American Journal of Biochemistry and Biotechnology

Original Research Paper

Analysis of Research Progress on Peanut Disease and Insect Pest Control Based on VOS Viewer

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Article history
Received: 11-05-2024
Revised: 20-06-2024
Accepted: 15-07-2024

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Abstract: Peanut cultivation spans across more than 100 countries globally as a vital oilseed crop. Nevertheless, the menace of pests and diseases poses a threat to peanut yield and quality, consequently impeding economic prosperity. To delve into the current research landscape concerning peanut disease and pest control, this study adopts a bibliometric methodology and employs a VOS viewer for multidimensional visualization analysis of pertinent literature published between 2004 and 2023, cataloged in the WOS database. Three stages of research progression are identified: Initial, steady growth flourishing. Key areas include cultivation practices, biological control, and resistance breeding genetic studies. Biological control and genetic breeding are prominent. The US, India, and China lead research efforts, emphasizing collaboration. Recommendations include enhancing surveillance, fostering collaboration, promoting interdisciplinary research, and translating findings into practical solutions for agricultural productivity and food security.

Keywords: Peanut Disease and Insect Pest, Disease Monitoring, Disease Control, Bibliometric, VOS Viewer

Introduction

Peanut, a leguminous plant, is rich in protein, with its kernels containing an oil content of around 50% (Li *et al.*, 2022). Due to agricultural policies, technological advancements, and improvements in cultivation efficiency, the yield per unit area of peanuts has been continuously increasing (Bo-Shou, 2020). However, during the planting and maturation process, peanuts are susceptible to various diseases such as fungi, viruses, and bacteria pests, which can affect the leaves, roots, and stems of peanut plants, leading to a decrease in peanut quality and yield, thereby impacting economic returns (Essandoh *et al.*, 2022).

Peanuts are susceptible to various diseases and pests, prompting extensive research by scholars worldwide. Peanuts face various diseases caused by bacteria, fungi viruses, as well as threats from insects and nematodes. In terms of diseases, bacterial diseases such as peanut bacterial wilt (caused by Ralstonia solanacearum) lead to severe wilting and leaf damage in peanut plants. Fungal diseases include early leaf spot and late leaf spot (caused by Cercospora arachidicola and Cercosporidium personatum, respectively), as well as rust (caused by Puccinia arachidis), which spread rapidly, causing leaf drop and pod damage. Stem rot, another fungal disease caused by Sclerotium rolfsii, leads to the decay of peanut plant stems, potentially causing plant death in severe cases. Insects commonly affecting peanuts include thrips, aphids Helicoverpa moth, which feed on leaves, and flower pods, significantly impacting yield and quality. Root-knot nematodes (*Meloidogyne* spp.) among nematodes hinder nutrient uptake by damaging roots, severely affecting peanut growth and development. Scholars globally have extensively researched these diseases and pests using various approaches. Vaishnnave *et al.* (2020) utilized deep convolutional neural networks to detect and classify peanut leaf diseases. Daudi *et al.* (2021) examined the genetic diversity and population structure of peanut germplasm using phenotypic traits and SSR markers, offering insights into rust disease resistance breeding. Gong *et al.* (2022) provided a comprehensive review of peanut stem rot in China, encompassing its occurrence, distribution, pathogen characteristics, symptomatology, transmission, prevention measures progress in resistant breeding. Tang *et al.* (2022) conducted a survey on grub occurrence patterns in peanuts and proposed effective control strategies. Presently, research on peanut diseases and pests predominantly emphasizes identification and integrated pest control, yet quantitative studies and structured analyses in this domain are scarce.

Bibliometric analysis, a methodological approach for assessing academic research status and trends through statistical examination of literature data, emerges as a potent instrument for gauging research accomplishments. Li *et al.* (2021) employed mathematical statistics and bibliometrics to analyze journal articles and invention patents in the agricultural drone domain, delineating research into two primary facets: Drone platform construction and agricultural applications. Lan *et al.* (2022) utilized bibliometric methods to scrutinize the research dynamics, and frontier hotspots of smart orchards, unveiling the developmental trajectory and current landscape of smart orchard research while offering guidance for future endeavors. In order to further explore the research status and development trend in the field of peanut pests and diseases, this study adopts the method of bibliometrics to conduct research from the aspects of keywords, authors, bibliometrics, published journals and institutions, systematically analyze and summarize this field provides a reference for subsequent researchers.

Materials and Methods

Data Sources

The data for this study was sourced from the Web of Science Core Collection database (WoS). Two searches were conducted with different focuses. The first search, conducted on April 22, 2024, emphasized the identification and control of peanut diseases and pests. The search query was "(TS = (peanut AND (disease OR pathogen) AND (identify* OR monitor* OR warn* OR forecast*))) AND PY = (2004-2023)", resulting in 1019 documents. The second search, also conducted on April 22, 2024, focused on specific peanut diseases and pests. The search query was "(TS = (peanut AND ("stem rot" OR "root rot" OR "crown rot" OR "leaf spot" OR "black spot" OR "brown spot" OR " web blotch" OR "scorch spot" OR "bacterial wilt" OR "rust" OR "*Sclerotium rolfsii*" OR "scab disease" OR "root-knot nematode disease" OR "stripe virus disease" OR "common mosaic disease" OR "cutworm*" OR "grub*" OR "aphid*" OR "bollworm" OR *"Spodoptera litura*" OR "beet armyworm" OR "red spider"))) AND PY= (2004-2023)", yielding 588 documents. After screening and removing duplicates, a total of 452 relevant documents were obtained. The workflow for data processing is illustrated in Fig. (1).

