Bibliometric Analysis of Pesticide Residues in Soil-Vegetable System on CiteSpace

Jing Jiang [#], Shuang Cui *[,#], Lianghe Lv [#], Jianyu Jiang and Ziyue Zhu

College of Environmental and Chemical Engineering, Shenyang Ligong University, Shenyang 110159, China
[#] These authors contributed equally to this work and should be considered co-first authors

Abstract. In order to ensure the improvement of crop yield, the use of pesticides has gradually increased, resulting in a large number of pesticide residues in environmental media such as soil. In this paper, the data are derived from the Web of Science (WOS) database, and the literature in the field of soil-vegetable pesticide pollution from 2001 to 2024 is visually analyzed by using CiteSpace 6.1.R6 visualization software, and the current status and future development trend of related research in this field are discussed. The results show that the number of papers published in the field of soil-vegetable pesticide pollution is generally on the rise, and China, the United States, India and other countries have the largest number of papers, and the research institutions are mainly the Chinese Academy of Agricultural Sciences and the Ministry of Agriculture and Rural Affairs. From the keyword center and frequency analysis, the main research hotspots are pesticide residues, detection methods and degradation mechanisms in soil-vegetables. From the perspective of keyword prominence analysis, the important direction of future research in this field will focus on the food safety of pesticide residues and sustainable agriculture.

1 Introduction

With the world's population expected to reach 9.15 billion to 9.51 billion by 2050[1], the demand for agricultural products such as grains and vegetables is also increasing, and the use of pesticides in modern cultivation is inevitable in order to ensure the availability of food and vegetables. Pesticides mainly include insecticides, herbicides, fungicides, etc. [2], and 108 insecticides, 30 fungicides, 39 herbicides, 5 acaricides, and 6 different types of rodenticides have been used in developing countries [3], among which insecticides are the most used in developing countries, and herbicides are more widely used in industrialized countries [4-5]. Global pesticide use has increased by more than 40% over the past two decades, stabilizing at around 4.1 million tonnes per year since 2017 [6]. However, it is estimated that only about 0.1% of pesticides are effective against target pests, while more than 90% of pesticides enter environmental media through various routes [7]. Pesticides are persistent, toxic, bioaccumulative, and lipophilic [8], and excessive pesticide diffusion into the environment can lead to soil degradation, deterioration of agroecosystems, groundwater pollution, potential threats to animal and human health and safety, and problems such as residues and pesticide resistance in target organisms [9]. At present, there are many studies on pesticide pollution residues, but the statistical analysis of pesticide residues in vegetables and soil using bibliometric data is rarely reported. Based on Citespace 6.1.R6, the study took Web of Science as the database, with the themes of "pesticide", "herbicide", "vegetable", "soil", etc., and carried out analysis according to the selected range of literature, and identified influential authors, institutions and countries, key citations, and high-frequency and emerging keywords.

2 Data Sources and Research Methods

2.1 Data Sources

The literature data of this study were selected from the Web of Science TM Core Collection in the Web of Science (WOS) database, A total of 1944 articles were retrieved from 2001 to 2024.

2.2 Research Methods

In this paper, CiteSpace (6.1.R6) and Origin 2021 were used for quantitative analysis.

3 Results and Analysis

3.1 Analysis of the number of publications

Fig. 1 is the statistical chart of the annual number of papers published in the first half of 2001-2024, from which it can be seen that in general, in the WOS database, the number of papers published in this field is less in the period from 2001 to 2014 and the trend of the number of papers published is stable, not every year there are articles

*Corresponding author's email: ccshuang@163.com

published, there is a fault phenomenon after the publication in 2001, and the articles continue to be included in 2005; Since 2015, the number of published papers has increased significantly; From 2015 to 2024, there are articles published in this field every year, and the number of published papers has shown an overall upward trend since 2015. It showed that since 2015, more and more attention has been paid to soil-vegetable pesticide residues and other related issues at home and abroad.

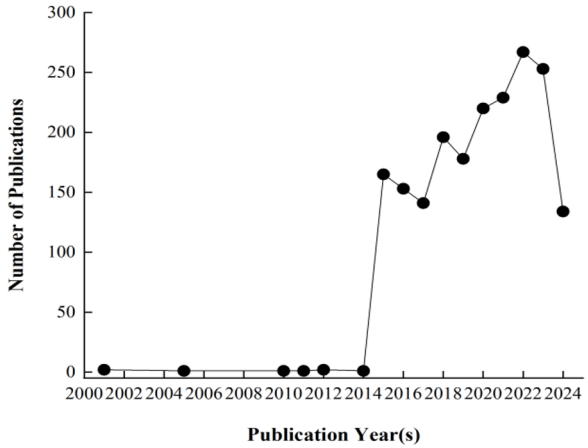

Fig. 1. The Temporal Distribution Trend of Published Literature.

