

Rice Allelopathy in Weed Control Research: A Bibliometric Perspective

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ABSTRACT

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Weed control using synthetic herbicides is widely practiced due to its cost-effectiveness and ease of application. Allelopathy, a natural biochemical process, has strong potential for development as an environmentally friendly bioherbicide in sustainable weed management systems. Scientific documents were retrieved from the Scopus database covering the period from 2000 to 2026. Bibliometric indicators—including publication growth, the most productive authors and institutions, the most productive document sources, the most cited papers, and cluster analysis—were analyzed and presented using general statistical methods. The results show that the number of publications and citations on rice allelopathy in weed control has fluctuated over the past two decades. Ill-Min Chung, Hisashi Kato-Noguchi, and Fujian Agriculture and Forestry University ranked first as the most productive authors and institution, respectively. A substantial number of papers have been published in *Allelopathy Journal* and the *Journal of Chemical Ecology*, with East Asian countries contributing the highest volume of research and publications related to rice allelopathy. Research on rice allelopathy focuses on the interaction between rice plants and *Echinochloa crus-galli* as a dominant weed in rice cultivation, the identification and mechanisms of action of allelochemicals, and the development of more environmentally friendly weed suppression strategies. Overall, the research trend points toward the use of allelopathy as a biological approach within sustainable weed control systems. weed management strategies as an alternative bioherbicidal approach.

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1. Introduction

Weeds are one of the plant pests that play a significant role in reducing the productivity of cultivated plants due to competition for nutrients, soil water, carbon dioxide (CO₂), and sunlight [1]. Economical weed control is generally carried out through the application of synthetic herbicides, which are the primary choice of farmers due to their effectiveness and ease of use. However, repeated use of herbicides without rotating active ingredients has the potential to trigger the emergence of weed resistance.

Most cases of resistance are reported to occur in herbicides with mechanisms of action that inhibit the enzymes acetolactate synthase (ALS), acetyl-CoA carboxylase (ACCase), and photosystem II [2]. In addition, excessive use of synthetic herbicides contributes to environmental pollution, including degradation of soil and water quality, decline in biodiversity, and reduction in soil microorganism populations such as heterotrophic bacteria and fungi [3].

Naturally, crops, including rice (*Oryza sativa* L.), produce secondary metabolites as an adaptive mechanism in response to environmental stress and other biotic stress. One such mechanism is allelopathy, which is the release of allelochemical compounds such as phenolics, terpenoids, alkaloids, and flavonoids that inhibit the growth of competing organisms. These compounds are known to interfere with germination, root and shoot growth, and biomass accumulation through changes in cell division, physiological activity, and nutrient uptake [4]. Allelochemicals play an important role in inhibiting the growth of competing organisms and therefore have potential for use in weed management [5]. Allelopathy in rice is phytotoxic in nature and includes phenolics, diterpenoids, flavones, fatty acids, indoles, and momilactones, which play a role in inhibiting weed growth [6].

Several studies have shown the potential of rice allelopathy as a natural weed control agent. [7] reported that the diversity of phenolic compounds in rice extracts was higher than in sorghum, although the concentration of compounds in sorghum was relatively greater. Meanwhile, the use of rice allelopathy and plant residues contributes to natural weed control through biochemical mechanisms, which are not only environmentally friendly but also support production efficiency by reducing control costs and the risk of weed resistance [8].

The increase in the number of publications related to allelopathy over the past two decades (2003–2025) shows growing scientific interest in this topic. However, comprehensive mapping of research trends, thematic focus, and patterns of scientific collaboration in rice allelopathy studies is still relatively limited. Therefore, bibliometric analysis is needed as an alternative to provide an overview of research developments and future research directions.

Experimental research on rice allelopathy has been extensively conducted, especially on a laboratory scale and in the context of specific research themes in various countries. However, studies highlighting global publication dynamics are still minimal. This study aims to analyze trends in rice allelopathy research as a natural weed control using the Scopus database through a bibliometric approach. Specifically, this study examines annual publication patterns, citation trends, major journals, and author and country collaborations in the field of rice allelopathy in weed control.

