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Research Article

Visualized analysis of licorice research hotspots and trends in the field of traditional Chinese medicine resources based on VOSviewer and CiteSpace knowledge maps

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Abstract: The purpose of this study is to analyse the relevant research literature of traditional Chinese medicine (TCM) licorice (*Glycyrrhiza uralensis* Fisch.), understand the research context, hot spots and development situation of licorice resources, guide the research direction by predicting the research trend, and provide theoretical support for the development of licorice in the field of resource science. The methods we adopted are: Chinese literature through the China National Knowledge Infrastructure (CNKI) platform, foreign literature through the Web of Science (WOS) platform, collect and sort out the literature data, database build library up to 31 December 2023 included licorice related Chinese and English literature, using CiteSpace 6.2.R6 and 6.3.R1 keywords, authors and institutions such as visual analysis, using VOSviewer1.6.20.0 draw the core keywords, the author and national cooperation co-occurrence network. The analysis has found that: A total of 801 Chinese documents on the topic of liquorice resources, 142 English articles, the total number of documents published gradually increased, the recent slight downward trend; keyword co-occurrence and cluster analysis show that the main content of research focused on chemical composition, clinical efficacy, artificial cultivation, biosynthesis and other aspects; keyword emergent analysis showed that TCM, salt stress, tolerance and accumulation are the recent research hotspot of this discipline; the field has now formed several professional research teams, the author team with outstanding contributions in China is a team represented by Wang Wenquan and Hou Junling, who study germplasm resources as keywords, and a team of authors who have made outstanding contributions internationally, the represented author is Muranaka, Toshiya, Saito, Kazuki and Seki, Hikaru (Japan); the research institutions are mainly centred on Beijing University of Chinese Medicine (BUCM) (China), close cooperation among various agencies, the international institutions with outstanding contributions are mainly concentrated in Osaka University (Japan) has the largest number of publications and works in cooperation with several institutions. In conclusion, licorice resource-related research hotspot mainly around its botany and ecology research, chemical composition and clinical application, new technology application development, in recent years, the change of external factors such as environmental climate make people pay more attention to licorice resource use and protection, heat in the field of resources, analyze the current licorice in the research progress in the field of resources, summarize past experience for future research, in the future, it is expected to achieve more scientific, sustainable and efficient use, contribute to the Chinese herbal medicine industry and the healthy development of the ecological environment.

Keywords: *Glycyrrhiza uralensis*; liquorice; resources; research progress; CiteSpace; VOSviewer; visual analysis

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1 Introduction

The herb liquorice, belonging to the legume family, is a perennial herb. Its root usually has a sweet flavour, which is the origin of its name. Licorice has a long history in Chinese medicine and is widely used in a variety of formulas for its tonic and harmonizing properties. Modern studies have confirmed its pharmacological effects such as anti-inflammatory, antiviral,

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antioxidant, anti-ulcer, as well as its ability to regulate the immune system and combat stress[1]. Among them, Uracil liquorice, as the dominant species of liquorice, occupies a major portion of both scientific research and the general public, and is also the most important object of study in this paper. Licorice plants are widely distributed around the world, mainly growing in Asia, Europe and North America. Different species of liquorice plants differ slightly in morphology and ecological habits, but all of them have medicinal and economic values. Licorice resources include both cultivated and wild forms, and in many regions, people grow licorice through cultivation to meet the market demand. Meanwhile, wild liquorice resources also exist in the natural environment, but attention should be paid to reasonable collection and protection. Licorice resource is an important medicinal and economic plant resource, which is widely used in the fields of medicine, food and cosmetics, etc. Further research on licorice resources to rationally utilise licorice resources can make an important contribution to human health and economic development.

In recent years, changes in external factors such as the environment and climate have made people realize that the importance of resource utilization and conservation of licorice cannot be ignored, and how to cultivate high-quality varieties economically and environmentally friendly, and how to improve its utilization have been discussed endlessly in the field of resource science. It is important to analyze the current research progress of licorice in the field of resources and summarize the previous experience to point out the direction for future research, which plays an important guiding significance in the research of licorice. Nowadays, the development of visual analysis is becoming more and more mature, and CiteSpace and VOSviewer are more commonly used bibliometrics visual analysis software in various research fields[2]. CiteSpace can show the development of the research field, research hotspots and trend patterns in a clear and graphic way; VOSviewer is more inclined to show the keywords, authors and even the cooperation and correlation strength between national institutions in the research field. Therefore, this study uses CiteSpace 6.2.R6 and 6.3.R1 to visualize and analyze the research hotspots of keywords, authors and institutions, and VOSviewer 1.6.20.0 to map the core keywords, authors and national cooperation networks. The Chinese literature was searched and collected through the China National Knowledge Infrastructure (CNKI) database, and the foreign literature was searched and collected through the Web of Science (WOS) database, and the literature related to traditional Chinese medicine (TCM) licorice resources was analyzed by bibliometrics analysis, and the visual knowledge map was drawn, and the research hotspots and development were elaborated systematically, which is expected to provide certain guidance for future research, and to provide theoretical support for the rational use and sustainable development of licorice resources. It is expected to provide some guidance for future research and theoretical support for the rational utilization and sustainable development of licorice resources.

2 Materials and methods

2.1 Literature sources and collection

The Chinese search terms for licorice were licorice and resource, and the foreign search terms for licorice were liquorice, *Glycyrrhiza uralensis,* and resource; the CNKI search formula was "liquorice" AND "resource", and the WOS search formula was TS = (liquorice or *Glycyrrhiza uralensis*) AND TS = (resource); data from CNKI and WOS. The retrieved literature was collected and imported into EndNote to establish a database for archiving, and then manually reviewed to eliminate duplicates and literature unrelated to the topic. After manually reviewing and eliminating duplicates and literature unrelated to the topic, the obtained valid literature was imported into the software for visualization and analysis. The time range of the search was before December 31, 2023, and the total number of Chinese literature on licorice resources was 801, including 454 academic journals, 159 dissertations, 52 conferences, 39 patents, etc. The total number of foreign language literature on licorice resources was 142, including 120 articles, 12 reviews, etc. The total number of foreign language literature on licorice resources was 142, including 120 articles and 12 reviews.

2.2 Statistical analysis

The included Chinese and foreign literature publication data were imported into Excel, and a chart was established to analyze the trend of publication and discipline distribution of research in the field of liquorice; CiteSpace was used to carry out the visual analysis of keyword clustering, timeline, and bursts. Due to the time limitation of the software, only the longest time period of 1993-2023 could be selected, and the time slice (year per slice) was "1", and the node type was "keyword"; VOSviewer was utilized to perform co-occurrence analysis on the keywords, authors, and the cooperation of the institutions with the limited conditions respectively.According to Price's law ($N = 0.749 \times \sqrt{N_{max}}$, where max is the maximum number of articles published by the author), we obtained the number of articles published by the core authors, and if the number of articles published by the authors is more than N, they can be recognized as core authors[3]. If the author has published more than N articles, he can be recognized as a core author. Combined with CiteSpace selection conditions: time period 1993-2023, year per slice "1", node type "Author", cluster analysis of the core authors. We cluster analyze the topics and teams that have made outstanding contributions in this field.

