

Bibliometrics-based Visualisation of Research on Peach Tree Fertilization



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Abstract: In order to deeply solve the research focus, development status and hotspots in the field of peach tree fertilisation, and to provide a reference for the future research and development direction of peach tree fertilisation practice. In this paper, based on CNKI and Web of Science core paper databases, we searched the relevant literature during 2000-2024, and using analysis tools such as VOSviewer and CiteSpace, we carried out visual analysis of the number of articles, issuing institutions, authors, as well as keyword co-occurrences, clustering, and emergence, etc., and drew a knowledge map in the field of peach tree fertilisation. The results show that in recent years, peach tree fertilisation has become the most important topic in the field. The results show that the research on peach tree fertilization has made remarkable progress in recent years, especially in improving fruit quality, optimizing fertilization strategies, and reducing environmental pollution, which has become a research hotspot. The number of articles published per year shows a general upward trend, and a large-scale research team and research institutions have been formed. Keywords such as "yield", "quality" and "soil nutrients" are still the hot spots of current and future research. It is expected that "formula fertilization", "biofungi fertilizer", "bag-controlled slow-release fertilizer" may become the hot research direction in the field of peach tree fertilization.

Keywords: Peach Tree Fertilisation; Bibliometrics; Visual Analysis; CiteSpace; VOSviewer

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1 Introduction

Peach (*Prunus persica* L.) is one of the major fruits grown in China as a plant of the genus *Prunus* L. in the family Rosaceae [1]. Its delicate and juicy flesh, sweet flavour and unique taste are highly favoured by consumers, and it is therefore called the "treasure of fruits". As an important producer in the global peach industry, China's peach production continues to maintain a leading position in the world. According to the statistics of 2024, the cul-

tivated area of peach in China has reached 2.1×10^6 hm², with an annual production of about 5.1×10^7 t, maintaining a central position in the global supply chain [2].

Peach yield and fruit quality are closely related to the nutrient conditions of the fruit tree, and nutrient regulation of peach trees is mainly achieved through the synergy of fertilisation and pruning [3]. A large number of studies on the yield effect of peach tree fertiliser application have

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shown that the amount of fertiliser applied has a significant dose-effect relationship with yield, and when peach trees absorb mineral elements in an imbalance (deficiency or excess) during the phenological period, it will lead to the imbalance of nutrient growth and reproductive growth, which will in turn affect the process of fruit development [4]. Fertilisation significantly increased the fruit set rate (18-25%) and fruit weight (15-20g) of peach trees, and quality indicators such as soluble solids content (SSC) and fruit hardness were significantly ($p < 0.05$) regulated by different NPK ratios [5]. Precise application of fertiliser at key seasonal stages (budding, hardening and expansion) optimised the balance of carbon and nitrogen metabolism in peach trees, resulting in a 12-15% increase in yield while improving the sugar-acid ratio by 0.8-1.2 [6]. The response of different peach varieties (e.g., White Phoenix peach, Lakeview Honeydew) to the fertilisation programme varied significantly ($CV > 25\%$), and their optimal treatment combinations could lead to a yield per unit area exceeding $37.5\text{t}/\text{hm}^2$ [7]. Under the standing conditions of soil acidification ($\text{pH} < 5.5$) and organic matter scarcity ($< 1.2\%$) prevalent in peach orchards in China, the implementation of organic-inorganic rationing technology could increase fruit palatability by 8-10 percentage points, while reducing nitrogen loss rate by 34-40% [8]. By establishing a precision fertiliser application system based on analytical diagnosis of peach trees, not only can the economic benefits of peach orchards be improved (net income increased by 12-18,000 yuan/ hm^2), but also the annual increment of soil carbon pools of 0.3-0.5 g/kg can be achieved, which provides technical support for the sustainable development of the peach industry [9].

In recent years, relevant research in the field of peach tree fertilisation has been very active, and the experimental research results of a large number of scholars have promoted the high-quality development of the peach tree industry, so the importance of using bibliometrics to systematically analyse the issue of peach tree fertilisation is becoming more and more prominent. Bibliometrics uses mathematical and statistical methods to take the external characteristics of the literature as the object of study, and by means of quantitative analysis, objectively describes, scientifically evaluates, and effectively predicts the development trend of a specific research field [10]. At present, this method has been widely used in agricultural production research, such as scholars through bibliometric analysis reveals the current situation of peach fertiliser application research, analyse the existing problems and put forward the future development direction,

which provides an important reference to promote the green and efficient production of peach trees. Based on this, this paper applies bibliometric methods to comprehensively sort out the peach tree fertiliser application literature in the core collection database of China Knowledge Network (CNKI) and Web of Science during 2000-2024, and visually analyse the spatial and temporal distribution, quantitative characteristics and knowledge map of the literature with the help of VOS viewer and CiteSpace software to systematically summarise the peach tree fertiliser application research status and the future development direction. The research progress, hot spot and development trend in the field of peach tree fertilisation are systematically summarised to provide a scientific basis for the theoretical innovation and disciplinary development of peach tree fertilisation research in the future.

