

**GLOBAL RESEARCH TRENDS IN WHEAT STRAW RESIDUE MANAGEMENT AND  
SECONDARY CROP FIELD PREPARATION: A BIBLIOMETRIC ANALYSIS**

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**ABSTRACT**

The management of wheat straw residues after grain harvesting and the preparation of fields for secondary crops are important components of sustainable agricultural production systems. This study presents a bibliometric analysis of global scientific research related to wheat straw residue management and secondary crop field preparation. A total of 87 Scopus-indexed publications published between 2007 and 2026 were analyzed using bibliometric indicators and VOSviewer software. The study evaluated annual publication trends, leading authors, productive countries, journal distribution, citation impact, co-authorship networks, and keyword co-occurrence patterns. The results revealed a significant increase in scientific output after 2018, indicating growing international interest in conservation agriculture and residue management technologies. India, Mexico, and Belgium were identified as the leading contributors to this research field, while Soil and Tillage Research was the dominant publication source. Keyword clustering analysis showed that most studies focused on conservation agriculture, soil quality, residue management, and soil hydrology. However, limited attention has been given to agricultural machinery engineering, particularly the development of mechanized systems for straw handling and post-harvest field preparation. The study highlights the need for future research on multifunctional straw-management machinery, soil-machine interaction modeling, and region-specific conservation tillage technologies. The findings provide a scientific basis for researchers and agricultural engineers working on sustainable residue management and secondary crop production systems.

**Keywords:** wheat straw; residue management; secondary crop; tillage; conservation agriculture; bibliometrics; VOSviewer; Scopus

**1. INTRODUCTION**

Wheat (*Triticum aestivum* L.) is among the most widely cultivated cereal crops globally, covering approximately 220 million hectares and producing roughly 780 million metric tons annually [1]. Following grain harvest, enormous quantities of straw are generated in the field — estimated at a ratio of approximately 1.0–1.5 kg of straw per kilogram of grain — posing significant challenges for subsequent field operations and secondary crop establishment [2]. Wheat straw, if improperly managed, can impede tillage operations, restrict soil warming, harbor pests and fungal pathogens, and delay planting windows for secondary crops such as maize, soybean, sunflower, and rapeseed [3].

Globally, the predominant practice of open-field burning of straw residues, while effective in clearing fields rapidly, generates substantial greenhouse gas emissions, reduces soil organic matter, degrades air quality, and is increasingly subject to regulatory prohibition [4]. In contrast, conservation agriculture approaches — including no-till, minimum tillage, and residue incorporation — have attracted significant research attention as viable alternatives that simultaneously maintain soil health, reduce erosion, and facilitate secondary crop production [5]. The mechanized management of wheat straw residues for field re-preparation is therefore at the

intersection of agronomy, soil science, and agricultural engineering, requiring multidisciplinary solutions.

Bibliometric analysis is a well-established quantitative methodology for mapping the intellectual structure of a research field, tracing publication trends, identifying key contributors, and detecting emerging research frontiers [6]. Tools such as VOSviewer enable visualization of collaboration networks and keyword co-occurrence clusters, providing a structured overview of thematic evolution within a discipline [7]. Despite the growing volume of publications on wheat straw management and secondary crop field preparation, no comprehensive bibliometric study has systematically mapped this domain.

The present study addresses this gap by conducting a bibliometric analysis of 87 Scopus-indexed publications covering the period 2007–2026. The specific objectives are to: (i) characterize annual publication trends; (ii) identify leading authors, institutions, and countries; (iii) analyze citation impact and journal source distribution; (iv) map co-authorship and keyword co-occurrence networks; and (v) identify thematic clusters and future research priorities. The findings are intended to support researchers, policymakers, and agricultural machinery designers in navigating the existing knowledge base and identifying opportunities for scientific advancement.