3 Results

3.1 Analysis of trends and distribution of publications

The number of publications in the literature related to the topic of liquorice resources over the years was analysed. A line graph was made of the trend of publications in Chinese and foreign languages over the years. As shown in Fig. 1, the overall trend is that before 2000, the Chinese literature was in the initial stage of research, and the amount of literature published was relatively small; there was a significant increase in 2000-2006, and the number of articles published in this field reached a peak of 45 in 2006, which was the stage of rapid development of the research; the number of articles published basically showed a gradual decline after 2006, which indicated that the research enthusiasm of licorice resources had slightly declined recently. The publication of foreign language literature showed an increasing trend from 2005 to 2021, and then the enthusiasm declined. The number of articles published in Chinese literature is much higher than that of English literature, Chinese literature started to be published much earlier than foreign literature, and the rapid development time of Chinese literature is also earlier than that of foreign literature, and the development of this field is more rapid in China. In 2021, the

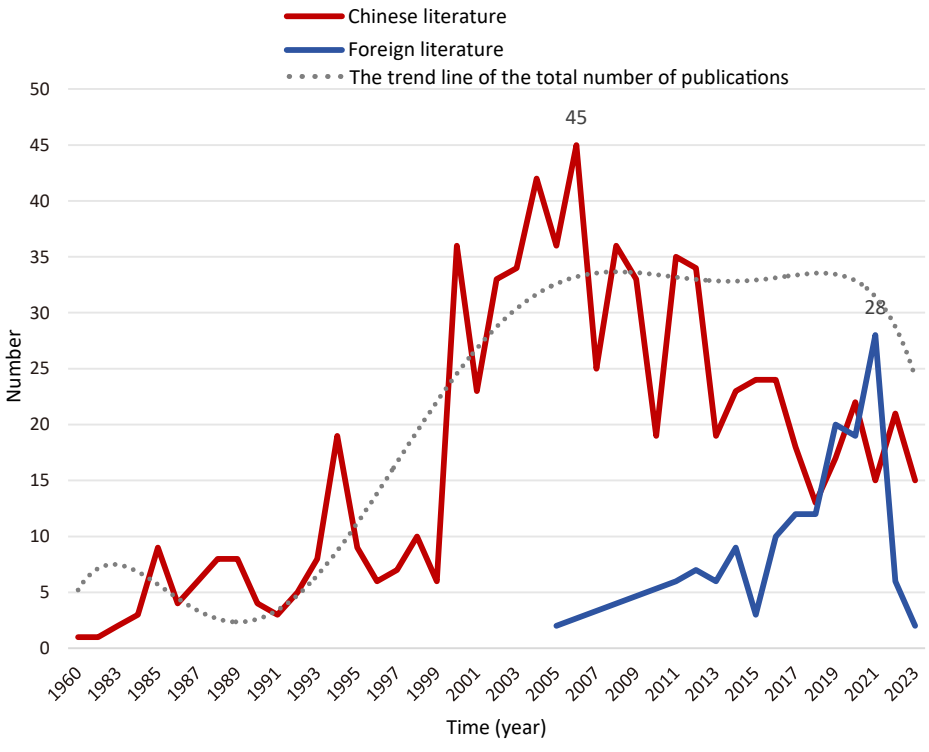


Figure 1 Trends in the number of publications of licorice resources in Chinese and foreign languages.

number of foreign literature reached the peak, and even exceeded the number of Chinese literature in that year, indicating that foreign scholars are also gradually increasing their attention to the research of licorice resources. Comprehensively analyzing the Chinese and foreign literature, it is found that the number of publications of licorice in the field of TCM resources showed a rapid increasing trend from 1994 to 2006, and then gradually stabilized to maintain a basic frequency of more than 30 items per year, indicating that the scholars' attention to this field is gradually growing, and the recent still maintains a higher degree of enthusiasm.

We counted the number of publications in each subject area of licorice resources and produced histograms of the number of publications in each discipline in Chinese and foreign language literature (Fig. 2). The highest proportion of the Chinese literature was in the discipline of agronomy, nearly half; the top 10 disciplines in order of the amount of publications were Crops, Traditional Chinese medicine, Agricultural economics, Biology, Environmental science and resources, Animal husbandry and animal medicine, Organic chemistry, Industrial economics, Resource science and Forestry. The research on licorice resources in foreign literature mainly involves the following fields: Agriculture, Plant sciences, Environmental sciences ecology, Pharmacology pharmacy, Biodiversity conservation, Biochemistry molecular biology, and so on, totaling 74 fields, of which the largest proportion is in Biology, followed by Environmental sciences ecology. The analysis of the distribution of disciplines shows that the research on licorice resources involves a variety of fields, and nowadays it is mainly focused on the disciplines of agronomy, medicine and biology.

3.2 Keyword heat trend analysis

Using CiteSpace software, the keywords were used as nodes for visual analysis, and a keyword co-occurrence network diagram could be obtained, in which the size of the circle represented the number of articles, the color represented the year of articles, and the connecting line represented the connection of the keywords. For the Chinese literature (Fig. 3), there were 698 valid documents, of which the keyword liquorice had the most articles,

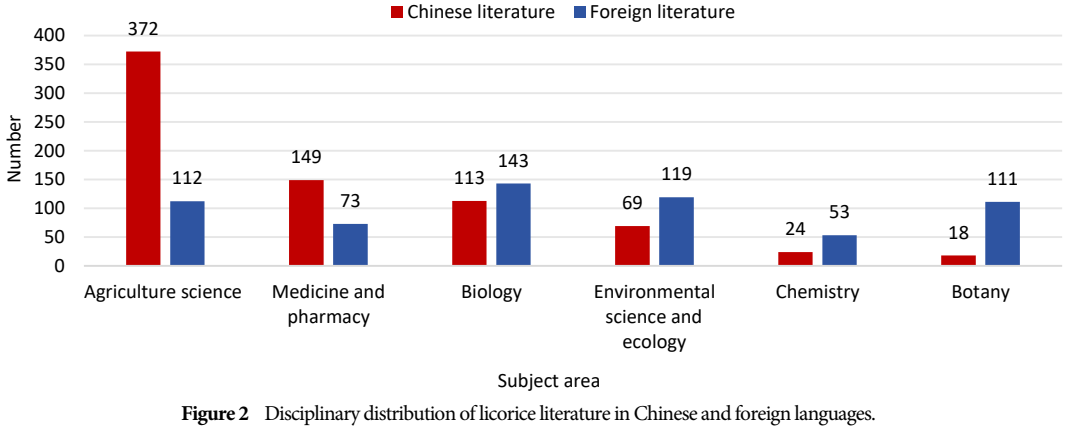


Figure 2 Disciplinary distribution of licorice literature in Chinese and foreign languages.