2 Data Sources and Research Methodology

2.1 Data Sources

Academic papers are the main way for scholars to present their research results, while journal papers, especially academic journals, become the main vehicle for understanding the status of research in the discipline and trends in the subject matter. The research data of this paper two databases: the core ensemble database in China Knowledge Network (CNKI for short) and Web of Science (WOS for short). For the Chinese data, we chose the relevant literature on peach tree fertilisation research included in CNKI; in the advanced search page, we only ticked the option of journals. For the subject terms, "peach, fertilisation" or "peach, fruit quality" or "peach, soil nutrients" or "peach, yield" or "peach, fruit quality" were filled in. "Peach, fertiliser" or "Peach, fruit quality" or "Peach, soil nutrients" or "Peach, yield" or "Peach, nitrogen, phosphorus and potassium ratios" and other combinations. The indexing period was set from 1 January 2000 to 31 December 2024. After checking the abstracts and manually removing the invalid data, and after sorting the data, finally, 378 Chinese valid literatures were identified. The English data in this paper were selected from the core collection database of WOS, and searched with the subject term of "Peach * fertilization", the type of literature was selected as Article, the language was selected as English, and the indexing time was also set as 1 January 2000 to 31 December 2023, and the indexing time was also set as 1 January 2000 to 31 De-

cember 2023. The indexing period was also set from 1 January 2000 to 31 December 2023, and a total of 299 articles were obtained through the screening process. The date of search was 19 March 2025, and the indexing period was also set from 1 January 2000 to 31 December 2023.

2.2 Research Methodology

Cite Space, as a knowledge graph construction tool developed on Java platform, dynamically tracks the evolution paths and key turning points of research hotspots in the field by generating visual maps such as keyword emergence, time zone evolution, etc., which provides technical support for identifying disciplinary fronts [11]; VOS viewer relies on its multi-dimensional network parsing capability, and employs clustering algorithms to quantitatively model the subject matter, relevance, and intensity of institutional cooperation of the literature data [12]. Relying on its multidimensional network analysis capability, VOS viewer uses clustering algorithm to quantitatively model the relevance and intensity of institutional cooperation in the literature data, and visually presents the characteristics of the domain knowledge structure through the heat map and density view, and its interactive visual interface significantly improves the interpretation efficiency of the complex data. The study integrates the literature data of peach tree fertilisation from China Knowledge Network (CNKI) and Web of Science core databases from 2000 to 2024, completes the literature screening and metadata standardisation through Note Express, combines with Excel to achieve the authors' distribution, frequency statistics of high-frequency keywords, and the construction of co-occurrence matrices, and then applies Cite Space to map

the authors' cooperation network and keyword time-zone evolution. Then, Cite Space was used to map the author cooperation network and keyword time zone evolution, and VOS viewer was used to generate the three-dimensional density view of institutional co-occurrence network and thematic clustering. Through the cross-validation of the above multi-dimensional analysis techniques, the spatial distribution characteristics of the core academic community in the field of peach tree fertilization, the temporal evolution of hot topics, and the theoretical boundaries of technological innovation are revealed, and ultimately, a comprehensive academic research judgement is formed which combines the analysis of the disciplinary evolution law and practice orientation, providing a scientific basis for the theoretical innovation of peach tree fertilization and the optimization of the production practice.

3 Literature Analysis

3.1 Volume and Temporal Characteristics of Publications

The annual number of publications in a field can indirectly assess the development of the field and the degree of attention it receives. By observing the changes in the annual number of publications in the field, the research trend and the degree of activity in the research field can be understood. Using the year as the horizontal coordinate and the number of publications as the vertical coordinate, the trend of the number of publications in the field of peach fertilisation at home and abroad with the year was plotted (Figure 1).