Research Tools and Methods

This study employs the analytical tool VOS viewer 1.6.17 to conduct a statistical analysis of literature related to the prevention and control of peanut diseases and pests published in the Web of Science (WoS) database from 2004 and 2023. It creates knowledge maps of keyword co-occurrence, author collaboration, institutional collaboration, and document citation. By focusing on aspects such as annual publication frequency, keywords, authors, publishing institutions, journal sources, and document citation counts, the paper conducts an in-depth exploration and analysis of the research hotspots and trends in the field of peanut disease control.

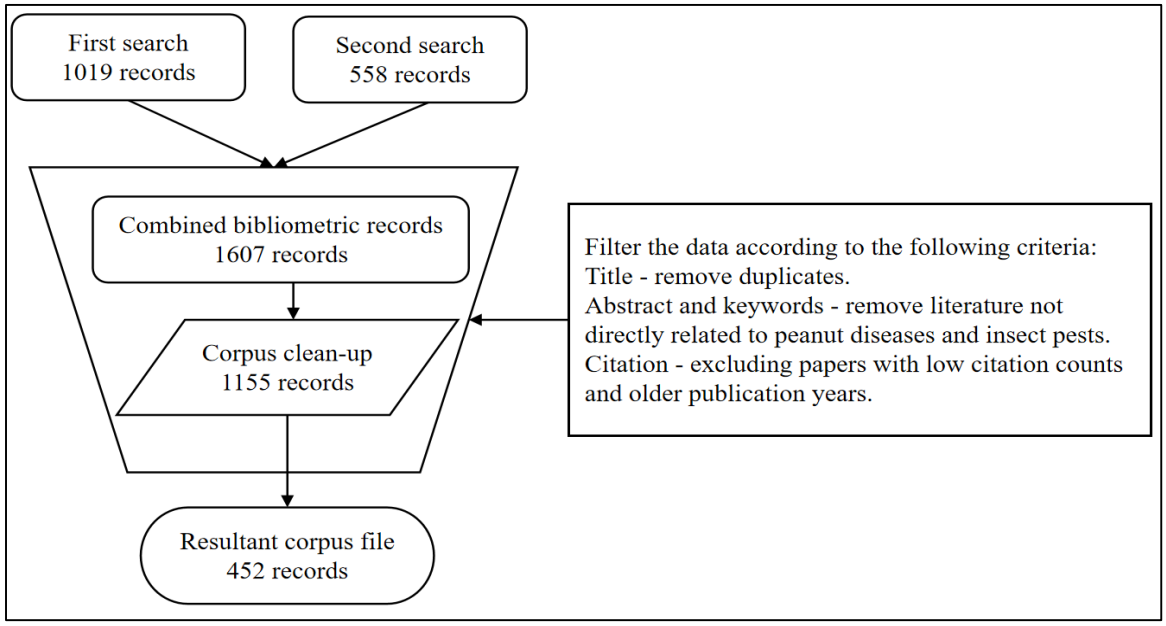

Fig. 1: Workflow to develop the corpus of publications from WoS

Results and Discussion

Development and Trends

The study collected relevant literature published in the Web of Science (WoS) from 2004 and 2023. The distribution of publications on peanut disease and pest control research over the years was statistically analyzed by publication year and quantity and a graph (Fig. 2) was plotted accordingly. The proportion of publications for each year was calculated using the formula:

$$\text{Percentage} = (\text{Record Count} / \text{Total Number of Publications}) \times 100\%$$

In this formula, record count represents the number of publications in a specific year and the Total Number of Publications represents the sum of publications across all years.

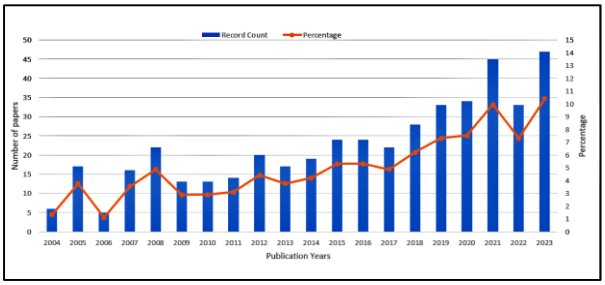

Fig. 2: Number and proportion of annual publications on peanut disease and pest control (2004-2023)

In recent years, the number of research papers on peanut diseases and pests has been increasing annually, indicating that research in this field is flourishing and attracting more and more researchers' attention. The research progressed through three stages: An initial phase (2004-2008) with low publication rates and fluctuations, a gradual growth phase (2009-2016), and a rapid growth phase (2017-2023) driven by industry expansion, during which the proportion of publications increased from 4.9-10.4%. Overall, there has been continuous growth in relevant publications over the past two decades, with expectations for further expansion given advancements in science, technology, and the peanut industry.