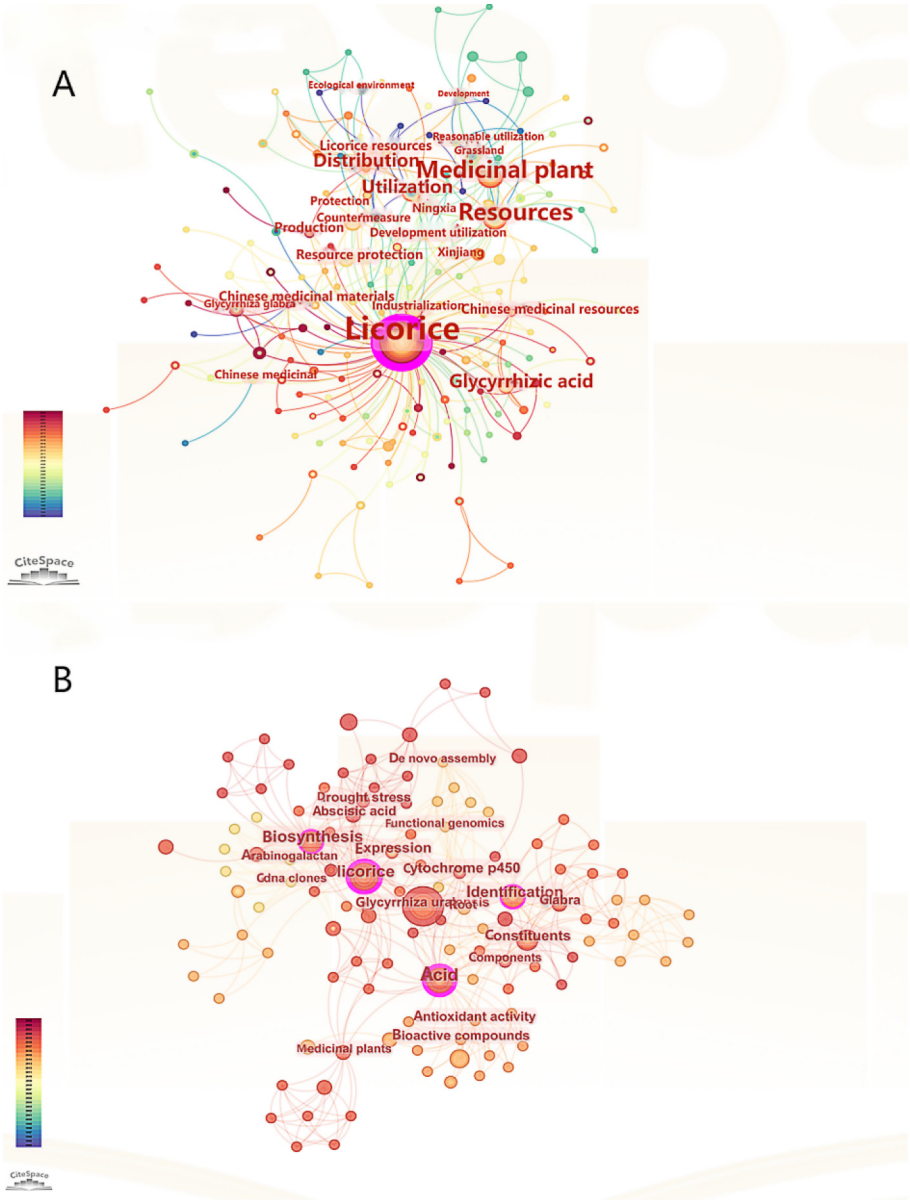


Figure 3 Co-occurrence network diagram of keywords in Chinese (A) and foreign (B) literature on licorice.

and the connecting lines around it were denser, suggesting a stronger connection with other keywords. The keyword medicinal plants was the second most frequent term in terms of the number of articles, and the keyword resources was the third most frequent term in terms of the number of articles. Other keywords that appeared more frequently were distribution, herbal medicine, glycyrrhizic acid, exploitation and utilisation.

There are 126 valid documents in foreign language literature, and the keywords *Glycyrrhiza uralensis*, licorice and acid nodes have larger shapes and denser connecting lines around them, suggesting that these three keywords are the words that appear more frequently with higher centrality. In today's academic environment, the research on licorice resources mainly focuses on the distribution of resources, active composition and biosynthesis.

Cluster analysis was performed with keywords, and the cluster labels were sorted according to the number of keywords. The Chinese literature was analyzed by clustering with keywords (Fig. 4), and the cluster labels were sorted according to the number of keywords, showing the top eight clusters, which were "Licorice" "Resources" "Distribution" "Chinese herbal medicines" "Chinese medicine resources" "Environmental protection" "*Glycyrrhiza inflata* Bat" "Modeling research", means that the top eight research hotspots. Among them, *Glycyrrhiza inflata* Bat and Modeling research are more closely related. Keywords details are given in the Table S1.

The foreign language literature was analyzed by clustering with keywords (Fig. 4), and the cluster labels were sorted according to the number of keywords to show the top 5 clusters, which were "Ultra-fast liquid chromatography coupled with triple" "*Glycyrrhiza uralensis* Fisch" "Salt stress" "Nutrient" "Salt stress" "Toxicity". This means that the top five research hotspots are ultra-fast liquid chromatography coupled with triple, *G. uralensis* Fisch, nutrients, salt stress, and toxicity, and that the research clusters are more closely related to each other. See Table S2 for details of the clustering labels.

According to the analysis of Chinese literature keyword clustering timeline graph (Fig. 5), it can be seen that Cluster #0 *Glycyrrhiza uralensis* Fisch runs through the whole of this study,