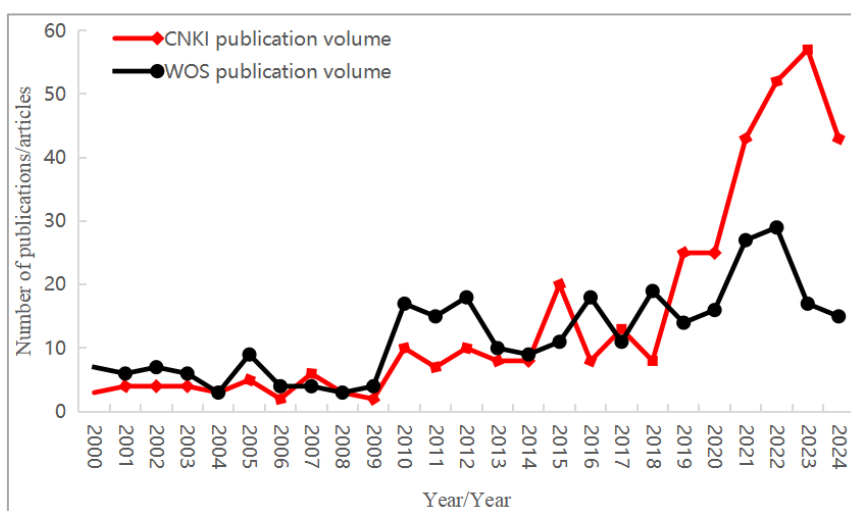


Figure 1 Distribution of annual number of publications, years in the field of peach tree fertilisation

In recent years, the overall trend of the number of articles issued in the field of peach fertilisation at home and abroad has shown an upward trend, but it has also fluctuated to a certain extent in individual years. In the WOS database, the number of publications is relatively stable, with less than 30 publications per year, among which, the number of publications in this field from 2000 to 2009 was less, all less than 10, and then began to show an upward trend, reaching a maximum of 29 publications in 2022, while the lowest number of publications was in 2008, with only 3. In contrast, the fluctuation of the number of publications in the CNKI database was larger, with the highest number of articles in 2023, 57 articles. From 2020 to 2024, the number of articles in this field generally shows an upward trend, indicating that the heat of research in this field is increasing. Combining the trend of the number of publications at home and abroad, it can be concluded that research related to peach tree fertilisation remains a hot topic for research now and in the future.

3.2 Analysis of Published Journals

In-depth analysis of literature source journals helps to accurately understand the major published journals in a

specific research field, thus providing guidance for researchers to select appropriate journals for submission and reading, and further promoting the research progress in this field [13]. With the help of Note Express literature management software, 378 journals selected from CNKI were statistically analysed, and Table 1 shows the top 10 journals in terms of the number of articles published in the research on peach tree fertilization in China from 2000 to 2024, with the main type of journals being agricultural science and technology journals. The journals with higher amount of publications were Anhui Agricultural Science, China Fruit Industry Information, Northern Fruit Tree, Agricultural Science and Technology Newsletter, China Soil and Fertiliser, Fruit Tree Practical Technology and Information, Northern Horticulture, Fruit Farmer's Friend, Agricultural Engineering Technology and Southern Agriculture, and the highest amount of publications were Anhui Agricultural Science and China Fruit Industry Information, which reached a total of 16, with a proportion of 4.22% and a proportion of 4.22%. The lowest number of articles was in Southern Agriculture, with only 5 articles, but its impact factor was 0.38.

Table 1 Top 10 journals in the field of peach fertilisation in China

Published Journals	Number of articles	Area share (%)	citations (times)	Integrated 2023 Impact Factor
Anhui Agricultural Science	8	2.11	28	0.494
China Fruit Industry Information	8	2.11	4	0.98
Northern Fruit Tree	7	1.85	22	0.51
Agricultural Science and Technology Newsletter	7	1.85	18	0.179
China Soil and Fertiliser	7	1.85	36	2.246
Fruit Tree Practical Technology and Information	6	1.58	3	0.16
Northern Horticulture	6	1.58	78	1.013
Fruit Farmer's Friend	6	1.58	3	0.22
Agricultural Engineering Technology	6	1.58	1	0.189
Southern Agriculture	5	1.32	8	0.38

3.3 Analysis of Literature Authors

As the cornerstone of scientific research, authors play a pivotal role in the academic field. In-depth analysis of authors can help us gain a more accurate insight into the core group of authors with high academic reputation and influence in a certain field, and explore their key role in promoting academic progress [14]. By systematically analysing the co-occurrence network of authors, we are able to explore in detail the mode of co-operation between different authors in the field, the degree of closeness, and the

dynamics of such co-operation over time. The results of the statistical analysis of the data showed that the cumulative citation frequency of the 378 journals selected in this study was as high as 1928 times in Knowledge.com, which fully demonstrated that the research results of the previous authors have had a far-reaching impact in the field of peach tree fertilisation research in China. The authors who ranked the top 8 in terms of the number of publications in the field of peach tree fertilisation in China from 2000 to 2024 were further counted (Table 2), and the authors' collaborations were mapped (see Figure 2). Among them, Peng Futian and Zhang Yafei had the highest number of publications,

reaching 6 articles each, accounting for a total of 4.22% of the total number of publications, and his research results provided a solid theoretical foundation for subsequent research in the field of peach tree fertilisation. In the network analysis of the author collaboration mapping in Figure 2, it can be clearly seen that the research in the field of peach tree fertilisation mainly focuses on the core authors for collaboration, for example, authors such as Peng Futian, Zhang Yafei, and Wang Guodong have formed their own collaboration network. However, it is also noted that there is relatively little cross-team collaboration between the core author teams. In the future, if the objective conditions permit, we can focus on strengthening the cooperative interac-

tion and communication frequency among the core authors. By building a more diversified and efficient communication platform, the potential for cooperation among academic teams can be fully stimulated and the effect of cooperation can be maximised. We will actively promote the extensive sharing and in-depth exchange of research results to form an academic atmosphere of mutual inspiration and synergy, thus injecting a strong impetus into the innovation of peach tree fertilization technology, significantly shortening the transformation cycle from innovative results to practical application, and comprehensively accelerating the innovation process and popularization and application of peach tree fertilization technology.