Research Topic Analysis

From the 452 papers retrieved from WoS, a total of 2153 keywords were obtained. Before the analysis, the keywords were inspected and organized, removing those without analytical significance, such as "peanut", "hypogaea", "disease" and "resistance" and merging synonyms. Keywords appearing more than 5 times were classified as high-frequency keywords. Using VOS viewer, the final 144 keywords were analyzed for co-occurrence, resulting in a keyword co-occurrence network map containing three clusters (as shown in Fig. 3). Keywords represented by nodes of the same color in the figure belong to the same cluster. The research topics of each cluster were inferred based on the terms appearing most frequently in each cluster.

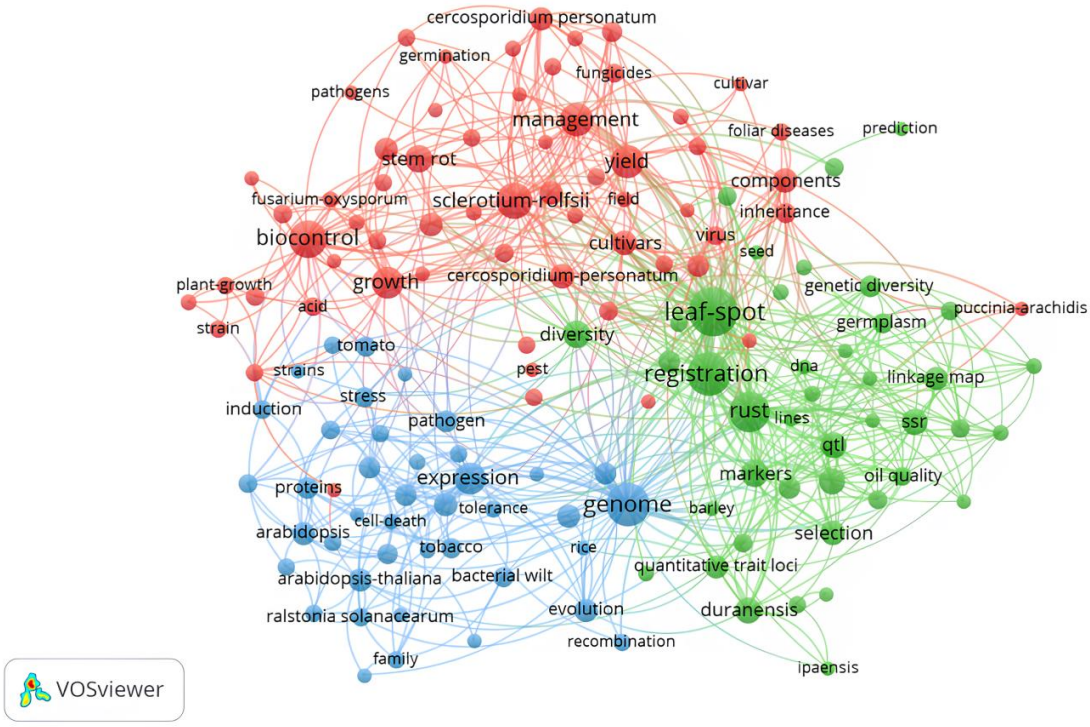

Fig. 3: Co-occurrence cluster mapping of keywords on the topic of peanut diseases and insect pest control

The largest cluster (red cluster in Fig. 3) focuses on the biological control of peanut diseases and pests, involving peanut growth and management. It primarily revolves around utilizing various biocontrol agents to prevent diseases such as peanut root and stem rot, screening and optimizing fermentation media, and evaluating the effectiveness of biocontrol agents against diseases. Erazo *et al.* (2021); Paramasivan *et al.* (2022); Hirpara *et al.* (2021); Ahsan *et al.* (2022); (2023).

The green cluster primarily investigates resistance breeding against peanut diseases such as leaf spot and rust. Researchers are dedicated to exploring the genetic characteristics of peanut disease resistance (Zanjare *et al.*, 2020; Rathore *et al.*, 2023; Ahmad *et al.*, 2020), studying the genetic diversity and population structure of peanut germplasm using phenotypic traits and SSR markers and breeding new varieties with resistance to address disease issues, thus reducing reliance on pesticides (Daudi *et al.*, 2021; Shasidhar *et al.*, 2020; Denwar *et al.*, 2021;). Additionally, it involves the registration of intellectual property rights for newly bred varieties (Holbrook *et al.*, 2022; Bertioli *et al.*, 2021).

Blue clustering focuses more on genomic research, which overlaps with the content of green clustering to some extent. Relevant studies include in-depth analysis of the genomes and transcriptomes of pathogenic bacteria, to understand the genomic composition, variations, and pathogenicity causing peanut diseases (Arias *et al.*, 2023; Gangurde *et al.*, 2021); conducting whole-genome association studies to identify genomic regions and candidate genes associated with resistance to peanut diseases and yield traits, facilitating the selection of disease-resistant and high-yielding peanut varieties (Zhang *et al.*, 2023; Oteng-Frimpong *et al.*, 2023); developing high-yielding and disease-resistant peanut varieties through genome editing and marker-assisted breeding techniques (Daudi *et al.*, 2021). These studies provide an important theoretical basis and technical support for genetic improvement and disease control of peanuts and also offer insights and guidance for genetic improvement and environmental adaptability research in other crops.