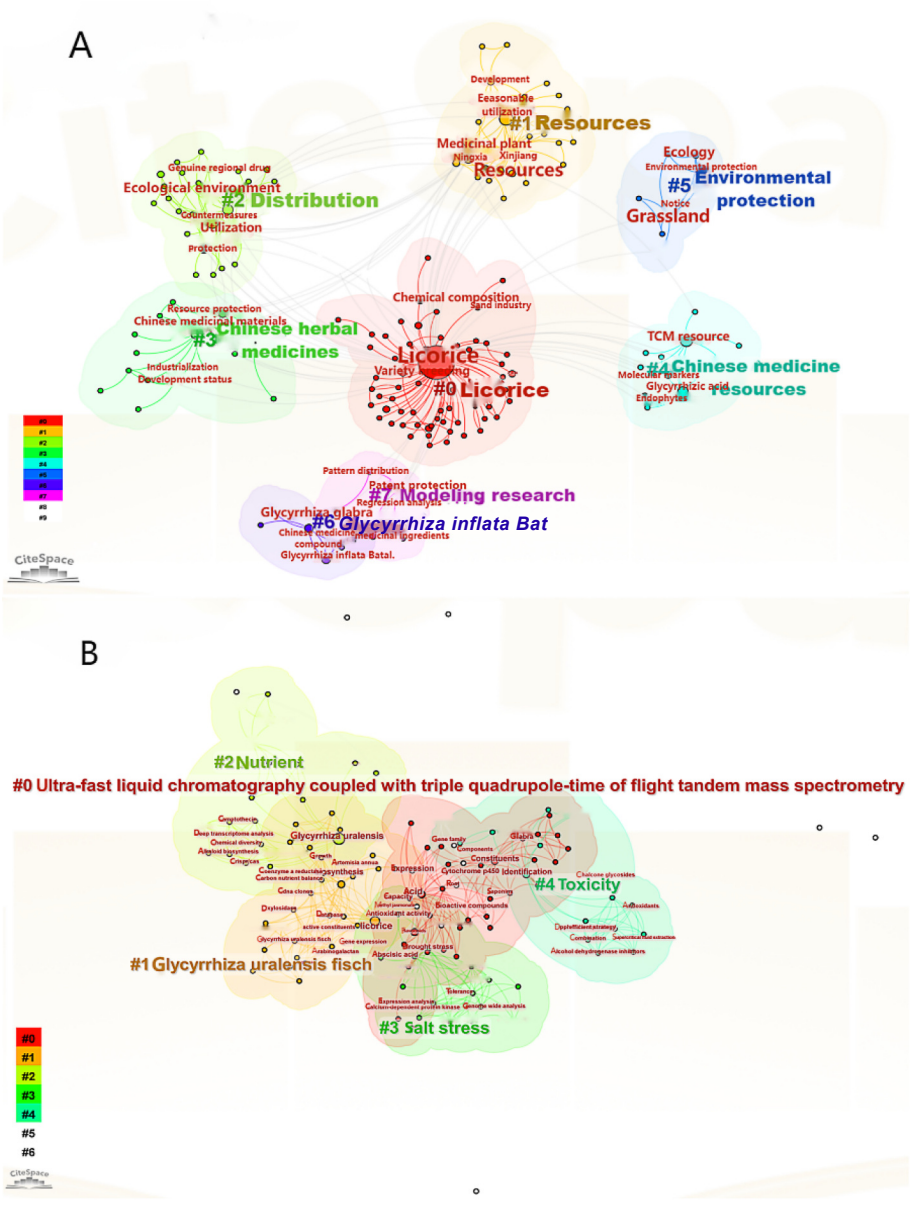


Figure 4 Keyword clustering network diagram of licorice literature in Chinese (A) and foreign languages (B).

with high research heat; the keyword *Glycyrrhiza uralensis* Fisch under this cluster has the highest number of articles and is most closely linked with other keywords. Cluster #5 Environmental protection related research is concentrated in the early stage, and the heat of research has decreased recently. Cluster #7 Modeling research is mainly concentrated in the period of 2005-2015.

According to the analysis of the keyword clustering time line graph of foreign literature (Fig. 5), it can be seen that Cluster #1 *Glycyrrhiza uralensis* Fisch runs through the whole of this study, with high research heat, and the keyword *Glycyrrhiza uralensis* Fisch has the highest number of publications under this cluster and is most closely linked to other keywords. Cluster #3 Salt stress related studies were concentrated at a later stage. Cluster #4 Toxicity has seen a recent decline in research activity.

The bursts, the keyword that occurs emergence, represents that the keyword has a high degree of attention in a certain period of time, which indicates the change and trend of the research hotspot in this field. From the analysis chart of the bursts (Fig. 6), it can be seen that the difference of the keyword's hotness in different time periods can also predict the trend of research hotspots, which can express the development history of a keyword. From left to right are the node type, the time when the node appeared, the strength of the burst, the time when the burst appeared, and the time when the burst ended. The red and blue bar lines are red, the time period of the emergence, light blue means the node has not appeared, and dark blue means the node has appeared.

The Chinese literature was analyzed by analyzing the map of the bursts, and the 20 keywords with the strongest burst were screened out. Among them, glycyrrhizic acid with the strongest burst (4.01) occurred in 2006—2007. In addition, the keyword grassland has the longest red line, so the word has been mutated from 1993 to 2004, and the heat lasted the longest. The keywords Grassland, Utilization, Conservation, and Glycyrrhizic resources bursts were concentrated in the early years, and the bursts of Chinese herbal medicines began to occur in 2019, and the term has had a higher level of heat in the country in the recent past.

The foreign language literature was analyzed and the 10 keywords with the strongest burst were screened. Among them,