2. Method

This study applies a qualitative approach based on literature review through bibliometric analysis using the Scopus database as the main source. The bibliometric method is a quantitative approach that can explore and map the development of a field of science by analyzing large collections of scientific data, such as publication patterns, citations, and collaborations [9][10]. The literature search was conducted on January 11, 2026, using Boolean operators to identify publications discussing rice allelopathy in weed control. The search strategy included the keywords (“Rice” OR “Paddy” OR “Oryza” OR “rice Variet*”) AND (“Allelopathy” OR ‘Allelopathic’) AND (“Weed Control” OR “Weed Management”) applied to the title, abstract, and keywords (Figure 1).

The search results yielded 267 articles, which were then selected by limiting the document type to research articles in English-language scientific journals published between 2000 and 2026, and excluding secondary articles such as systematic reviews and bibliometric reviews. The search yielded 192 articles, which were then reviewed based on their abstracts and titles related to rice allelopathy. Approximately 112 documents were excluded, resulting in a final selection of 80 articles, all of which were journal articles in English, which were then exported in CSV format. The collected data then underwent a cleaning and keyword standardization stage using Open Refine software, mainly to fill in the list of articles with empty keywords and to standardize or remove redundant keywords.

The cleared database was analyzed using VOSviewer (version 1.6.20) to map the relationships between publications and form thematic clusters through co-occurrence, co-authorship, and citation analysis. The VOSviewer application in bibliometric studies analyzes and describes complex relationships in research data in a valid and informative manner [11]. In addition, bibliometric analysis was also conducted using Rstudio (version 2025.09.02+418) Biblioshiny to examine

publication trends and the dynamics of the development of rice allelopathy research topics worldwide.

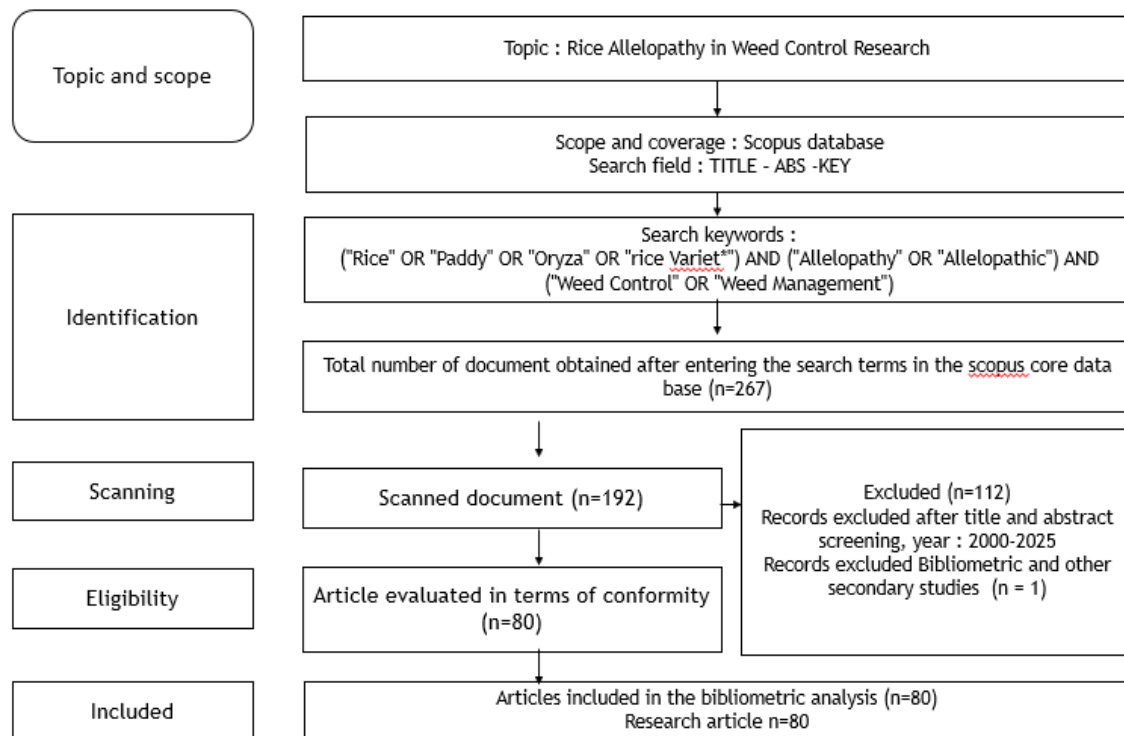


Figure 1. Systematic methodology of data collection from scopus database.