Figure (4) displays the evolution of research focus on peanut disease and pest prevention and control over time, as reflected by keyword co-occurrence maps overlaid with publication years. Early studies emphasized variety improvement, growth environment optimization, and pest control, mainly through traditional breeding methods, soil enhancement, and chemical pesticides. In contrast, recent research prioritizes understanding resistance mechanisms and molecular-level analysis, facilitated by advanced sequencing and molecular marker techniques. Future studies may further explore green control technologies and genetic mechanisms to provide effective technical support for disease and pest management in peanuts.

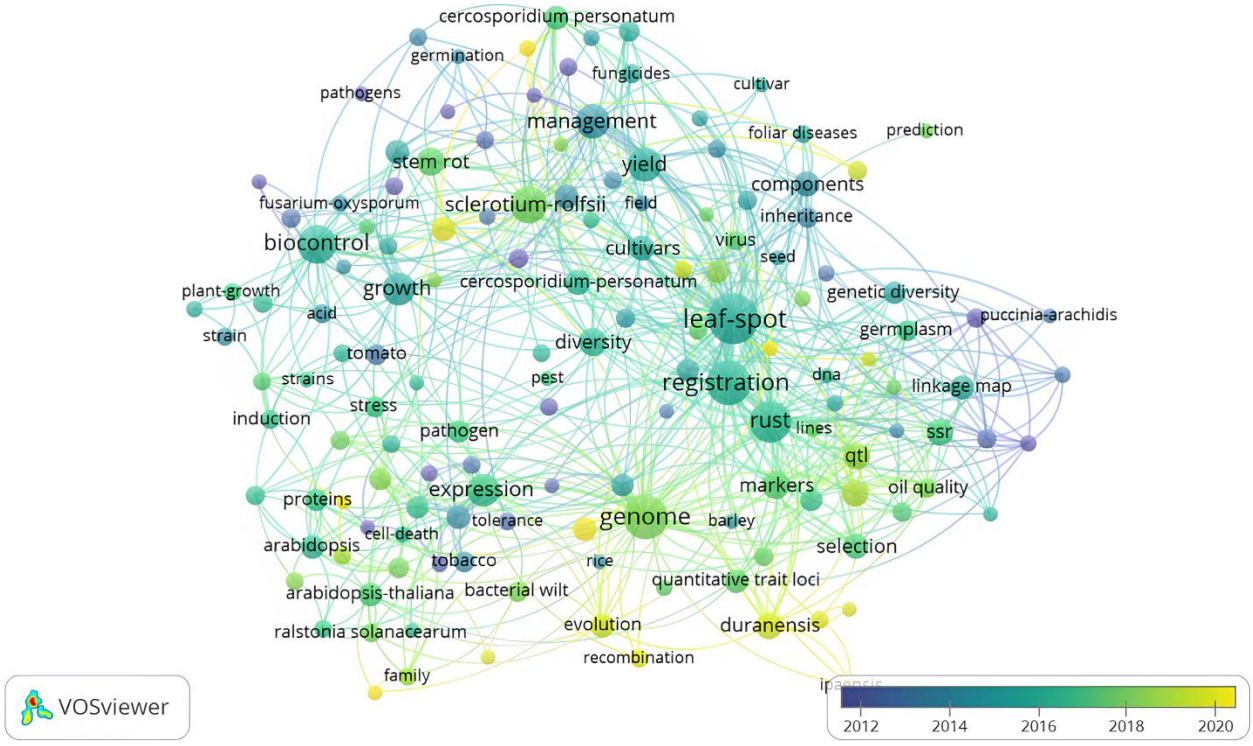

Fig. 4: Co-occurrence cluster mapping of superimposed time of keywords on the topic of peanut diseases and insect pest control

Author Collaboration Analysis

Figure (5) illustrates the collaboration relationships among authors in the field of peanut disease and pest control. By analyzing these collaborations, we can understand the interactions and exchanges among different authors. The top three authors in terms of publication volume are Varshney, Rajeev K. (28 papers), Pandey, Manish K. (27 papers), and Culbreath, Albert K. (18 papers). Varshney, Rajeev K. maintains a close collaboration with Pandey, Manish K., with their research primarily focusing on peanut breeding and genetics, while Culbreath, Albert K. is dedicated to research on peanut leaf spot disease (Varshney *et al*., 2014; Pandey *et al*., 2017; Culbreath *et al*., 2021). These authors have published a considerable number of papers in this field and possess a high academic influence. Varshney, Rajeev K. has the most collaborations with other authors, including the second-ranked Pandey, Manish K., and the less prolific Leal-Bertioli, Soraya C. M., indicating his strong influence and collaborative ability in the field, making it easier for him to collaborate with other authors. Additionally, among authors with lower publication volumes, such as Janila, and Pasupuleti, although their total publication count is relatively low, they also have close collaborative relationships with other authors. This indicates that collaboration among different authors in the field of peanut disease and pest control is extensive, with collaborations not only between authors with high publication volumes but also between those with lower publication volumes, facilitating the advancement of research in this field. This broad collaboration helps promote knowledge exchange and sharing, enhancing the quality and impact of research outcomes.