3.2 CiteSpace Knowledge Graph Analysis of Collaborating Authors

Fig. 2. Visualization of Collaborating Authors.

Using CiteSpace to analyze the group of authors in the field of soil-vegetable pesticide residues, it was found that Dong Fengshou, Zheng Yongquan, Liu Xingang, Xu Jun and Wu Xiaohu were the five authors with the largest number of published papers, all of whom published more than 25 papers. As shown in Fig. 2, the results of CiteSpace's analysis show that the overall author population distribution is relatively scattered, among which the five authors with the largest number of published papers are from the same team, which has made great contributions to the development of this field. In addition to this team, there is also a team with Wang Minghua as the core, whose team also has a certain influence in this field; There are also some small-scale teams, and their influence should not be underestimated; The close connection between the authors within the group proves that the cooperation is close, and the connection between the teams but less indicates that there is less cooperation and communication between the scientific research teams, so the density of the graph network is not high, and more communication and cooperation between the scientific research teams should be carried out to promote the better development of the project.

3.3 Distribution of Publishing Journals

Table 1 was obtained by searching the literature, sorting out the research institutions in this field, and sorting the top 10 institutions in terms of the number of published papers, as shown in Table 1, in the WOS database, the number of Chinese Academy of Agricultural Sciences has published 93 pieces, ranking first in the number of published papers, indicating that the Chinese Academy of Agricultural Sciences has a significant presence in the field and is a major research institution in this field. Ministry of Agriculture & Rural Affairs ranked second in this field, with 70 papers; The top two publishing institutions and the fourth largest number of publications, the Chinese Academy of Sciences, have similar research directions in this field, focusing on the research of organochlorine pesticides, and there is a close cooperation between the institutions. Close cooperation between institutions will be more conducive to the development of the discipline in this field, so research institutions should work more closely together in their respective research processes.

Table 1. Journals Ranking Top 10 in Article Publication.

Ranking	Research Institutions	Number
1	Chinese Academy of Agricultural Sciences	93
2	Ministry of Agriculture & Rural Affairs	70
3	Egyptian Knowledge Bank (EKB)	55
4	Chinese Academy of Sciences	46
5	Institute of Plant Protection	44
6	China Agricultural University	39
7	United States Department of Agriculture (USDA)	37
8	Nanjing Agricultural University	36
9	State University System of Florida	32
10	Indian Council of Agricultural Research (ICAR)	32

3.4 Analysis of the number of publications by every country

The top 10 countries with the largest number of papers in the field of pesticide residues in soil and vegetables are ranked in Fig. 3. China leads the way with 528 articles, followed by the United States with 235 articles, followed by India, Spain, Italy, etc.

Combined with the analysis of the state and research institutions in the field of vegetable-soil pesticide pollution research, among the top ten scientific research institutions in the WOS database, Chinese scientific research institutions account for a large part, and the

number of published papers is also far ahead of China, indicating that China, as a large agricultural country, attaches great importance to the study of pesticide pollutants and source analysis in the vegetable-soil system.

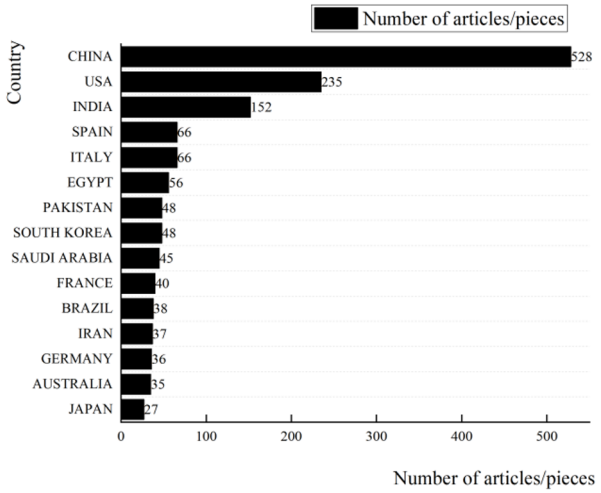

Fig. 3. Top 10 Countries by The Number of Publications.