3. Results and Discussion

3.1 Publication and Citation Trends

The dynamics of the number of publications and total citations of rice allelopathy research in weed control during the period 2001–2026 (Figure 2). The number of publications showed a fluctuating and relatively low pattern in the early 2000s, then increased in the period 2012 to 2014, with the number of publications reaching around 6–7 articles per year. After a brief period of stagnation in 2015–2017, the number of publications increased again in 2018–2020 and higher in 2024.

The total number of citations shows a different pattern, with the highest peak occurring in the early 2000s, particularly around 2004, and a second spike in 2012. After 2015, the citation trend tended to decline even though the number of publications increased. The difference in patterns between the number of publications and total citations indicates a shift in the development phase of the research field. The surge in citations in the early 2000s reflects the basic research phase, in which a number of key publications became the main references and formed the conceptual basis of rice allelopathy. Articles from this period generally had a long-term impact on the direction of subsequent research.

Meanwhile, the increase in the number of publications in the 2012–2014 period and again in 2018–2024 indicates a phase of expansion and diversification, marked by an increase in applied, experimental, and integrative approaches. However, the low number of citations in the most recent period can be explained by citation lag, whereby relatively new articles have not had enough time to accumulate citations. The peak in publications in 2024 indicates a resurgence of research interest, likely triggered by increasing problems of herbicide resistance and the need for environmentally friendly and sustainable weed control strategies. Thus, this trend confirms that rice allelopathy is increasingly positioned as a relevant biological alternative.

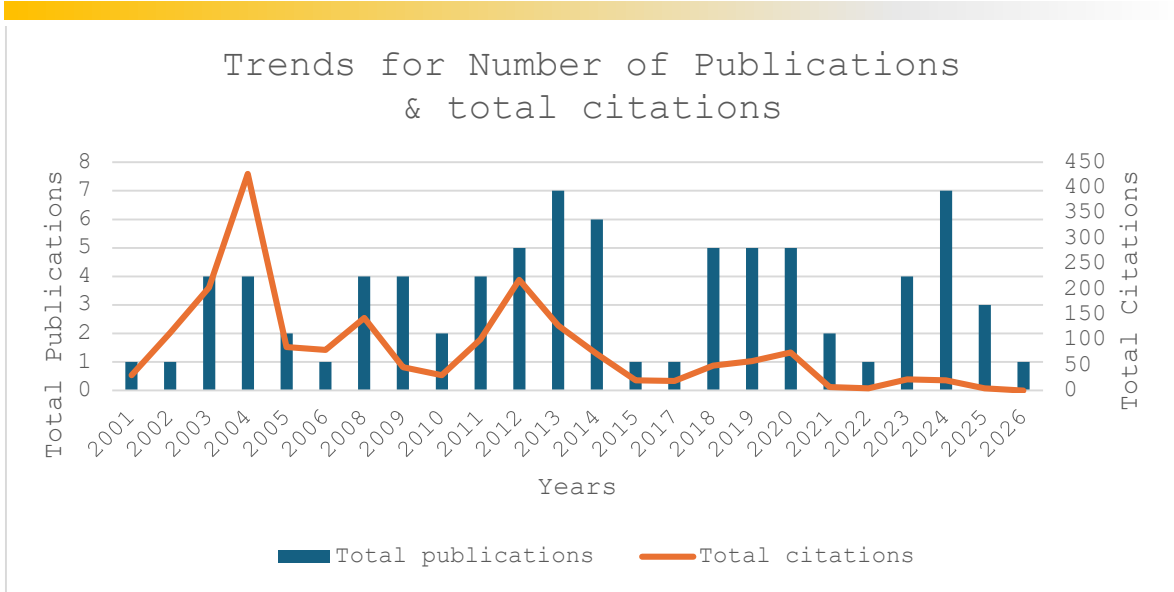


Figure 2. Trends Publications and citations

3.2 Most relevant authors, affiliation and countries

The results of the study show that contributions to publications in the field of rice allelopathy in weed control are dominated by several authors from East Asia (Figure 3). Ill-Min Chung and Hisashi Kato-Noguchi rank highest as the most productive authors with 6 documents, followed by authors with 5 documents, including David R. Geally, Tran Dang Khanh, Chui Hua Kong, Maria Olofsdotter, MD Abdus Salam, and Tran Dan Xuan. Other authors, namely Changxun Fang and Wenxiong Lin, each have 4 publications. The results of this study indicate a concentration of scientific contributions among a number of authors who play a significant role in the development of research on the topic of rice allelopathy. Authors from China and Japan indicate that research related to rice as a major food crop is important to study, supported appropriate research facilities.