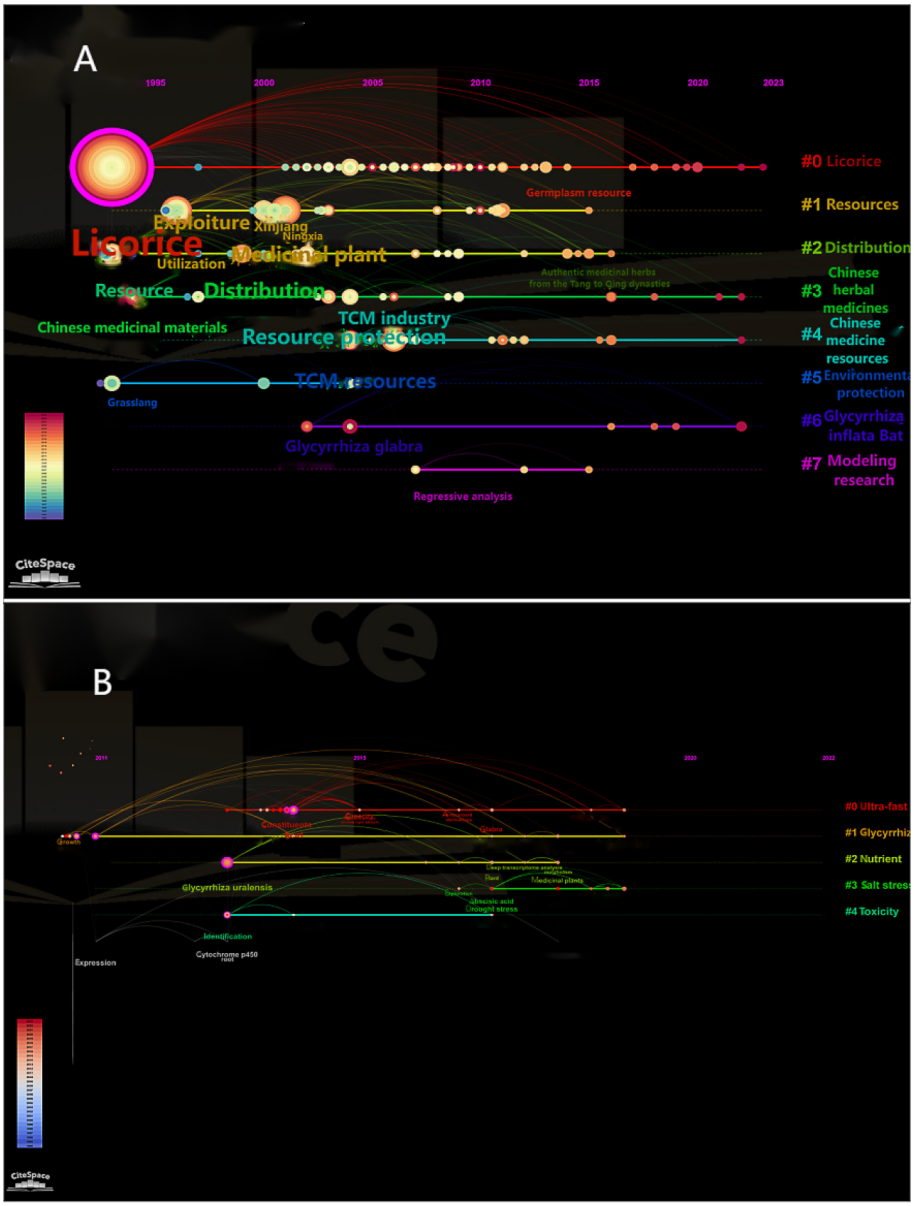


Figure 5 Timeline analysis of keyword clustering in Chinese literature (A) and foreign language literature (B).

the strongest burst (2.11) of flavonoids occurred in 2014. In addition, the keywords *Glycyrrhiza uralensis* Fisch and constituents have longer red lines and longer heat duration. In addition, the keywords roots, identification, and separation bursts were concentrated in the earlier period (before 2015), while the bursts of drought stress and antioxidant enzymes began to occur in the recent period, indicating that the recent hotspots of foreign research were concentrated in the above keywords.

3.3 Keyword co-occurrence network diagram

The Chinese literature with the topic of licorice resources retrieved from https://Knowledge.com was imported into VOSviewer in Refworks format, Type of analysis was selected as Co-occurrence, and Unit of analysis was keywords. Restricting the frequency of keyword occurrence to ≥ 5, 47 eligible entries were generated. As shown in Fig. 7, the size of the circle represents the frequency of occurrence of the word, different colors represent different clusters, and the thickness of the line represents the size of the correlation. The keyword licorice is basically connected with other keywords, which indicates that it is most closely connected with other words, located in the center, and is the word that produces the most co-occurrences. Among them, the keyword licorice has the highest strength of connectivity with glycyrrhizic acid (14) indicating that the two are more closely connected, followed by licorice and resources. Deriving the data table of relevance strength of keywords with top 10 occurrence weights (Table S3), the highest occurrence weight is the keyword licorice for 151, which also has the strongest linkage strength with other words (133); followed by medicinal plants weight 30. The second keyword with the second strongest linkage strength is resources (45).

The foreign language literature with the topic of licorice retrieved from WOS was imported into VOSviewer in plain text format. Type of analysis selected Co-occurrence, Unit of analysis was All keywords. Limiting the frequency of keyword occurrence to ≥ 5, 22 eligible words were produced. As shown in Fig. 8, the keyword licorice has the largest shape, the highest frequency of occurrence, and the surrounding connecting line is dense, which

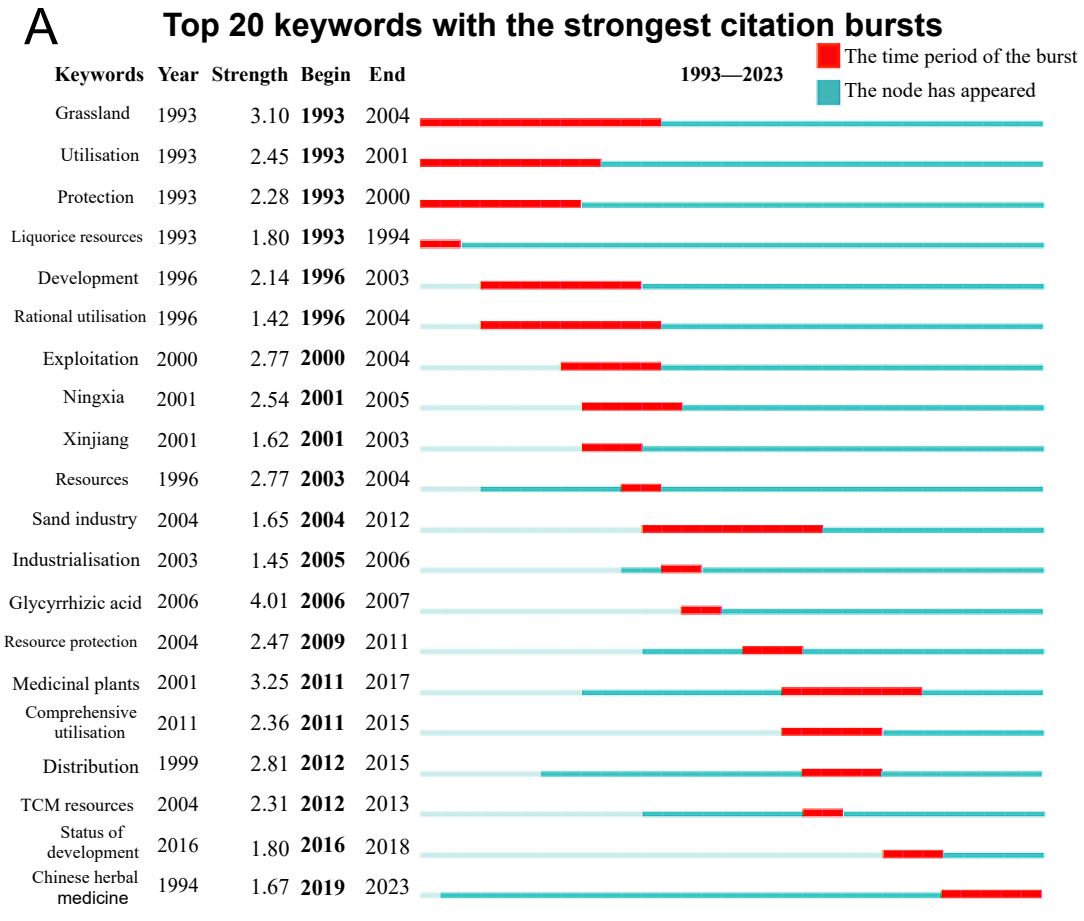


Figure 6 Plot of the analysis of the bursts in Chinese literature (A) and foreign language literature (B).

indicates that it is most closely connected with other words, located in the center, and is the word that generates the most co-occurrence, and its connecting line with *G. uralensis* is the thickest with the highest correlation, followed by the connecting line with biosynthesis; the second frequency of occurrence is the keyword *G. uralensis*, which has the highest coarsest correlation with licorice and the highest correlation with biosynthesis and glycyrrhizin, and the third most frequently occurring keyword is identification. The strongest keyword is licorice with a weight of 28, which also has the strongest connection with other words; followed by *G. uralensis* with a weight of 17. The keywords with high frequency of occurrence are concentrated in the clusters where licorice and glycyrrhiza-uralensis are located. Keywords in Cluster #1 Licorice are mainly *G. uralensis*, Biosynthesis and Expression. Keywords in Cluster #2 *Glycyrrhiza-uralensis* are mainly Identification, Flavonoids and Constituents.