3.5 Research Status and Hot Spots

3.5.1 CiteSpace Knowledge Graph Analysis of Keywords

Keywords are a summary of the content of the literature, and through the analysis of keywords, the research hotspots in this field can be condensed. Citespace 6.1 R6 was used to analyze and visualize the keyword co-occurrence analysis, and the keyword co-occurrence visualization map is shown in Fig. 4, among the 1944 literatures, 449 keywords were identified, and 8 keywords appeared 100 times or more. Among them, "soil" appeared the most often, with 334 times, followed by "vegetable" with 207 times, and "pesticide residue" with 162 times, indicating the importance and irreplaceability of these keywords in the research field. In addition, the frequency of "degradation", "pesticide" and "growth" followed closely behind, which can be regarded as a research hotspot.

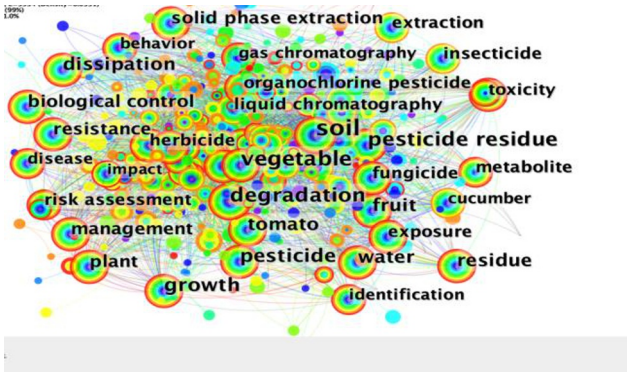

Fig. 4. Keyword Co-occurrence Network Map.

3.5.2 Keyword cluster analysis

A cluster analysis of CiteSpace keywords was performed for papers published in WOS between 2001 and June 2024. In order to highlight the research theme in this field, this study selects LLR algorithm to extract cluster labels, and performs cluster analysis on the keywords of 1944 literatures, as shown in Fig. 5. Keyword clustering parameters are as follows: Q = 0.4308 (> 0.3), S = 0.7513 (> 0.5). Q > 0.3 indicates that clustering is effective, S > 0.5 indicates that clustering is reasonable, and S>0.7 indicates that clustering is credible [10]. Therefore, it can be seen that the clustering results of 7 key words in the literature in this study are satisfactory and credible.

As can be seen from clustering Fig. 5, 6 of the 7 clustering blocks with different colors overlap to varying degrees, and the overlap area indicates that the clusters are closely related. Among them, #0, #2 and #4 are the main research objects; #1, #5 and #6 are the main research methods; #3 is the role of pesticides.

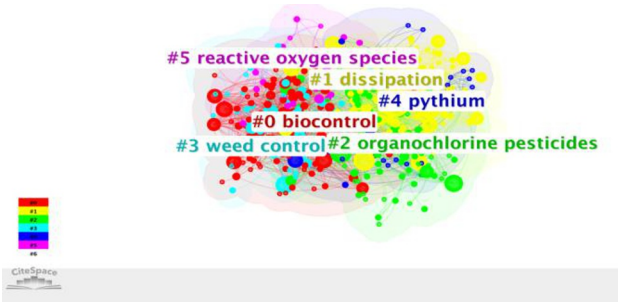

Fig. 5. Keyword Clustering Map.

3.5.3 Keyword emergence analysis and time line distribution

CiteSpace 6.1.R6Advanced was used to draw the time line map based on keyword clustering (Fig. 6), and the top 20 keywords with outbreak intensity were highlighted (Fig. 7).

According to the keyword clustering timeline, it can be found that the keyword distribution time zones contained in each cluster label are mainly 2001-2005 and 2012-2022. The first stage is the initial stage of research in this field, which presents few keywords. The second stage: Since 2012, the keywords have been continuously distributed. For the rapid development of research, the types of pesticides studied are more abundant, the detection methods of pesticides are more mature, and the risk assessment and management system of pesticides are more perfect.

Fig. 7 shows the results of sudden detection for high-frequency keywords, and the time period of strong outbreak keywords is mainly distributed in the second stage of each keyword's time line. As can be seen from Fig. 7, tandem mass spectrometry is the key word with the highest emergence intensity in this field. The research focus has shifted from detection means to research objects, and gradually shifted to food safety and sustainable agriculture in recent years.

Fig. 6. Keyword Timeline Map.