Table 2 Top 8 authors in the field of peach tree fertilisation in China

Author	Number of publications/article	% of total number of communications
PENG Futian	6	1.58
Zhang Yafei	6	1.58
Yang Jigang	4	1.06
Gong Peng	3	0.79
Gao Yanmin	3	0.79
Wang Guodong	3	0.79
Li Zhengqiang	3	0.79
Zhou Deping	3	0.79

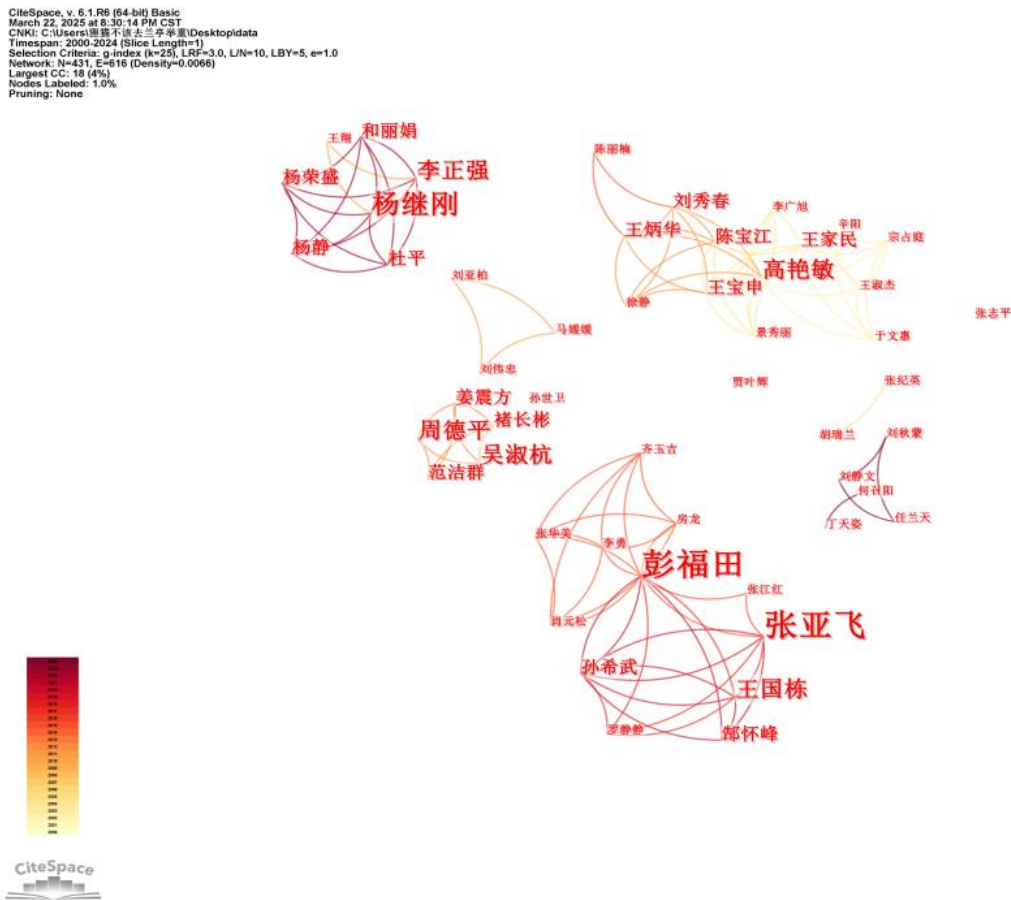


Figure 2 Mapping of author collaborations in the field of peach tree fertilisation

Table 3 Top 10 research institutes in the field of peach tree fertilisation in China with the highest number of publications

Mechanism	Number of publications/article
Shandong Agricultural University	11
Central South University of Forestry Science and Technology	11
Zhengzhou Institute of Fruit Tree Research, Chinese Academy of Agricultural Sciences	4
Fruit Tree Research Institute, Chinese Academy of Agricultural Sciences	4
Lijiang Soil Fertiliser Workstation	4
Liaoning Fruit Tree Research Institute	4
Horticultural Crops Research Institute of Xinjiang Academy of Agricultural Sciences	4
Central China Agricultural University	4
Shanghai Pudong New District Agricultural Technology Extension Centre	3
Horticulture College of Shanxi Agricultural University	3