Institutional Collaboration Analysis

Table (1), the top ten institutions in terms of publication volume in the international research field of peanut disease and pest control are listed. It can be observed that the institution with the highest publication volume is the University of Georgia (UNIV Georgia) in the United States, followed by the International Crops Research Institute for the Semi-Arid Tropics (INT crops res INST semi-arid trop) in India and the Agricultural Research Service of the United States Department of Agriculture (USDA ars). The combined publication volume of these three institutions accounts for nearly half of the total literature. Additionally, institutions from China such as the Shandong Peanut Research Institute (Shandong Peanut Res INST) and the Chinese Academy of Agricultural Sciences (Chinese Acad agr sci) also have significant publication numbers.

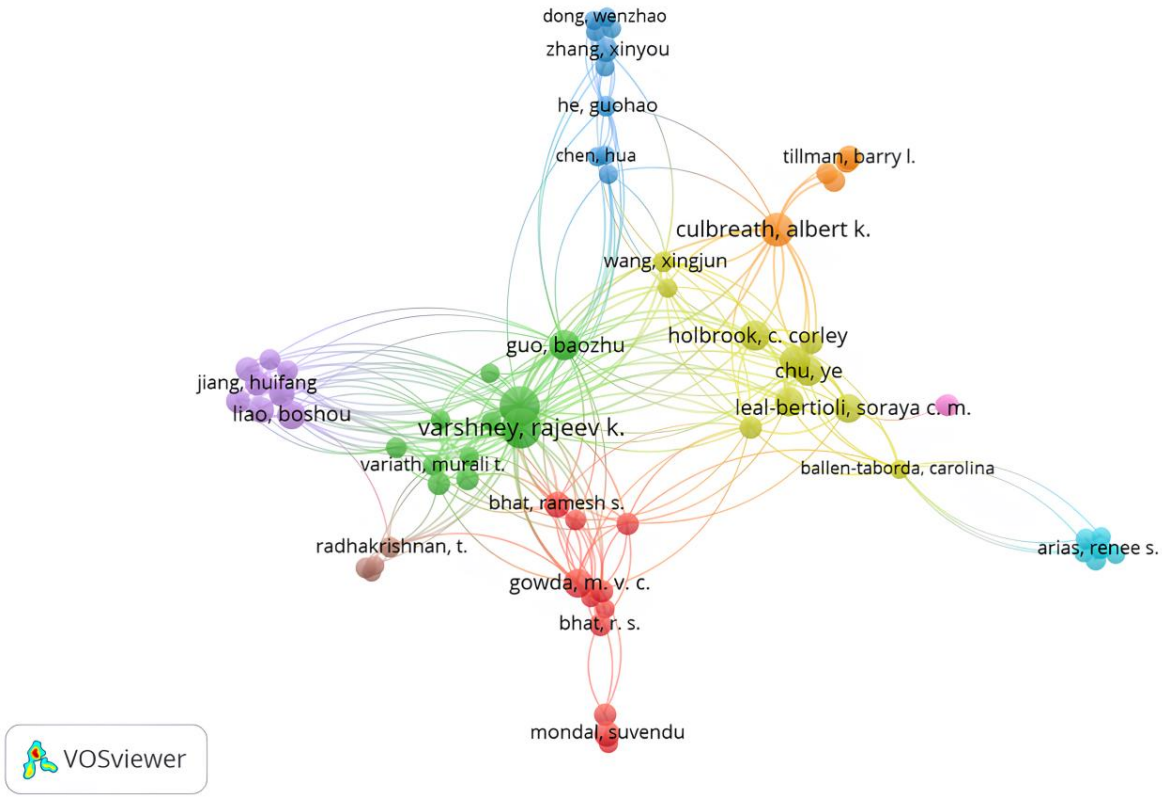

Fig. 5: Co-occurrence mapping of authors on the topic of peanut diseases and insect pest control

Table 1: Top 10 institutions based on an analysis of publications on the topic of peanut diseases and insect pest control

Ranking	Country	Institution	Number of documents	Proportion
1	United States	UNIV Georgia	82	18.14%
2	India	INT crops res inst semi-arid trop	64	14.16%
3	United States	USDA ars	44	9.73%
4	India	UNIV agr sci	22	4.87%
5	United States	UNIV Florida	21	4.65%
6	China	Chinese acad agr sci	15	3.32%
7	India	UNIV Hyderabad	13	2.88%
8	China	Henan acad agr sci	12	2.65%
9	India	Bhabha atom res ctr	12	2.65%
10	China	Shandong peanut res INST	12	2.65%