3.4 Author co-occurrence network diagram

VOSviewer analyzes authors' cooperation, Chinese literature retrieved from CNKI with the theme of resources is imported into VOSviewer in Refworks format. Type of analysis selects Co-authorship, and Unit of analysis is Authors. Restricting the number of authors' publications to ≥ 3 produces 11 eligible and interconnected entries. As shown in Fig. 9A, author Wang Wenquan has the most publications, has strong connections with multiple authors and has the strongest connection with Wei Shengli and Hou Junling, which is located in the center; followed by author Wei Shengli, with the second largest number

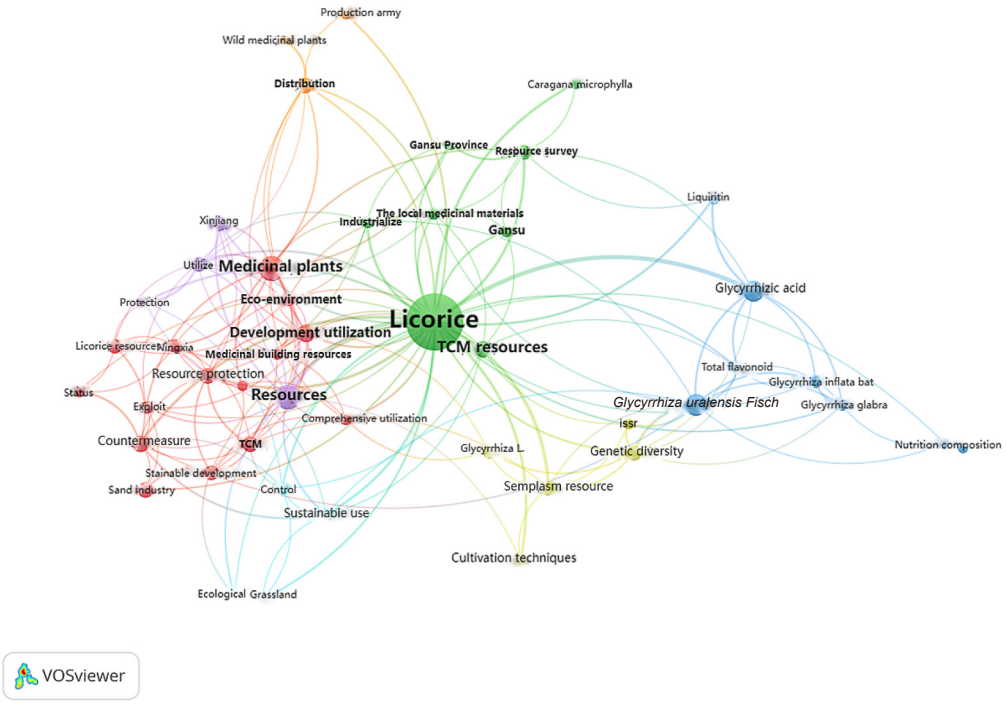


Figure 7 Keyword co-occurrence network diagram of Chinese literature.

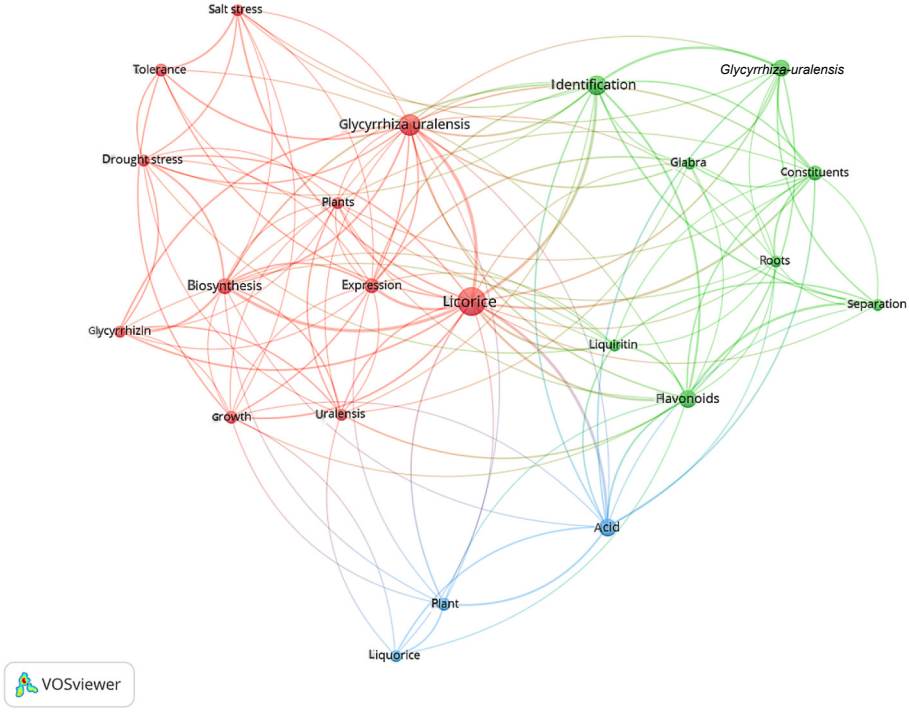


Figure 8 Keyword co-occurrence network diagram of foreign literature.

of publications, and has stronger connections with Chen Hua and Li Gang. The authors' literature collaboration is consistent with the authors' relevance strength data table (Table S4). Combined with CiteSpace analysis of author clustering according to the number of keywords (Fig. 9B) and sorting of labels, the top five clusters were shown, which were "Germplasm resources" "Farm weeds" "Cropping system" "Cellulase" "Water resources". The figure shows that the representative authors of the keyword research on germplasm resources are Wang Wenquan and Hou Junling, etc., the authors of the keyword research on farmland weeds are Li Ming and Liu Hua, etc., the authors of the keyword research on planting system are Liu Changle and Li Guolong, etc., the authors of the keyword research on cellulase are Zhang Sen and Zeng Fei, etc., and the authors of the keyword research on water resources are He Fangyin and Liu Shizeng, etc. The team of authors with outstanding contributions in the field of domestic licorice resources is the team represented by Wang Wenquan (China Academy of Traditional Chinese Medicine) and Hou