4 Analysis of Research Hotspots in the Field of Peach Tree Fertilisation

4.1 High-frequency Keyword Analysis

As a semantic unit characterising the knowledge structure of a discipline, the co-occurrence law of keywords can systematically reveal the theoretical framework and development of the research in the field. Through in-depth analysis of keywords, we can quickly understand the research hotspots and future development direction in the field [17]. As can be seen from Table 4, in the CNKI database, "yield", "quality", "fruit quality" are the keywords with the highest frequency, reaching 57 times, 40 times, 27 times, respectively. The keywords "yield", "quality" and "fruit quality" appeared most frequently, 57, 40 and 27 times, respectively. Fruit yield and quality are important indicators for the evaluation of the benefits of fertiliser application, which

highlights the effectiveness of fertiliser application measures. In the WOS core collection database, "prunus persica", "yield" and "growth" were the most frequently occurring keywords. 29, 28 and 27 times, respectively. As the condensed expression of the core content of the article, keywords can reflect the research hotspot of a specific field to a large extent. By comparing and analysing the high-frequency keywords in the databases of China Knowledge Network (CNKI) and Web of Science (WOS), it is easy to find that at this stage, China's fruit tree industry is in a critical period of transformation and upgrading. From the point of view of research dynamics, the focus of attention at home and abroad has gradually transitioned from the effect of fertilisation on peach tree yield to the role of fertilisation on peach tree fruit quality. Soil quality, as an important indicator of the ability of soil to supply nutrients to crops, plays a decisive role in the productivity and competitiveness of green agriculture. As the living standard of the population continues to improve, more and more scholars are focusing on research on fruit quality optimisation and soil nutrient assessment.

Table 4 Top 8 keywords in the field of peach tree tree fertilisation

Chinese Keywords	Frequency/times	English Keywords	Frequency/times
Yield	57	prunus persica	29
Quality	40	yield	28
Fruit quality	27	growth	27
Soil nutrients	23	fertilization	20
Organic fertiliser	18	management	16
Fertilisation	16	fruit quality	15
Peach Tree	15	peach	15
Nectarine	9	soil	13

4.2 Keyword Co-occurrence Analysis

Keyword co-occurrence analysis, as a crucial research method in bibliometrics, is used to build a visual map of the

co-occurrence network, which can methodically show the correlation characteristics and dynamic evolution of core concepts in the subject area [18]. The power of this approach lies not only in its ability to quantitatively identify high-frequency hot topics and the strength of co-occurrence

between these topics, but also in its ability to deeply analyse the mediating role of key concepts based on the topology of the network. Further, in the two-dimensional presentation space of the knowledge graph, the radius of the nodes directly reflects the co-occurrence frequency of the keywords, which is like a measure that clearly presents the hotness level of the concepts; while the spatial position of the nodes depends on their mediator centrality, and the higher the mediator centrality of the concepts, the more prominent the structural holes played by the concepts in the knowledge dissemination network, and these concepts often correspond to the basic theories in the disciplinary knowledge system. Fundamental theories in a disciplinary knowledge system, or key nodes connecting different fields [19]. This research model, which integrates quantitative statistics and network topology analysis, on the one hand, provides researchers with dual quantitative indicators for assessing the importance of the topic, making the assessment more scientific and accurate; on the other hand, it also expands the methodological scope of detecting the dynamics of the research frontiers and predicting the paths of knowledge growth, and provides a new way of thinking and direction for the in-depth development of academic research.

4.2.1 Domestic Research Hot Spots and Keywords

As can be seen from the co-occurrence mapping of

Chinese keywords in Figure 4, high-frequency keywords such as "peach", "yield", "fruit quality", "soil nutrients" and other high-frequency keywords are closely linked to each other, which indicates that the research in the field of domestic peach tree fertilization has developed from the pursuit of high fruit yield to the direction of high quality, in which the impact of fertilization on peach fruit yield and quality is a research hotspot, and the "formulated fertilizer", "biofungi fertilizer The effects of "formula fertilization", "biofungi fertilizer" and "bag-controlled slow-release fertilizer" on fruit quality [20] and orchard soil [21] have also become a new development direction in this field.

4.2.2 Foreign Research Hot Spots and Keywords

From the co-occurrence map of English keywords in Figure 5, it can be seen that "fertilisation", "growth", "nitrogen", "prunus persica", "peach" and other high-frequency keywords are closely related to each other, "prunus persica", "peach" and other high-frequency keywords are closely related to each other, indicating that the hotspots in the field of peach tree fertilization in foreign countries are mainly focused on fruit tree fertilization technology, fruit tree yield and quality, etc. In recent years, more and more scholars began to focus on the study of fertilisation on fruit quality [22] and soil [23].