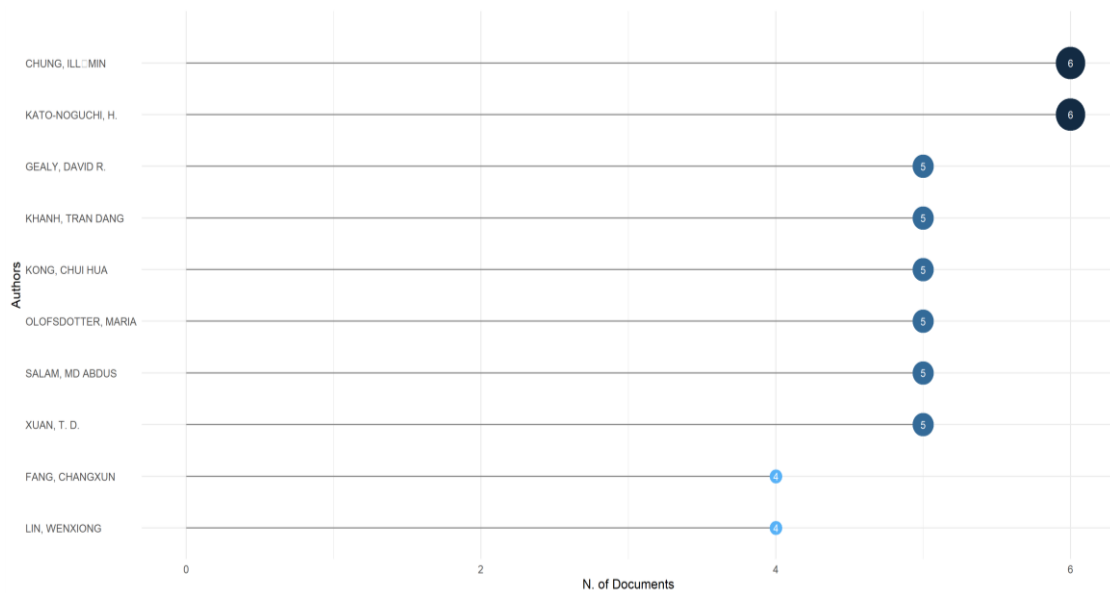


Figure 3. most relevant authors

The results of the analysis for the most relevant affiliations with publications on the topic of rice allelopathy in weed control show that Fujian Agriculture and Forestry University is the main contributor to publications on rice allelopathy with 50 articles (Figure 4). In addition, there are also China Agricultural University and South China Agricultural University, each with 10 articles, which are also affiliations from China. China has been a pioneer in hybrid rice production since the 1970s [12], demonstrating its dominance in rice research, including rice allelopathy in weed control.

The most affiliation followed by Konkuk University ranked second with 20 publications, followed by Hiroshima University with 19 articles and Universiti Putra Malaysia with 16 articles. Significant contributions from a number of Japanese affiliates, such as Hiroshima University, University of Ryukyus, Kagawa University, and Kagoshima University, indicate that research related to rice allelopathy is concentrated in Asia, especially East Asia, in line with the region's role as the world's main rice-producing area, including its focus on developing sustainable weed control technologies based on biological mechanisms.