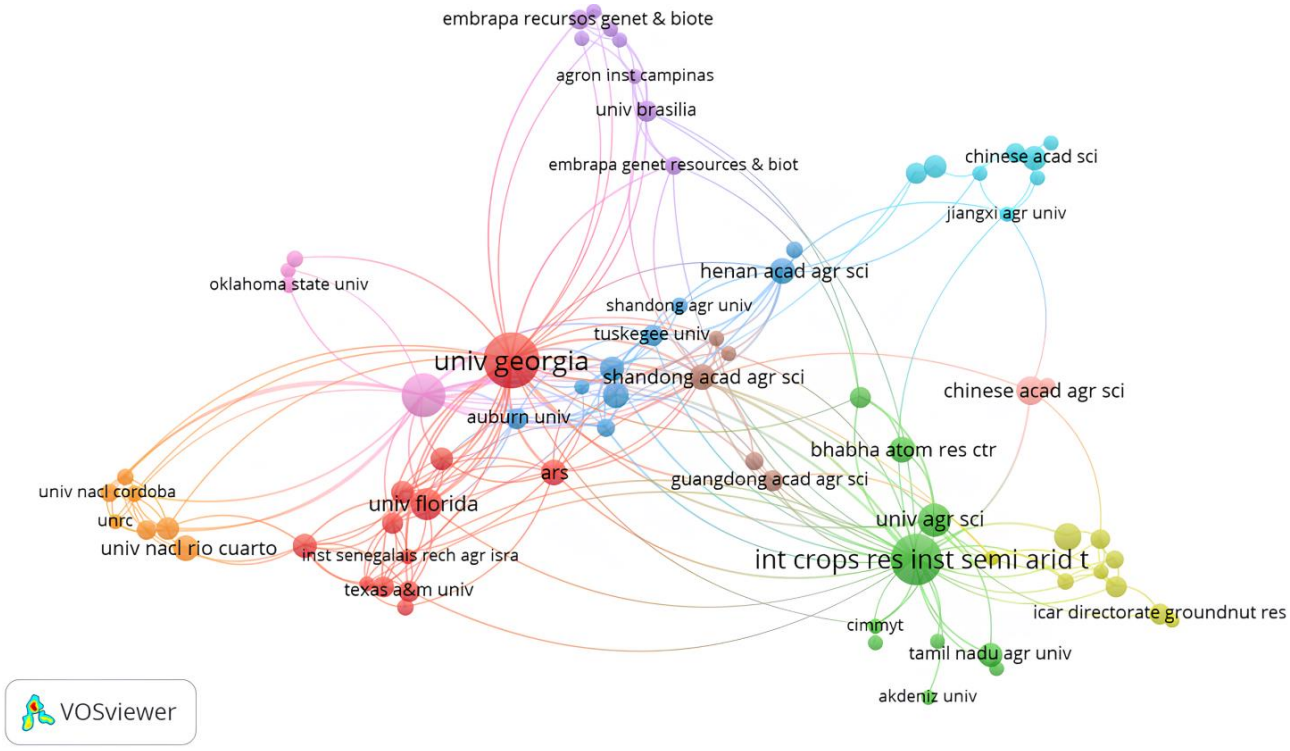

Fig. 6: Co-occurrence mapping of research institutions on the topic of peanut diseases and insect pest control

Among the 452 foreign language documents, a total of 459 institutions are mentioned. Of these, 78 institutions have a publication volume greater than 3. VOS viewer was used to visualizing the collaboration network among the 74 institutions that have cooperative relationships with each other, as shown in Fig. (6). Analyzing both the collaboration graph and the statistical table of published literature, it is evident that the University of Georgia has the strongest collaborative relationships, collaborating with 37 institutions. Following closely are the International Crops Research Institute for the Semi-Arid Tropics and the Agricultural Research Service of the United States Department of Agriculture. It can be noted that institutions with higher publication volumes also tend to have stronger collaborative relationships with other institutions. Further investigation into collaborative institutions outside of the mentioned ones reveals that although some universities and research institutes have lower publication numbers, they engage in collaborative publications with a diverse range of institutions. This indicates that foreign institutions and universities in the field of peanut disease and pest control have substantial publication outputs and they engage in extensive collaborations with research institutions and universities from other countries when their publication output is significant enough.

Distribution of Published Articles in Journals

The analysis includes 452 papers from 150 journals. Table (2) shows the top ten journals ranked by publication volume. The top three journals are Plant Disease (33 papers), frontiers in Plant Science (20 papers), and Euphytica (19 papers), leading in peanut disease and pest control. Together, they account for 15.9% of total publications. Plant disease and frontiers in plant science are notable in plant pathology and science respectively, while EUPHYTICA focuses on plant genetics and breeding. Peanut disease-related articles tend to be published in specialized journals, yet relevant research can also appear in journals from other fields, albeit less frequently. Non-traditional journals offer opportunities to broaden research impact.

