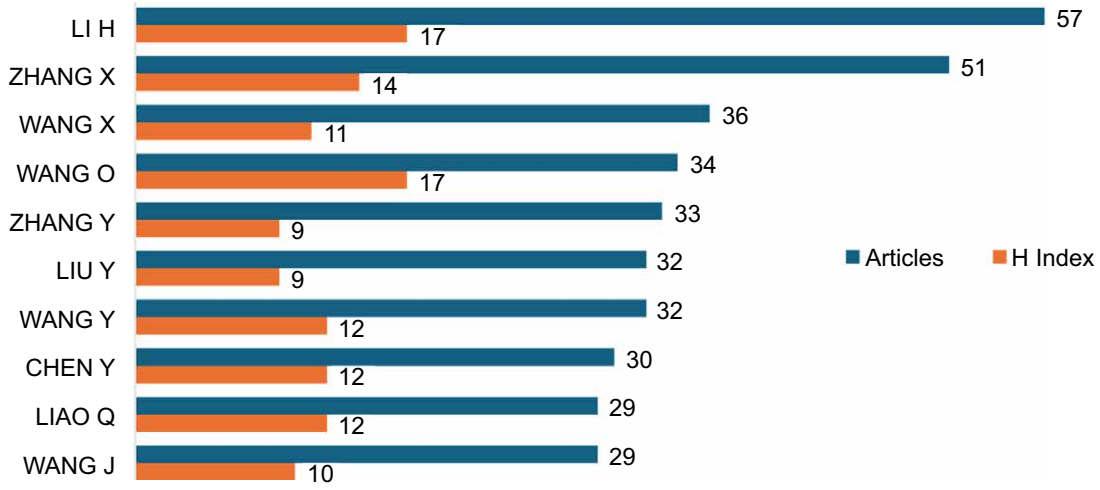


Figure 4. Most cited authors.

of Agricultural Mechanization, and Northeast Agricultural University are major contributors. The predominance of Chinese institutes and universities reflects China's substantial investment and focus on agricultural technological advances. An interesting point is that Brazil, occupying the fourth place in the ranking of publications by countries (Figure 1), has the affiliation Universidade Federal Santa Maria with the highest number of published articles (46) after the Chinese affiliations (Figure 5).

The evaluation of the most cited documents points in the first position the 2008 publication "No-Tillage Crop Production: A Revolution in Agriculture!" by author Triplett Jr [8], has 400 citations related to the theme of this study (Figure 6), shows a direct connection between the publication, innovation, and sustainability-driven by techniques improvements in agriculture such as no-tillage (NT), enabled by better planters, modern herbicides, and accumulated experience has revolutionized agriculture by allowing more efficient land management with less energy, labor, and machinery. NT improves erosion control and water and fertilizer use efficiency, often yielding better crops than tilled systems. Despite its sustainability, challenges remain for broader adoption and crop variety [8].

Figure 5. Most relevant affiliations.

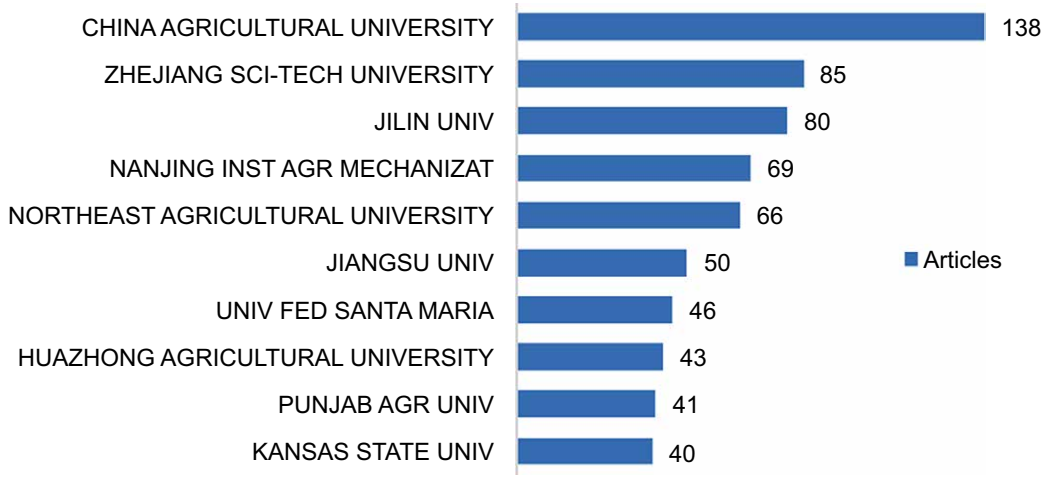
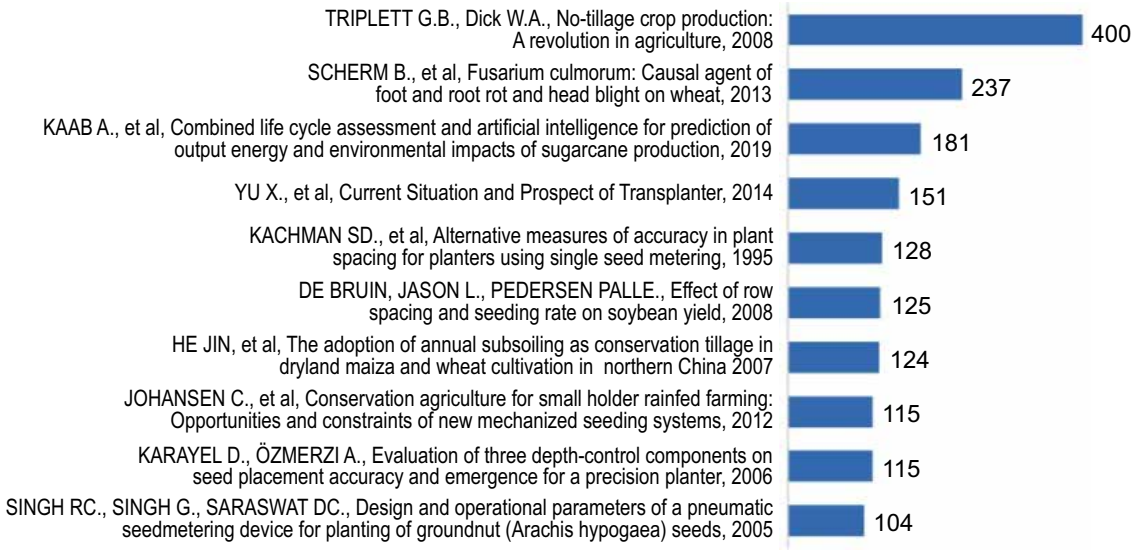