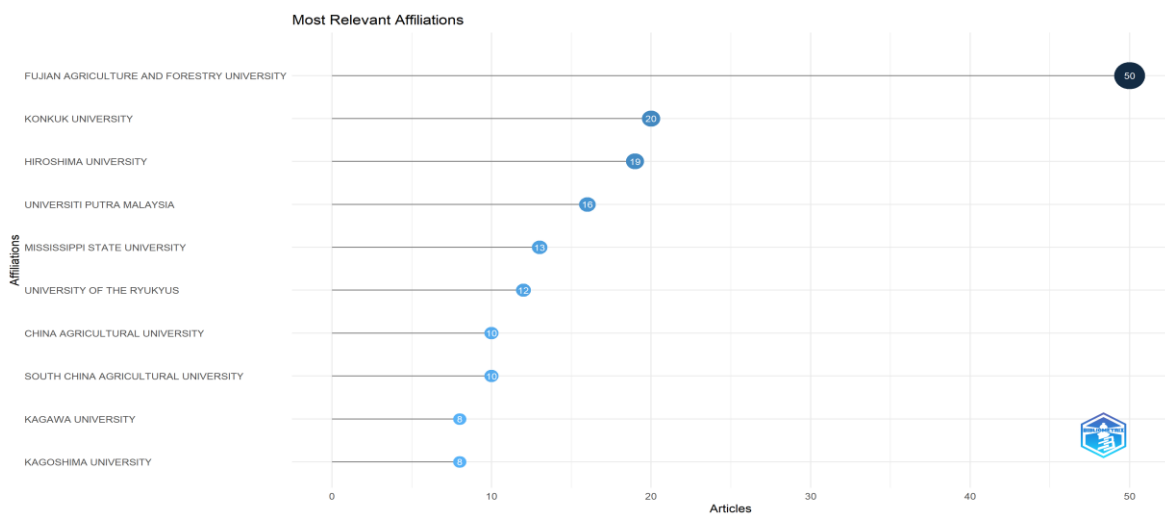


Figure 4. Most relevant affiliation

The countries most frequently cited are those whose publications have had the greatest scientific impact, reflecting the role of these countries in shaping fundamental and widely cited research on rice allelopathy. Based on Figure 5, China ranks first as the country with the highest number of citations (537), followed by the USA (482), Korea (209), Japan (136), Malaysia (80), and Australia (38).

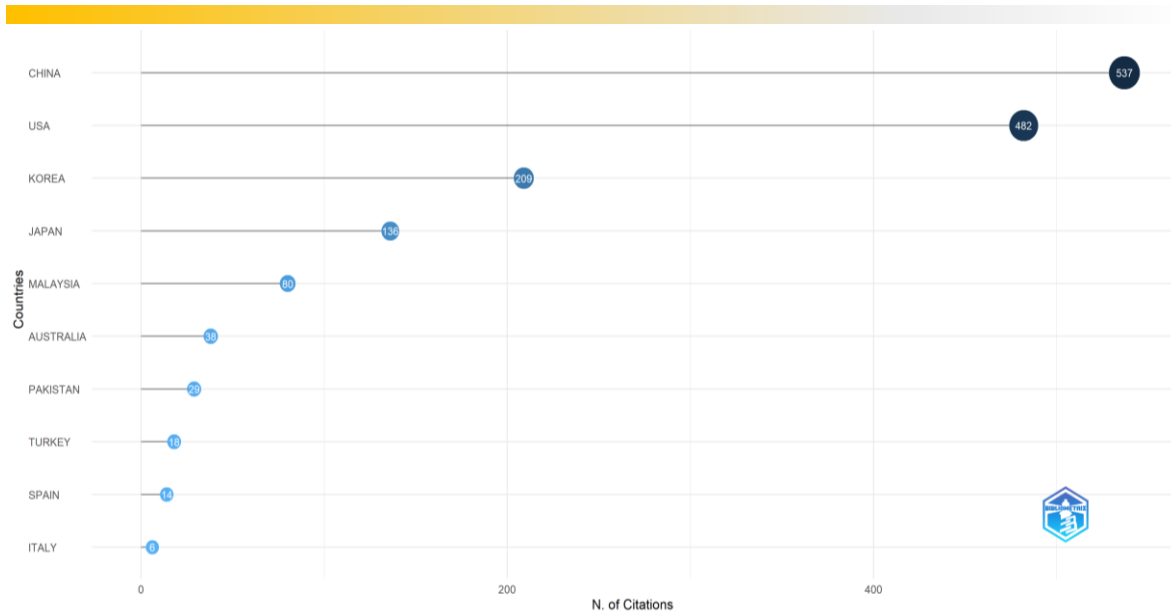


Figure 5. Top 10 most cited countries

3.3 Most Relevant Journal distribution

Based on a search of the Scopus database, there are 80 documents relevant to the discussion published by the journals that publish the most on rice allelopathy, namely 9 journals, namely Allelopathy journal, followed by Journal of Chemical Ecology and Weed Biology and Management, each with 5 documents (Table 1). Several other journals, such as Pest Management Science and Weed Science, also contributed significantly with 4 documents. Meanwhile, agronomy and crop production-based journals, such as the Agronomy Journal, Asian Journal of Crop Science, and Australian Journal of Crop Science, showed a more limited number of publications, with only 2 documents.