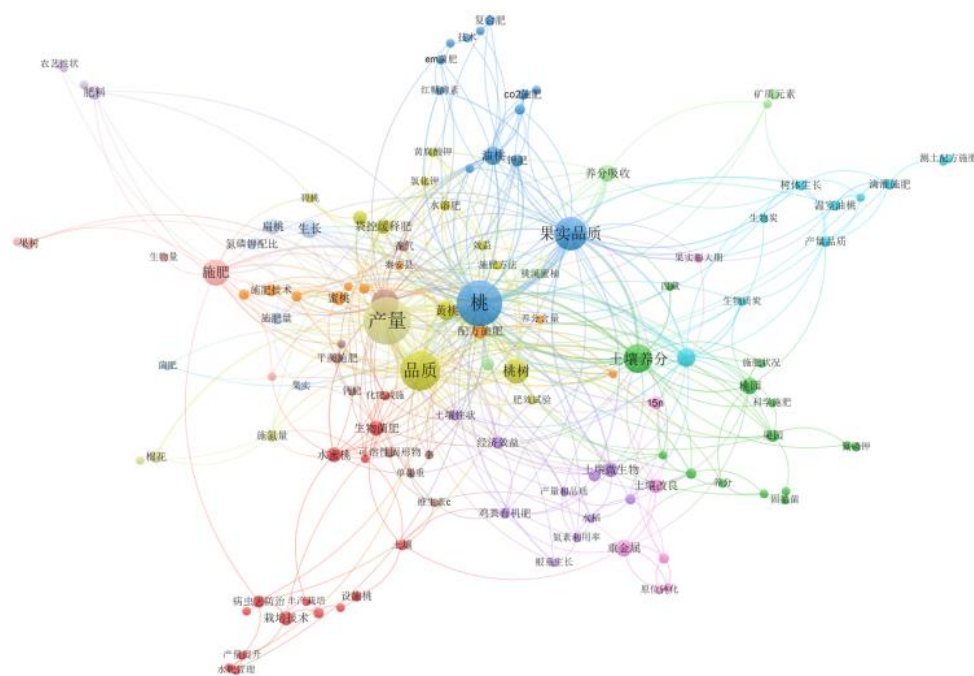


Figure 4 Keyword co-occurrence network based on CNKI peach tree fertilisation study