## **2. MATERIALS AND METHODS**

### **2.1. Literature Search and Database Selection**

The Scopus database (Elsevier) was selected as the primary data source due to its comprehensive and multidisciplinary coverage of peer-reviewed scientific literature across engineering, agricultural sciences, and environmental disciplines [8]. The search was conducted on May 6, 2026, using the following Boolean query applied to Title, Abstract, and Keywords:

TITLE-ABS-KEY ( ( "wheat straw" OR "straw residue" OR "crop residue" ) AND ( "tillage" OR "field preparation" OR "conservation agriculture" OR "residue management" OR "secondary crop" ) )

No restrictions were applied to publication year or language at the query level. The search returned 87 peer-reviewed journal articles published between 2007 and 2026. Conference papers, book chapters, and editorial materials were excluded from the dataset.

### **2.2. Data Extraction and Quality Assessment**

The complete bibliographic records — including author names, institutional affiliations, countries of origin, source journals, publication years, author-assigned abstracts and keywords, and citation counts — were exported in CSV format for subsequent processing. Data integrity was verified through systematic cross-checking for duplicate entries and correction of author name inconsistencies arising from transliteration or abbreviated first names. All 87 records satisfied quality criteria and were retained in the final analytical dataset.

### **2.3. Bibliometric and Visualization Tools**

Descriptive bibliometric statistics — including annual publication output, country-level productivity, source journal distribution, and top-cited articles — were compiled using the Python programming language (pandas library v.2.1). Network visualization was performed in VOSviewer (version 1.6.20; Centre for Science and Technology Studies, Leiden University), which was applied to generate: (i) co-authorship networks (minimum threshold: 2 publications

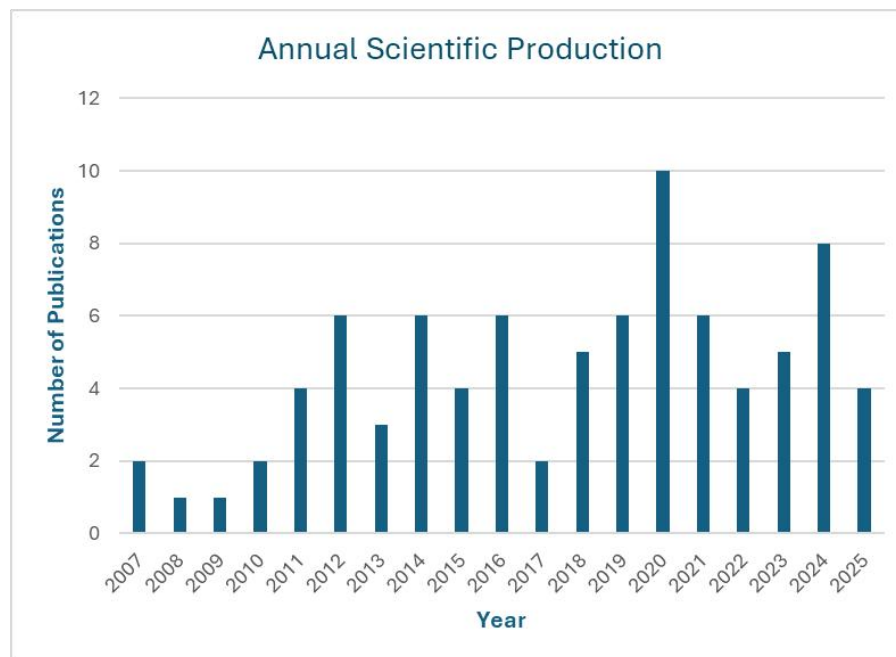
per author; 2 citations per document); (ii) country collaboration maps; and (iii) keyword co-occurrence networks (minimum occurrence threshold: 3 per keyword) [9]. The resulting network maps were analyzed to identify major research clusters and to trace thematic evolution over the study period.