Analysis of Document Citations

Figure (7) depicts a citation map of literature, indicating that the most cited article is "Growth promotion and yield enhancement of peanut (*Arachis hypogaea* L.) by application of plant growth-promoting rhizobacteria" (Dey *et al*., 2004). This article discusses how inoculation with certain plant growth-promoting rhizobacteria (PGPR) isolates can reduce the incidence of stem rot in peanuts, thereby lowering plant mortality rates and significantly improving peanut yield and quality. Additionally, "A QTL study on late leaf spot and rust revealed one major QTL for molecular breeding for rust resistance in groundnut (*Arachis hypogaea* L.)" (Khedikar *et al*., 2010) is also frequently cited. This study identifies a QTL associated with rust resistance, offering the potential for breeding rust-resistant peanut varieties, which is crucial for disease control and breeding programs. QTLS are specific gene regions located on chromosomes that are closely associated with controlling quantitative traits such as disease resistance and yield. Through QTL analysis, researchers are able to accurately identify and locate gene regions that influence target traits, which helps to gain insight into genetic background, predict phenotypic variation, and significantly accelerate the breeding process.

Table 2: Top 10 sources of publications on the topic of peanut diseases and insect pest control

Ranking	Journal	Number of publications	Proportion
1	Plant disease	33	7.30%
2	Frontiers in plant science	20	4.42%
3	Euphytica	19	4.20%
4	Crop Science	18	3.98%
5	Plos one	15	3.32%
6	Crop protection	14	3.10%
7	Legume research	12	2.65%
8	Journal of plant registrations	12	2.65%
9	Plant breeding	10	2.21%
10	Theoretical and applied genetics	9	1.99%

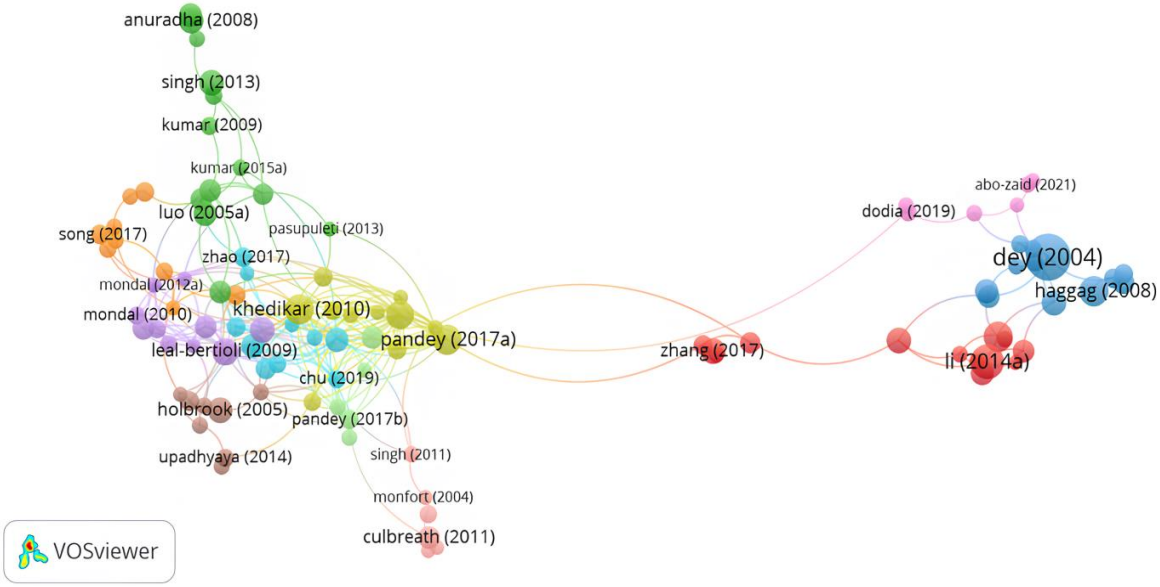

Fig. 7: Cited mapping of literature on the topic of peanut diseases and insect pest control

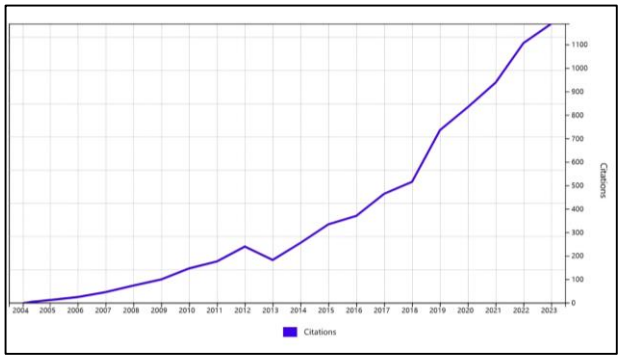

Fig. 8: Annual citation frequency distribution of literature on the topic of peanut diseases and insect pest control

Highly cited articles cover various aspects of peanut cultivation, including pest control, fungal disease management, and genetic breeding. The distribution of annual citation frequency is illustrated in Fig. (8), showing an overall upward trend from 2004-2023, indicating increasing scholarly interest in peanut disease and pest research. Occasional decreases in citation frequency in certain years do not affect the overall phenomenon and trend.

The extant literature on peanut disease and pest control encompasses an array of measures, spanning scientific rotation, biological control, and chemical interventions. There is relatively limited literature on the accurate identification of peanut diseases. This is primarily due to the complex and varied nature of pathogens and pests that affect peanut plants, making the diagnosis of diseases challenging and complex. Researchers typically require in-depth knowledge of plant pathology and entomology for accurate identification, which restricts the scale of research and the production of related literature. In addition, research on prevention and control strategies for peanut diseases provides more direct assistance to agricultural production, hence dominating the literature. In contrast, research on disease identification, although important, may be viewed as a secondary issue that comes after disease occurrence, resulting in relatively limited funding and manpower resources.