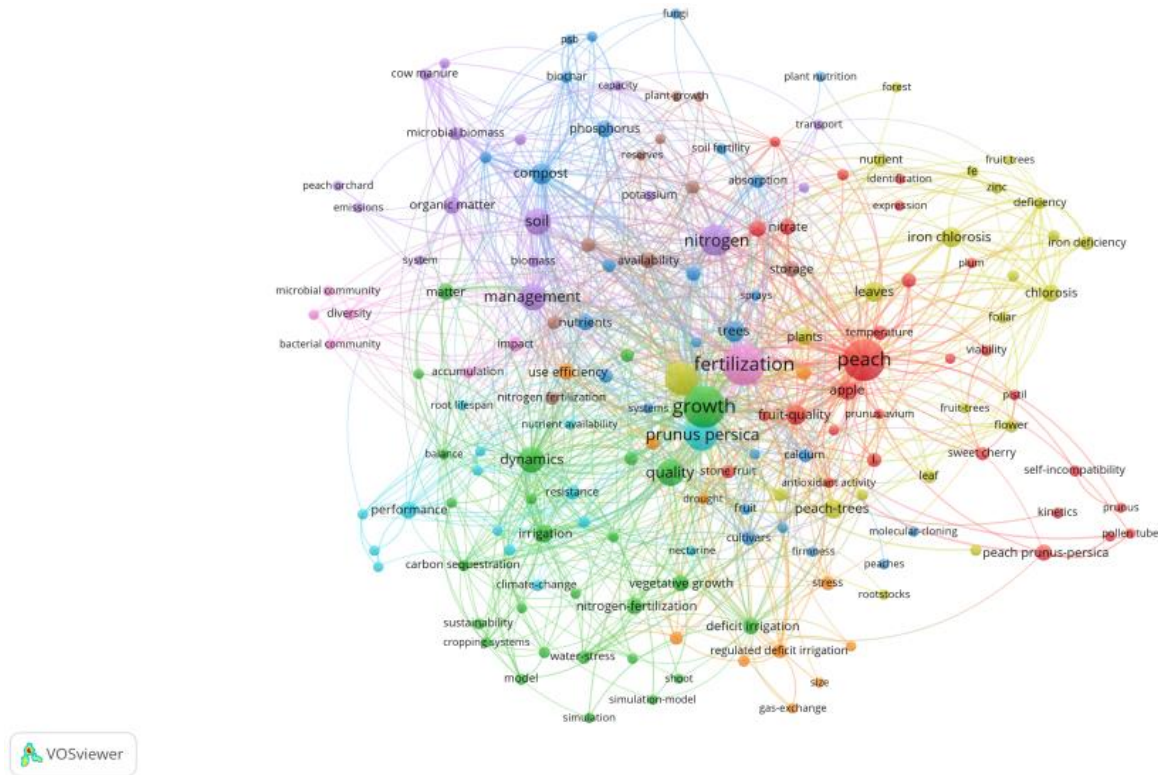


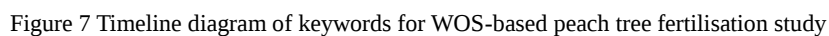
Figure 5 Keyword co-occurrence network based on WOS peach tree fertilisation study

4.3 Keyword Emergence Analysis

The CNKI and WOS databases were visualised and analysed using Cite Space software to draw keyword timeline graphs (Figures 6 and 7) and keyword emergence graphs (Figures 8 and 9). With the help of the keyword timeline, we are able to gain a clear insight into the changing dynamics of keywords over the years. By sorting out these changes, it not only helps to grasp the development of the field and analyse its historical evolution, but also reasonably speculate the possible future research direction based on the existing trends. As another important dimension of analysis, emergent terms refer to keywords or terms that show a significant jump in frequency of occurrence in a specific period of time compared with the previous period [24]. By identifying emergent words, researchers can quickly capture the research themes that the academic community focuses on during a specific period of time, pinpoint the research hotspots, and help anchor the direction of the research work.

The research themes in the field of domestic peach tree fertilisation are evolving, among which quality, yield, and organic fertilisation studies have a long time span and high number of publications, mainly including long-term

studies on the yield, quality and soil nutrients of peach trees by different fertilisation treatments, as well as discussions on economic and ecological benefits. The keywords that are still in the emergent state as of 2024 include organic fertilizer, indicating that fertilization in the field of improving soil nutrients in peach orchards is still a research hotspot of interest to domestic scholars, a result that is consistent with the results of the analysis of the keyword timeline mapping; in the past ten years, with the emphasis of the society on environmentally friendly agriculture, green fertilizer application and organic cultivation have gradually become a hotspot of research, and researchers have devoted themselves to exploring the green and organic fertilizer application scheme to reduce the use of chemical pesticides and fertilisers. While focusing on economic benefits, we are also focusing on the green and sustainable development of future orchards and moving closer to eco-friendly peach orchards. The high intensity of management and yield highlighted in the English database suggests that the study focuses on exploring the needs of peach trees for different nutrients and the effects of different fertilisation programmes on peach yield and quality.