Figure 6. Most global cited documents.



Continuing the relevant article's quick review, "Alternative measures of accuracy in plant spacing for planters using single seed metering," by Kachman [9], that examines the performance of planters using single seed metering mechanisms by evaluating the accuracy of seed placement. It discusses factors affecting seed spacing and compares various accuracy measures, including mean, standard deviation, quality of feed index, multiples index, miss index, and precision. The study concludes that mean and standard deviation are not suitable measures of accuracy [9]. Another remarkable article with significant citations, "Current Situation and Prospect of Transplanter—2014" by author Yu [10] and colleagues discuss the importance of transplanting agronomy for China's agriculture, emphasizing the role of potted-seeding transplanting machines in boosting grain yields. It reviews the evolution of transplanting machinery, analyzes current development levels, and forecasts future trends, stressing the need for advanced knowledge and skills to progress in this field [10].

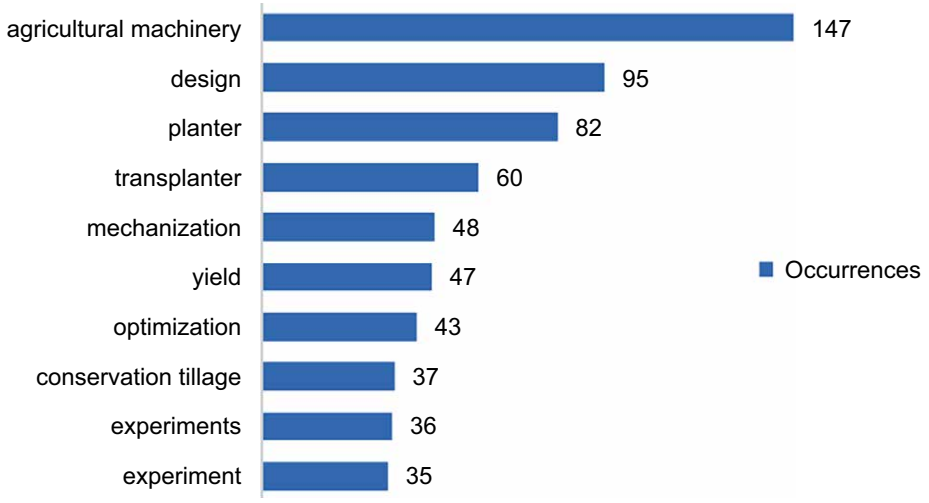
Regarding the most frequent author's Keywords, the 15 most frequent (Figure 7), The result points to a particular relevance for the term agricultural machinery with 147 mentions, followed by design, planter, transplanter, and mechanization as the 5 most cited. One point that stands out is that the crops of corn and rice appear approximately 30 times, which makes it possible to conclude that they must be the cultivars with the most research and publications related to technological advances linked to improvements in yield, performance, and efficiency in planting equipment. Also, rice cultivation in Asia is related to a flooded technique, which requires modifications in standard machinery to work in those conditions.

Conclusion

This bibliometric review highlights the significant advancements in agricultural planting machinery over the past three decades. The analysis reveals a substantial increase in scientific publications, particularly precision equipment and sustainable technologies. China and the USA lead research output, with notable contributions from India and Brazil.

The findings show the rapid evolution of planting equipment technology, driven by the global need for increased agricultural efficiency and sustainability. Adopting new techniques and integrating automation, sensors, and renewable energy sources has enhanced the performance and precision of these machines, contributing to higher crop yields and reduced resource usage. This review also emphasizes the importance of international and interdisciplinary collaboration in advancing agricultural technologies.

Figure 7. Most frequent words (author's keywords).



Overall, the research landscape for agricultural planting machinery is dynamic and growing, with significant contributions from leading institutions and prolific authors. Future research should continue to focus on emerging technologies and sustainable practices to address global challenges in food security and environmental sustainability.

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