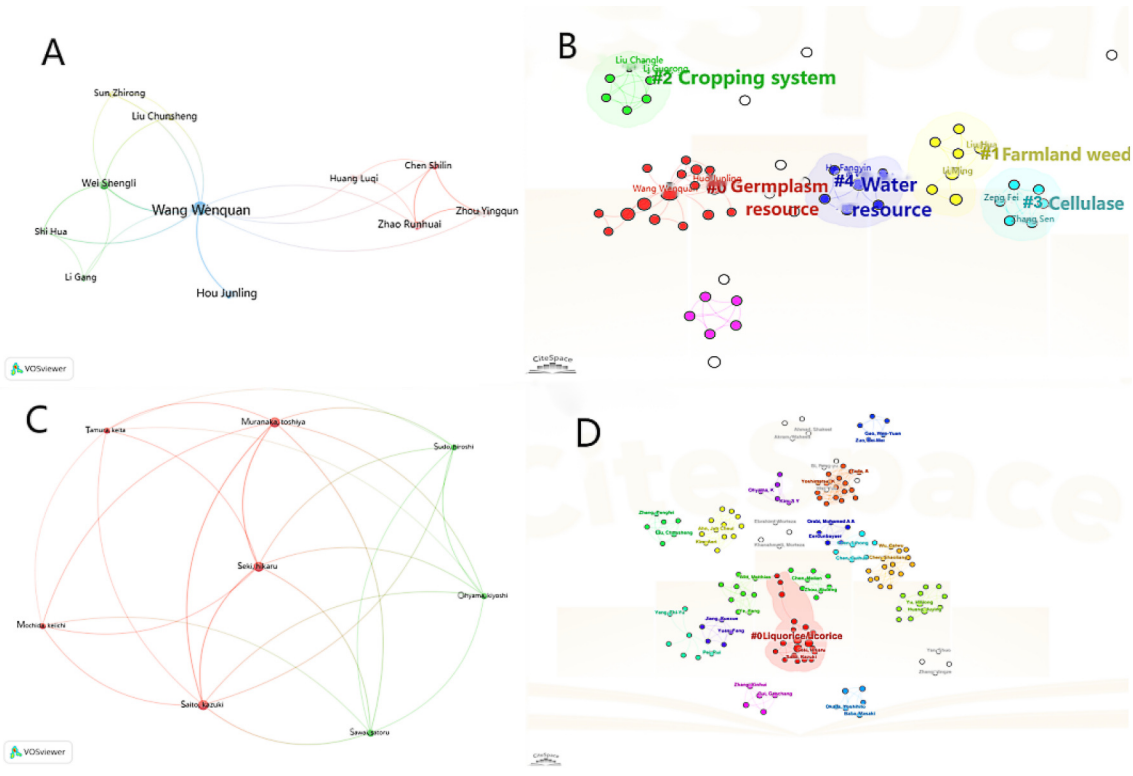


Figure 9 Author co-occurrence visualization analysis. (A) VOSviewer Chinese author co-occurrence network graph, (B) CiteSpace Chinese author cluster analysis graph, (C) VOSviewer foreign author co-occurrence network graph, (D) CiteSpace foreign author cluster analysis graph.

Junling (Engineering Research Center of Good Agricultural Practice for Chinese Crude Drugs of Ministry of Education), who studied germplasm resources as the keyword.

The search results collected from WOS were imported into VOSviewer, and Co-authorship was selected for Type of analysis, and Authors for Unit of analysis. Limiting the number of author publications to ≥ 3 produced 14 entries that met the conditions and were related to each other. As shown in Fig. 9C, authors Muranaka, Toshiya (Osaka University), Saito, Kazuki (RIKEN), and Seki, Hikaru (Osaka University) have a high number of publications and are strongly related to each other. Combined with CiteSpace clustering of authors according to the number of keywords (Fig. 9D), the system clustered a major cluster due to the small sample size, i.e., Cluster #0 Liquorice/Licorice. The main authors represented in this cluster are Saito, Kazuki and Seki, Hikaru. The authors Saito, Kazuki and Seki, Hikaru are proved to be a team of authors who have made outstanding contributions to the field of licorice resources at the international level.

3.5 View of the cooperation of documentary institutions

VOSviewer analyzes the cooperation between institutions, with Co-authorship selected for Type of analysis and Organizations for Unit of analysis. The Chinese literature analysis, limiting the minimum number of articles issued by an institution to five, produces seven entries that meet the conditions and are related to each other. The view of institutional cooperation (Fig. 10) showed that Beijing University of Chinese Medicine (BUCM), Nanjing University of Chinese Medicine (NJUCM) and China Agricultural University (CAU) cooperated closely with each other, and a number of institutions, such as Institute of Medicinal Plant Development, Chinese Academy of Medical Sciences (IMPLAD), Engineering Research Center of Good Agricultural Practice for Chinese Crude Drugs of Ministry of Education, and School of Chinese Materia Medica. BUCM cooperated closely with each other, and the institution with the largest number of articles in Chinese language literature on liquorice was BUCM.

The foreign language literature analysis, which restricts institutions to a minimum number of publications (3), produces eight eligible and interconnected terms. The view of institutional collaborations (Fig. 11) shows that institutions with outstanding international contributions in this field are basically concentrated in Japan, with Osaka Univ. (Osaka University) having the largest number of publications, and collaborating closely with a number of institutions such as Institute of Physical and Chemical Research (RIKEN) and Chiba Univ. (Chiba University).

4 Discussion

In this study, we collected literature through data retrieval, and used CiteSpace and VOSviewer visual analysis software to analyze the research results of TCM licorice from multiple perspectives such as keywords, authors, and institutions, and to visualize the research history trends and hotspots of concern in the field of licorice resources.

The analysis of the trend and distribution of Chinese and foreign literature showed that the Chinese literature showed a significant growth from 2000 to 2006, and the number of articles published in this field peaked in 2006, during which the research was in the stage of rapid development; after 2006, the number of articles basically showed a gradual downward trend, and the research enthusiasm for licorice resources has slightly declined in the recent past, or the progress of this field is slower. The progress in this field is slow. The publication of foreign language literature shows an increasing trend from 2004 to 2021, and then the enthusiasm decreases. The field is developing more rapidly in China, and the research attention of foreign scholars in the field of licorice resources has been growing gradually recently. The overall

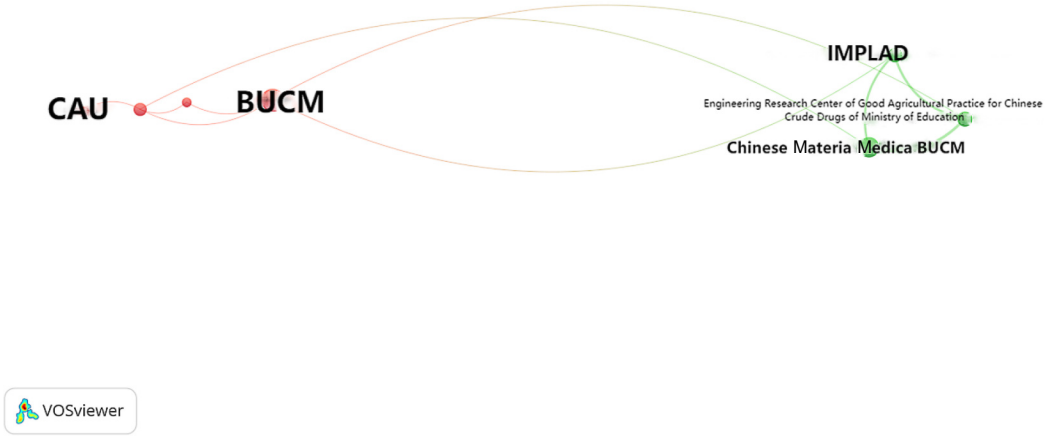


Figure 10 View of institutional cooperation in Chinese literature.