Table 1. Most relevant journal distribution

Journal	Number of documents	JIF	JIF Quartile	H-index
Allelopathy journal	9	0.19	Q4	39
Journal of chemical ecology	5	0.70	Q1	136
Weed biology and management	5	0.38	Q2	46
Pest management science	4	0.90	Q1	165
Weed science	4	0.63	Q1	109
Pakistan journal of botany	3	0.26	Q3	78
Plant production science	3	0.50	Q2	65
Agronomy journal	2	0.57	Q2	159
Asian journal of crop science	2			22
Australian journal of crop science	2	0.20	Q3	61

The dominance of Allelopathy journal confirming that research results on allelopathy are more widely accepted and published in this journal, which focuses on the ecological aspects and applications of allelopathy, and concentrates on the identification of allelochemicals, growth inhibition effects, and plant interactions. The existence of the Journal of Chemical Ecology as a primary source reinforces that this research is aimed at chemical ecology aspects, including the role of phenolic compounds and root exudates in weed suppression.

The relatively lower contribution of Agronomy and crop science journals indicates that the integration of rice allelopathy into cultivation systems and field practices is still limited. This reveals a research gap between fundamental research and agronomic applications, particularly in the context of sustainable weed control and the breeding of allelopathic rice varieties. Thus, the distribution of

these publications shows that although rice allelopathy is already known as a biological concept, there are still vast opportunities for research to expand studies towards field trials, integrated weed management, and integration into rice breeding programs as a solution and anticipation of herbicide resistance.

3.4. Most Cited Article

Using the Scopus database as the data source, the keywords corresponding to the most cited articles are summarized in Table 2.

Table 2. Top 10 Cited Articles

No	Article	Total citations	Reference
1	Genetic evidence for natural product-mediated plant–plant allelopathy in rice (<i>Oryza sativa</i>)	153	[13]
2	Release and Activity of Allelochemicals from Allelopathic Rice Seedlings	149	[14]
3	Identification and Quantitation of Compounds in a Series of Allelopathic and Non-Allelopathic Rice Root Exudates	123	[15]
4	Why phenolic acids are unlikely primary allelochemicals in rice	114	[16]
5	Rice cultivar differences in suppression of barnyard grass (<i>Echinochloa crus-galli</i>) and economics of reduced propanil rates	108	[17]
6	Evaluation of Putative Allelochemicals in Rice Root Exudates for Their Role in the Suppression of Arrowhead Root Growth	96	[18]
7	Evaluation of allelopathic potential and quantification of momilactone A, B from rice hull extracts and assessment of inhibitory bioactivity on paddy field weeds	80	[19]
8	Breeding of commercially acceptable allelopathic rice cultivars in China	72	[20]
9	Effect of allelopathic rice varieties combined with cultural management options on paddy field weeds	67	[21]
10	Comparison of Allelopathic Potential of Rice Leaves, Straw, and Hull Extracts on Barnyard grass	62	[22]

The most cited document in the study of allelopathy in rice for weed control is Genetic Evidence for Natural Product-Mediated Plant–Plant Allelopathy in Rice (*Oryza sativa* L). This article provides genetic evidence that allelopathy in rice is controlled by genetic factors that play a role in the production of certain secondary metabolites, making it an important reference.

3.5 Bibliometric Cluster Analysis

A comprehensive understanding of the development of scientific knowledge can be achieved through the analysis of keyword relationships represented in network maps. Keywords in scholarly documents function as essential indicators for identifying research emphases, encompassing the principal concepts, theoretical frameworks, methodological approaches, and thematic orientations addressed in academic publications. Such analysis facilitates the identification of research trends, intellectual structures, and the dynamic evolution of a given field of study.