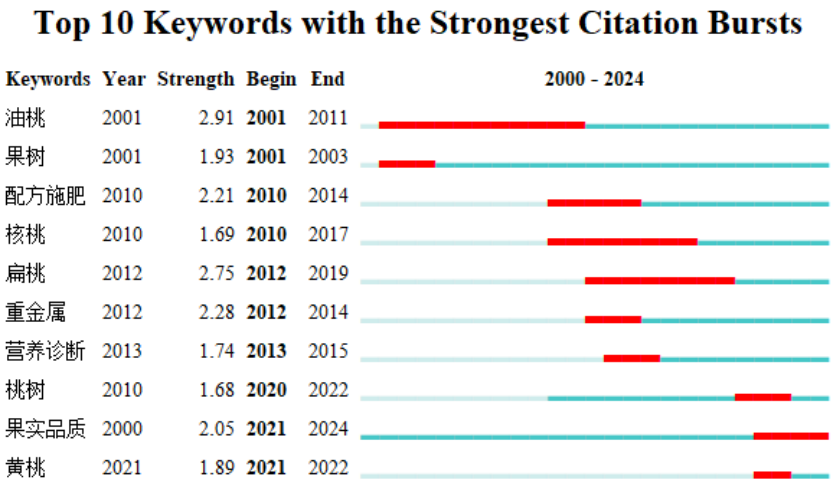


Figure 8 CNKI peach tree fertilisation emergent keywords, 2000-2024

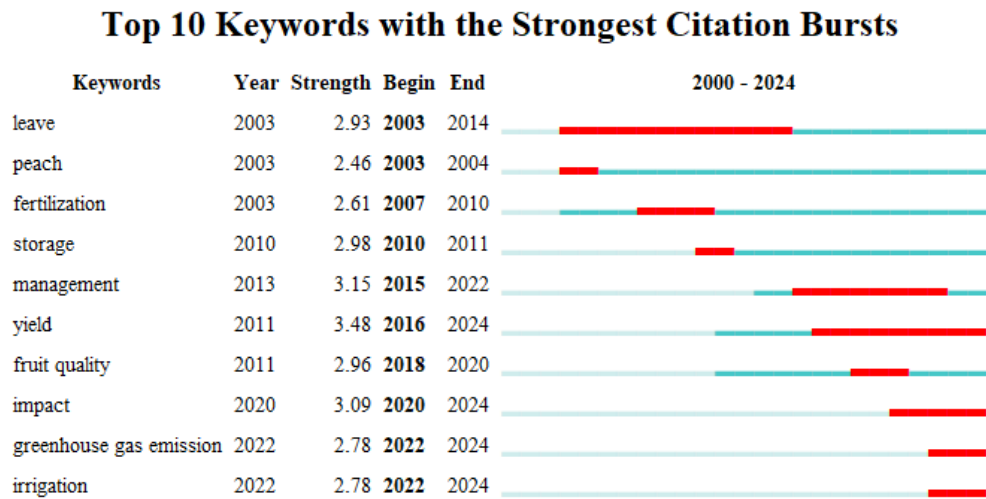


Figure 9 Keywords for WOS peach tree fertiliser emergence, 2000-2024

5 Conclusion and Outlook

5.1 Conclusion

Based on the statistical results of CNKI and WOS literature database on the number of publications from 2000 to 2024, this paper, with the help of bibliometric methods, outlines the development status, research hotspots and research frontiers in the field of peach fertilization in the past 25 years, and analyses the research dynamics of this field both at home and abroad, and draws the following conclusions.

(1) From the point of view of the number of publications, the overall trend of growth, indicating that the impact of fertilisation on peach trees is still a hot topic for research now and in the future. Domestic researchers tend to publish the relevant research re-

- sults in the core journals of the North University, showing a high level of scientific research and the influence of research results, which has strongly promoted the rapid development of this field.
- (2) In terms of the research team of peach tree fertilisation, a research team with Peng Futian, Zhang Yafei and Yang Ji gang as the core team has been formed in China. However, there is relatively little exchange and cooperation among these core teams.
- (3) In terms of the main research forces, Shandong Agricultural University, Central South Forestry University of Science and Technology, and research institutes are represented, but these institutions are more independent from each other and have less cooperation.
- (4) From the analysis of keywords, although the research hotspots are in constant change, the core of them always revolves around key topics such as

fruit yield, quality and soil nutrients.

- (5) From the analysis of emergent words, the current fruit tree quality, quality, organic fertiliser application programme, and soil nutrients are the research frontiers in the field of peach tree fertilization at home and abroad. At the same time, with the dynamic changes in research, the research on the topics of formulated fertiliser application, biofungal fertiliser, bag-controlled slow-release fertiliser, etc., has gradually become a popular direction.

5.2 Outlook

Over the past 25 years, research on peach tree fertilisation in China has continued to deepen. The consumer market's demand for high-quality fruits is increasing day by day, and the peach industry urgently needs to change from the pursuit of yield to focusing on quality. In this context, optimising soil nutrient management in peach orchards to achieve sustainable development of the cultivation system has become a research hotspot for academics at home and abroad.

Led by the concept of ecological agriculture and green development, peach tree fertilisation technology will accelerate the transition towards organicisation. The focus of future research lies in exploring the practical application effects of green fertilizers such as organic fertilizers, bio-organic fertilizers and microbial fungal fertilizers, to further enhance the nutritional quality and edible safety of peach fruits by reducing the use of chemical fertilizers and repairing the soil microbiological environment. In addition, the scientific combination of organic amendments, functional microbial agents and soil conditioners can not only improve the soil granular structure of peach orchards, but also enhance the soil nutrient storage capacity and biological activity, thus creating a soil environment conducive to the growth of peach tree roots and fruit sugar-acid ratio regulation.

With the rapid development of smart agriculture technology, remote sensing monitoring, soil sensor networks and intelligent decision-making systems will be deeply integrated to dynamically monitor and accurately regulate the physiological state and nutritional needs of peach trees, which will become an innovative breakthrough point in the digital management of peach orchards. With the help of these technologies, the construction of variable fertilisation models is expected to significantly improve the efficiency of nutrient use and promote the high-quality and sustainable development of China's peach industry.

At present, China's peach fertilization research has formed a multi-institutional collaborative pattern of research, and has made significant progress in the research and development of new fertilizers and soil improvement technology, but the academic collaboration network between the cross-regional core team has yet to be perfected, and the chain of technological achievement transformation still needs to be strengthened. In the future, it is necessary to build an innovation consortium for the deep integration of industry, academia and research, and through sharing experimental data and field validation platforms, to promote the evolution of peach tree fertilisation system towards precision, green recycling and diversification of modes, and ultimately to achieve a synergistic enhancement of the ecological, economic and social benefits of the peach orchard production system.

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