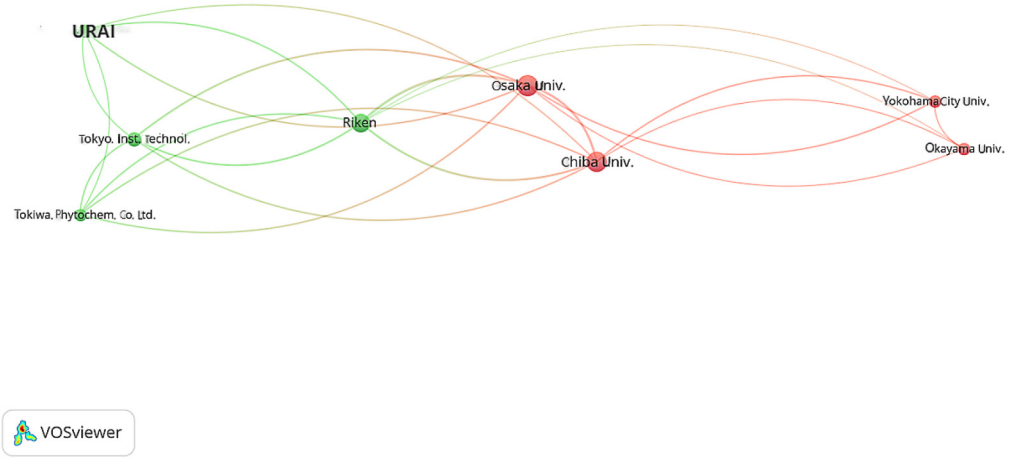


Figure 11 View of institutional cooperation in foreign languages.

trend is continuously upward, and research on licorice resources at home and abroad involves many fields, which nowadays mainly focuses on the disciplines of agronomy, botany and pharmacy.

The keyword heat trend analysis visualized using CiteSpace software showed that the keywords distribution, medicinal plants, development and utilization had a high frequency and centrality, and that today's academic environment is relevant to the study of the distribution of resources, active ingredients and biosynthesis aspects. Combined with the timeline and emergent word analysis, the keywords herbal medicine, salt stress, tolerance, drought stress, are the hotspots of recent research in this field.

Using VOSviewer and CiteSpace to analyze the connection between keywords, authors and institutions, the keywords licorice, glycyrrhizic acid, medicinal plants, resources, the frequency and relevance are higher in the Chinese literature; in the foreign literature, licorice is associated with the keywords flavonoids, biosynthesis, expression, growth; analyzing the cooperation of authors, the team of authors with outstanding contributions in the field of domestic licorice resources is Wang Wenquan, who researched with the keywords germplasm resources[4] (China Academy of Traditional Chinese Medicine, China), Hou Junling[5] (China Academy of Chinese Medicine, China) and Hou Junling (Standardized Production Engineering Research Center of Chinese Materia Medica, Ministry of Education, China), and the Japanese authors Saito, Kazuki[6] (RIKEN) and Seki, Hikaru[7] (Osaka University) are the team of authors who have made outstanding contributions to the field of licorice resources in the international arena. In the analysis of the cooperation between institutions, the institution with the most publications in Chinese literature on licorice is BUCM[8], which cooperates closely with many other institutions. Osaka Univ.[9] has the largest number of publications, and cooperates closely with several institutions.

By visualising and analysing the research results at home and abroad from multiple perspectives, the hot research content can be mainly classified into five categories: the first category, Botany and ecology[10], study the botanical characteristics of liquorice, including the growth environment, ecological behavior, growth cycle, etc, analyses the distribution of different species and varieties of liquorice in different regions[11,12], and explores its adaptability and ecological distribution pattern[13]. The second one is Resource science and quality control, to study the yield, harvesting, processing and quality control[14] of liquorice resources[15], and to explore the high-quality varieties, optimal harvesting timing and processing techniques[16] of liquorice resources. The third category, Chemical composition and clinical application, analyses the main chemical components of licorice, especially glycyrrhizic acid[17] and other secondary metabolites, and investigates the pharmacological effects of liquorice[18], including the mechanisms of anti-inflammatory[19], anti-tumour[20], immunomodulation[21] and neuroprotection[22]. Investigate and study the application of liquorice in Chinese medicine and TCM, including the use of classical formulas[23] and monopharmaceuticals, and analyse the function and compatibility application[24] of licorice in TCM treatment system. The fourth category, sustainable use and

conservation, investigates the sustainable use of liquorice resources, including the sustainability of cultivation, collection and processing, analyses the distribution and quantity of wild liquorice resources, and proposes relevant conservation measures[25, 26]. The fifth category, Application of new technologies, explores the application of new technologies in the study of liquorice resources, such as remote sensing technology[27], molecular biology[28] methods, etc., and analyses the research progress of these new technologies[29] in improving the efficiency of resource use and quality control.

5 Conclusion

The study of the TCM licorice has always been a hot topic in the field of TCM, and the research literature related to licorice is even more numerous, but the attention in the resource field of licorice is not able to match with its own hotness. In recent years, changes in the environment, climate and other external factors have made people realize the importance of resource utilization and conservation of licorice, and how to cultivate high-quality varieties economically and environmentally friendly, and how to improve the utilization rate of licorice have been discussed in the field of resource science.

This study suggests that the future development of licorice resources will mainly focus on the following aspects: in terms of sustainable utilization and protection, strengthen research on the sustainable utilization and ecological protection of licorice resources, and develop new cultivation techniques and management modes to ensure its long-term sustainable utilization; apply modern biotechnological means, such as genomics and transgenic technology, to study the genetic background and molecular mechanisms of licorice; explore new extraction and isolation techniques to improve the purity and efficacy of licorice herbs; to study the feasibility of industrialization of licorice, including processing technology, product development, market demand, etc., in order to promote the healthy development of the licorice industry; and to promote research cooperation on licorice resources among countries, share experience, technology and research results, and promote the influence of licorice research in the international arena.

Considering various aspects such as resource protection, scientific and technological innovation, industrial development, and national participation, it is necessary to comprehensively take into account the interests of all parties and implement targeted policies and programs in the actual promotion process. The research on licorice resources is closely interconnected with various disciplines, and by taking advantage of the strengths of various specialties in order to promote the development of licorice research, it is expected to achieve a more scientific, sustainable and efficient utilization in the future, and to contribute to the healthy development of the Chinese herbal medicine industry and the ecological environment.

Conflicts of interest

The authors declare that there are no conflicts of interest.

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