Top 25 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2001 - 2024
polychlorinated biphenyls	2015	4.6	2015	2017	
multiresidue method	2015	3.68	2015	2017	
tandem mass spectrometry	2015	10.42	2016	2018	
weed control	2016	3.11	2016	2018	
water samples	2017	4.11	2017	2018	
adsorption	2015	4.12	2018	2019	
populations	2018	3.19	2018	2019	
responses	2018	3.05	2018	2020	
performance liquid chromatography	2015	3.09	2019	2020	
integrated pest management	2020	4.39	2020	2021	
lettuce	2015	4.05	2020	2021	
mechanisms	2015	3.45	2020	2021	
validation	2020	3.41	2020	2021	
oxidative stress	2017	5.02	2021	2024	
food safety	2019	4.41	2021	2024	
induction	2021	4.27	2021	2024	
in vitro	2019	4.65	2022	2024	
essential oils	2022	4.02	2022	2024	
silver nanoparticles	2019	3.66	2022	2024	
sustainable agriculture	2022	3.62	2022	2024	
roots	2022	3.22	2022	2024	
stress	2022	3.22	2022	2024	
solanum lycopersicum	2022	3.22	2022	2024	
sensitivity	2020	3.15	2022	2024	
meloidogyne incognita	2015	3.04	2022	2024	

Fig. 7. Keyword Collocation Map.

4 Conclusions

Using the visualization software CiteSpace6.1.R6, this paper analyzed the samples of 1944 research papers and reviews, and found that the number of published papers in the field of soil-vegetable pesticide pollution was on the rise in general; China, the United States and India were the countries with the largest number of published papers. The research institutions are mainly Chinese Academy of Agricultural Sciences and Ministry of Agriculture and Rural Affairs, and China is far ahead in the breadth and depth of research in this field. From the keyword center and frequency analysis, the main research focus is the detection of pesticide residues in soil-vegetables and the degradation mechanism. The key words highlight the analysis and time line distribution, the impact of pesticide residues on food safety and how to carry out sustainable agriculture are important directions for future research in this field.

Acknowledgements

This work was financially supported by Basic scientific research project of Liaoning Provincial Department of Education (General Project), Special fund for basic scientific research business expenses of undergraduate universities in Liaoning Province (JYTMS20230179) and Shenyang Scientific Plan Project (21-109-3-06).

References

1. Bremner J, Frost A, Haub C, et al. World population highlights: Key findings from PRB's 2010 world population data sheet[J]. Population Bulletin, 2010,65(2):1-12.
2. Nayak P, Solanki H. Pesticides and Indian agriculture—a review[J]. Int J Res Granthaalayah, 2021, 9(5): 250-263.
3. Moreno J L F, Liébanas F J A, Frenich A G, et al. Evaluation of different sample treatments for determining pesticide residues in fat vegetable matrices like avocado by low-pressure gas chromatography–tandem mass spectrometry[J]. Journal of Chromatography A, 2006, 1111(1): 97-105.
4. Liu Y, Ma Z, Liu G, et al. Accumulation risk and source apportionment of heavy metals in different types of farmland in a typical farming area of northern China[J]. Environmental Geochemistry and Health, 2021,43:5177-5194.
5. Zhang J, Wang Y, Hua D. Occurrence, distribution and possible sources of organochlorine pesticides in peri-urban vegetable soils of Changchun, Northeast China[J]. Human and Ecological Risk Assessment: An International Journal, 2017, 23(8): 2033-2045.
6. Canton H. Food and agriculture organization of the United Nations—FAO[M]//The Europa directory of international organizations 2021. Routledge, 2021: 297-305.
7. Liu B, Wang Y, Yang F, et al. Construction of a controlled-release delivery system for pesticides using biodegradable PLA-based microcapsules[J]. Colloids and surfaces B: biointerfaces, 2016, 144: 38-45.
8. Khan N, Yaqub G, Hafeez T, et al. Assessment of health risk due to pesticide residues in fruits, vegetables, soil, and water[J]. Journal of Chemistry, 2020, 2020(1): 5497952.
9. Zheng T, Chen K, Chen W, et al. Preparation and characterisation of polylactic acid modified polyurethane microcapsules for controlled-release of chlorpyrifos[J]. Journal of Microencapsulation, 2019, 36(1): 62-71.
10. Chen C. CiteSpace II: Detecting and visualizing emerging trends and transient patterns in scientific literature[J]. Journal of the American Society for information Science and Technology, 2006, 57(3): 359-377.