### 3. RESULTS

#### 3.1. Annual Scientific Production (2007–2026)

The temporal distribution of 87 publications reveals a broadly increasing trajectory of scientific output in wheat straw residue management and secondary crop field preparation over the study period (Figure 1). Publication activity was modest between 2007 and 2014, averaging approximately 3.3 articles per year, which corresponds to the early establishment of conservation agriculture as a formalized research paradigm in developing agricultural economies. A notable intensification occurred after 2018, with annual output consistently exceeding five publications and reaching a peak of ten articles in 2020. This surge coincides with growing international policy attention toward sustainable land management, post-harvest residue burning restrictions, and the integration of mechanized agriculture into climate-smart farming frameworks.

The years 2023–2024 also demonstrated strong productivity (5 and 8 articles, respectively), while 2026 data ( $n = 2$ ) reflects only the first five months of the year. The overall trend confirms that this research domain is scientifically active and expanding, consistent with broader global priorities in food security, soil conservation, and agricultural machinery development.



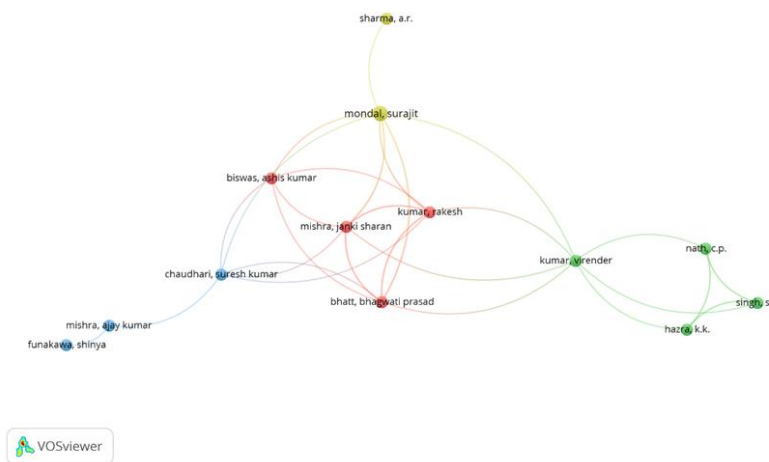
**Figure 1.** Annual scientific production related to wheat straw residue management and secondary crop field preparation research during 2007–2026 ( $n = 87$ ; source: Scopus, retrieved May 6, 2026). Bar heights denote the number of publications per year; the overlaid curve represents the five-year moving average trend.

#### 3.2. Most Productive Authors and Co-authorship Networks

Co-authorship network analysis identified the most productive contributors to the field (Figure 2). B. Govaerts (CIMMYT, Mexico) led with 13 publications, followed by N. Verhulst

(10), K.D. Sayre (8), J. Deckers (7), and L. Dendooven (6). The prominent role of CIMMYT-affiliated researchers reflects the institution's long-standing investment in conservation agriculture research across the Global South, particularly in wheat-maize double-cropping systems. M.L. Jat and H.S. Jat, representing Indian agricultural research institutions, contributed 5 and 4 publications respectively, underscoring South Asia's growing contribution to this field.

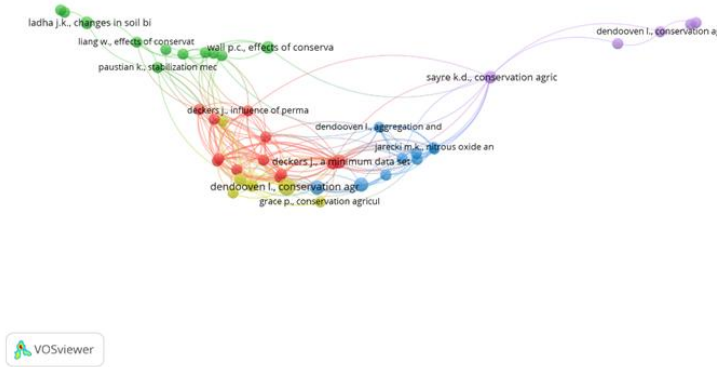
The VOSviewer co-authorship map revealed a densely connected primary cluster dominated by Govaerts, Verhulst, and Sayre, with international collaborations extending to European (Belgium, Netherlands) and Asian (India, Japan) research groups. A secondary cluster centered on Indian researchers highlights parallel national research programs focused on the Indo-Gangetic Plains context.