Conclusion

Research on the prevention and management of peanut diseases and pests has perennially been a focal point in both domestic and international scholarly arenas. This study undertook an analysis of 452 papers on peanut disease and pest control spanning from 2004-2023 within the WoS database, scrutinizing six key facets: Publication timeline, journal distribution, keyword co-occurrence and clustering, author and institutional collaborations, and citation patterns. Through the application of VOS viewer software to delineate a knowledge map outlining the research landscape of peanut disease and pest control, this study discerned the following conclusions:

1) Analysis of publication timelines revealed a consistent increase in the number of papers published in the realm of peanut disease and pest control, particularly in recent years. This developmental trajectory exhibits three discernible stages: An initial phase, a phase characterized by steady growth, and a current prosperous phase spanning from 2017 to 2023. Foreseeably, with the ongoing advancement of science and technology alongside the burgeoning peanut industry, ample opportunities for further research development are anticipated, with a continued expansion in publication output
2) Keyword analysis unveiled diverse research topics within peanut disease and pest control, encompassing peanut growth and management, biological control, resistant breeding, and genetics and genomics of peanuts. Of particular note, biological control emerges as a focal point for environmentally sustainable management practices, while genetic breeding research also demonstrates extensive engagement
3) Examination of publication journals highlighted plant disease, frontiers in plant science, and euphytica as prominent platforms within this field, significantly contributing to research and development endeavors. The distribution of publications across journals offers insights into the prevailing research hotspots and trends, furnishing valuable references and guidance for researchers. While specialized journals related to peanut disease and pest control remain primary avenues for dissemination, the publication of relevant research findings in journals from diverse fields serves as an effective strategy to broaden impact and reach
4) Institutions with notable publication outputs predominantly hail from the United States, India, and China, underscoring their roles as traditional agricultural powerhouses with extensive research engagement in peanut disease and pest control. Research endeavors are concentrated within universities and research institutes, fostering robust cooperation networks both domestically and internationally. Enhanced communication and collaboration between research institutions and universities across various countries hold promise for fostering knowledge exchange and innovation, thereby propelling sustainable development within the global peanut industry

Future research endeavors could benefit from integrating modern techniques such as machine learning, image recognition, and sensor technologies, thereby enabling rapid and precise detection and identification of peanut diseases and pests, bolstering monitoring and early warning systems.

Moreover, fostering international cooperation and exchange stands to facilitate the exploration of novel control techniques and strategies, alongside research and dissemination efforts pertaining to disease-resistant varieties, biological control methods, and environmentally friendly pesticides. Effective control of peanut diseases and pests necessitates a holistic approach, leveraging diverse methods and technologies. Recommendations include strengthening foundational research, particularly interdisciplinary studies encompassing ecology and microbiology while advocating for the adoption of green and biological control methods to curtail chemical pesticide usage.

Integral to comprehensive control efforts is the implementation of integrated pest management throughout the entirety of the agricultural production process from breeding and cultivation to harvesting and processing. Moreover, promoting the dissemination and adoption of peanut disease and pest control technologies, coupled with enhancing grower awareness of control measures, is imperative for realizing more efficacious control outcomes. It is emphasized that research endeavors in peanut disease and pest control not only serve to advance knowledge and theory but also hold practical implications for agricultural production and food safety. Researchers play a pivotal role in translating research findings into tangible applications, thereby enhancing peanut yield and quality, reducing pesticide usage, and ensuring the safety of agricultural products. Thus, future research endeavors should prioritize not only the generation of research output but also the dissemination and application of research findings in practical contexts.

Acknowledgment

We would like to express our deepest gratitude to Prof. Fernando Bacao, who provided invaluable insights and feedback on the early stages of this project. We are also thankful to the staff at International Joint Laboratory of agricultural big data and artificial intelligence in Henan Province for their assistance with data collection and analysis. Finally, we appreciate the constructive comments and suggestions made by the anonymous reviewers and the editor, which significantly improved the quality of this manuscript.

Funding Information

This research was funded by the national natural science foundation of China (32271993); key scientific and technological project of Henan Province (242102111193); the natural science foundation of Henan Province, China (232300420186); the Joint fund of science and technology research development program of Henan Province, China (222103810025); and the key research and development project of Henan Province, China (231111110100).

Author's Contributions

Ping Dong: Conceptualization, methodology, and funding acquisition.

Fei Peng and Yizhe Zhang: Collect the materials related to the experiment and visualization.

Jian Wang and Haiping Si: Designed the experiments and revised the manuscript.

Wei Guo: Supervision and funding acquisition.

Rui Gao: Supervised and revised the manuscript.

Ethics

The authors declare their responsibility for any ethical issues that may arise after the publication of this manuscript.

Conflict of Interest

The authors declare that they have no competing interests. The corresponding author affirms that all of the authors have read and approved the manuscript.

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