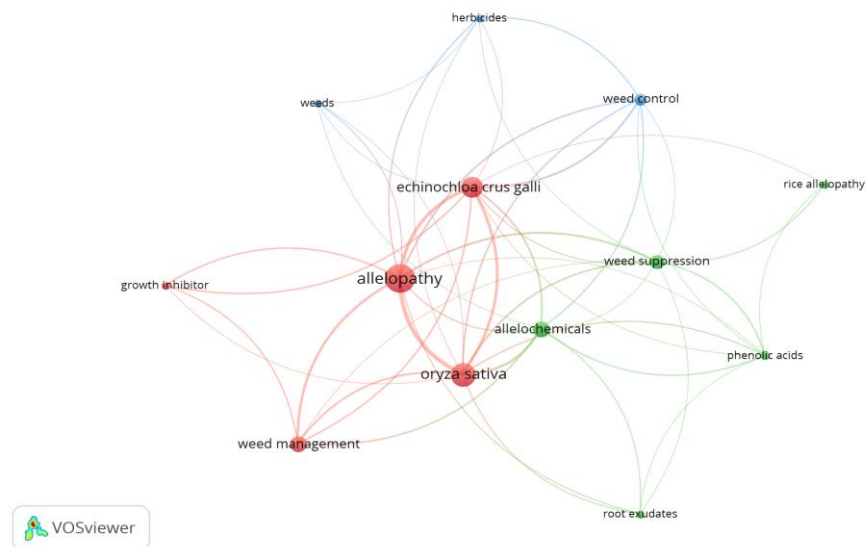


Figure 6. Network visualization of the occurrence keyword related to rice allelopathy

Based on the mapping results, a visualization of the keywords from the analysis was obtained using VOSviewer, which was divided into three clusters as shown in Figure 6. Each node and connecting line varies in size, reflecting differences in the frequency of occurrence and the strength of the relationship between keywords. The keyword allelopathy, with a large dot in the center, indicates that this topic is the main focus of the analyzed publications. The description of each cluster is presented as follows.

Cluster 1. The first category in cluster analysis is the red cluster. This cluster contains the keywords allelopathy, *Oryza sativa*, *E. crus-galli*, weed management, and growth inhibitor. This cluster shows studies related to the interaction between allelopathy and the main weed of rice, *E. crus-galli*. Genetic variation in rice can affect the suppression effect on *E. crus-galli* [23].

Cluster 2. The second cluster (green) consists of the keywords allelochemicals, phenolic acids, root exudates, and weed suppression. This cluster discusses studies on the biochemical mechanisms of rice allelopathy, particularly the identification of allelochemical compounds and root exudates as weed suppression factors. Phenolic acids are important allelochemical compounds that play a role in weed control [24], while physiological factors including roots and hormones can also increase allelopathic potential [25].

Cluster 3. The third cluster (blue) relates to weed control, with the keywords weed control, herbicides, and weeds appearing. This cluster shows the relationship between allelopathy and conventional weed control systems, including the use of herbicides.

According to the results, research on allelopathy in rice shows a focus on the interaction between rice plants and *E. crus-galli* as the dominant weed in rice cultivation, the process of identifying and understanding the mechanism of allelochemicals, and the development of more environmentally friendly weed suppression strategies. Overall, research trends point toward the use of allelopathy as a biological approach in sustainable weed control systems. In general, this study reviews rice allelopathy as a promising strategy for sustainable agriculture, with various allelochemical compounds—such as phenolic acids, fatty acids, indoles, and terpenes—released by rice plants through root exudates and decomposed residues, which inhibit the growth of nearby plants [26].

4. Conclusion

This bibliometric analysis explores the progression and intellectual structure of research on rice allelopathy in for weed management based on 80 papers published between 2000 and 2026. The

results indicate fluctuating publication growth, reflecting increasing scientific attention to allelopathy as a sustainable alternative for weed control. The evaluation highlights *Allelopathy Journal* and *Journal of Chemical Ecology* as leading publication outlets, while Ill-Min Chung and Hisashi Kato-Noguchi emerge as prominent contributors to the field. At the country level, China, the United States, and Japan demonstrate the highest scientific impact, highlighting their central roles in advancing rice allelopathy research. Keyword clustering revealed three interrelated themes: (1) the ecological interactions between rice and the major weed species *Echinochloa crus-galli*; (2) the biochemical basis of allelopathic activity, including the characterization of allelochemicals and root-derived exudates; and (3) the formulation of environmentally sustainable weed control strategies. This study provides a comprehensive overview of research trends, key contributors, and thematic evolution in rice allelopathy. It also identifies critical gaps, particularly the need for large-scale field validation and practical integration into sustainable weed management systems. These insights provide a strategic foundation for future scientific inquiry and policy formulation in environmentally friendly weed control.

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