**Figure 2.** VOSviewer co-authorship network of the most productive authors in wheat straw residue management and secondary crop field preparation research (minimum threshold: 2 publications and 2 citations per author). Node size represents total publication count; link thickness represents co-authorship strength. Generated from 87 Scopus records (2007–2026).

### 3.3. Citation Analysis and Most Cited Publications

Citation analysis provides a quantitative indicator of scientific impact within the research community (Figure 3). The ten most cited articles in the dataset are presented in Table 1. The most cited publication — Turmel et al. (2015), published in *Agricultural Systems* — accumulated 560 citations, synthesizing evidence on crop residue management in relation to soil health, productivity, and environmental sustainability across diverse farming systems [10]. The second most cited article (Govaerts et al., 2007; 321 citations) examined long-term effects of tillage, residue management, and crop rotation on soil microbial biomass and catabolic diversity. Notably, seven of the ten most cited articles were published before 2015, reflecting the citation-accumulation advantage of established publications. However, more recent articles (2019–2021) are rapidly building citation records, indicating continued scholarly engagement with the domain. The collective citation count of all 87 articles exceeded 3,200, confirming substantial scientific impact.



**Figure 3.** VOSviewer citation network map illustrating the most influential publications in wheat straw residue management and secondary crop field preparation research. Node size is proportional to total citation count; color gradient (blue → yellow) indicates publication year from earliest to most recent. Data derived from 87 Scopus records (2007–2026).

**Table 1.** Top 5 most cited articles in the wheat straw residue management and secondary crop field preparation research domain (Scopus, 2007–2026)

Rank	Authors	Title (abbreviated)	Year	Citations	Journal
1	Turmel et al.	Crop residue management as a component of sustainable crop production: A synthesis	2015	560	Agric. Systems
2	Govaerts et al.	Tillage, residue management, and crop rotation on soil microbial biomass	2007	321	Appl. Soil Ecol.
3	Van den Putte et al.	Assessing the effect of soil tillage on crop growth: A meta-regression	2010	293	Eur. J. Agron.
4	Valbuena et al.	Conservation agriculture in mixed crop-livestock systems across Sub-Saharan Africa	2012	253	Field Crops Res.

5	Govaerts et al.	Infiltration, soil moisture, root rot after 12 years of tillage management	2007	235	Soil Res.	Till.
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**3.4. Country-Level Scientific Production and Collaboration**

Country-level analysis reveals a clear geographic concentration of research productivity (Figure 4). India was the most prolific country with contributions affiliated to 26 articles (29.9% of the dataset), reflecting the agricultural importance of wheat-based double-cropping systems across the Indo-Gangetic Plains, where straw management and secondary crop establishment present critical agronomic challenges. Mexico ranked second (18 articles; 20.7%), largely attributable to the extensive output of CIMMYT's international wheat and maize improvement programs.

Belgium contributed to 11 publications (12.6%), primarily through researchers at KU Leuven collaborating with CIMMYT. South Africa (8 articles), Kenya (6 articles), and the Netherlands (6 articles) also featured prominently, highlighting the field's relevance across diverse agroecological zones in Sub-Saharan Africa and temperate Europe. The United States, Iran, Japan, Germany, and Canada each contributed between 3 and 5 publications, indicating broad international engagement.

The VOSviewer country collaboration map confirmed that Mexico and Belgium share the strongest bilateral collaboration linkage, reflecting long-standing CIMMYT–KU Leuven partnerships. A second major cluster involved India, Kenya, and the Netherlands, consistent with CGIAR collaborative programs. This pattern underscores the global, interdisciplinary nature of wheat straw residue management research.



**Figure 4.** VOSviewer country collaboration network map for wheat straw residue management and secondary crop field preparation research (2007–2026). Node size is proportional to the number of publications per country; link thickness represents the intensity of international collaboration; color coding indicates geographic clusters.



**Figure 5.** VOSviewer keyword co-occurrence network map derived from author keywords of 87 Scopus articles (2007–2026) related to wheat straw residue management and secondary crop field preparation. Minimum keyword occurrence threshold: 3. Node size represents occurrence frequency; link thickness represents co-occurrence strength. Five color-coded thematic research clusters are identified.

#### 4. DISCUSSION

The bibliometric landscape of wheat straw residue management and secondary crop field preparation reveals a maturing research domain with strong upward growth momentum. The acceleration of publications after 2018 aligns with global policy shifts toward sustainable agricultural intensification and the phased prohibition of residue burning in major wheat-producing countries, particularly India and China. These regulatory changes have created urgent demand for practical, scalable solutions — including mechanized field preparation technologies — that can process large volumes of straw without compromising planting timeliness for secondary crops [3].

The dominance of India and Mexico as leading producing countries reflects the geographic distribution of wheat-intensive double-cropping systems, where straw management has the most direct agronomic and economic consequences. CIMMYT's outsized contribution — through its Mexican base and global network of collaborators, particularly KU Leuven (Belgium) — has shaped the conservation agriculture framework underpinning most publications in the dataset. However, the relatively limited representation of other major wheat producers — China, Russia, and Ukraine — may indicate significant research output in national-language journals or grey literature not indexed by Scopus.

The citation structure, with a small number of articles accumulating the majority of citations (top 10 articles collectively exceeding 2,200 citations), is consistent with a Zipf-like distribution typical of bibliometric datasets in applied agricultural sciences [6]. The high citation rates of older publications (2007–2013) confirm that foundational studies on conservation agriculture, microbial soil responses, and long-term tillage effects have provided the conceptual backbone for subsequent work. Newer publications (2019–2024), while not yet citation-saturated, are building rapidly on these foundations.

From a thematic perspective, the clustering of keywords around conservation agriculture, soil organic carbon, and regional contexts suggests robust theoretical and empirical foundations in soil science, but comparatively less attention has been directed to engineering and mechanization aspects — specifically the design, optimization, and field-scale testing of machinery for straw chopping, incorporation, and field re-preparation. Terms such as "machinery design," "combine harvester," "straw chopper," and "field preparation machinery" are essentially absent from the keyword co-occurrence network despite their practical importance. This underrepresentation identifies a clear scientific opportunity.

The thematic cluster analysis confirms that most studies are framed within agronomy and soil science rather than agricultural machinery engineering. Given the growing importance of mechanized solutions — particularly two-stage field preparation systems capable of handling high-density straw loads in conservation agriculture contexts — there is substantial scope for interdisciplinary research bridging mechanical engineering, soil-machine interaction modeling, and cropping system agronomy.

## 5. CONCLUSIONS

This bibliometric analysis of 87 Scopus-indexed articles (2007–2026) provides the first systematic quantitative mapping of the global scientific literature on wheat straw residue management and secondary crop field preparation. The following principal conclusions are drawn:

1. Scientific production in this domain has grown substantially over the study period, with a marked acceleration after 2018 driven by global regulatory pressure on residue burning and growing adoption of conservation agriculture principles.

2. India, Mexico, and Belgium are the leading productive countries; B. Govaerts and N. Verhulst are the most prolific authors; and Soil and Tillage Research is the most influential publication outlet (14.9% of total publications).

3. Five major research clusters were identified: conservation agriculture practices, soil quality and carbon dynamics, crop residue management systems, regional agroecological contexts (Indo-Gangetic Plains; Sub-Saharan Africa), and soil hydrological responses.

4. A significant research gap exists in the engineering and mechanization dimension of straw management — specifically in the design, simulation, and optimization of field preparation machinery for post-wheat-harvest conditions.

5. Future research should prioritize the development and evaluation of multi-functional tillage and straw-management machinery systems compatible with conservation agriculture principles, particularly for smallholder farming contexts in South Asia, Central Asia, and Sub-Saharan Africa.

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