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# GLOBAL SCIENTIFIC COLLABORATION IN *ELAEAGNUS ANGUSTIFOLIA* L. RESEARCH: AN ANALYSIS OF PUBLICATION PATTERNS AND KEY THEMES

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Current Trends in Natural Sciences

#### Abstract

In the context of increasing the global interest in Elaeagnus angustifolia L., this study represents the first in-depth scientometric and bibliometric analysis covering the period 2013-2023. The article discusses the evolution of research on this species, using data extracted from the Web of Science and Scopus databases, where we have analyzed 203 and respectively 188 articles. The applied methodology involves quantitative and qualitative analyzes of publications, citations, and international collaborations, highlighting the main areas of interest and the dynamics of collaboration. The results show a significant focus of research in the fields of ecology, pharmacology, and agriculture, while highlighting the growing interest in the plant's bioactive properties. The findings point out promising future research directions, such as the potential of phytoremediation and its use in alternative medicine, although the study acknowledges its limitations, including incomplete coverage of non-English literature. The analysis revealed a clear need to explore the complex interactions between Elaeagnus angustifolia L. and other species in its native and introduced ecosystems. Understanding these interactions can contribute to the development of strategies for conservation and sustainable use, emphasizing the importance of interdisciplinary studies to promote effective ecological management and maximizing the species' ecological and pharmacological benefits.

Keywords: Elaeagnus angustifolia L., scientometry, bibliometrics, ecology, pharmacology, phytoremediation

### **1. INTRODUCTION**

*Elaeagnus angustifolia* L. is one of the 45 species of the genus *Elaeagnus* (Family Elaeagnaceae), having the center of origin in Southeast Asia and showing both great morphological diversity and significant importance (Hällzon et al., 2022). In general, four varieties are distinguished that differ

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by shape, color and leaf hairiness and by the presence or absence of thorns on the branches, but no geographical or habitat differentiation has been observed (Bartha & Csiszár, 2008).

The plant has adapted in many other areas of the world, from the arid steppes to temperate areas (Niknam et al., 2016), growing in regions such as Western Europe, Asia Minor, Central Asia and Southeast, Far East and North America (Alexandrov & Karlov, 2021). Its geographical broad spreading is a witness to its remarkable adaptability to various climatic conditions and soil (Borsukevych et al., 2023).

*Elaeagnus angustifolia* L., known also under the name of willow, willow odorous or Russian olive, often remain in shrub stage, though may grow up to 8-10 m high; with irregular, sinuous stem covered by a thin, scaly rhytidome; with spiny spikes. The leaves are elongated-lanceolate, 4-8 cm long, with a tip acute or obtuse, whole edge, gray green on one side, silver-shiny on the back, with stellate, scaly bristles. The flowers have no petals, but have a campanulate calyx with four lobes and appear singly or 2-3 at the axil of the leaves towards the end of spring, being silver-white on the outside and yellowish on the inside (Say et al., 2024). The flowers are pleasantly fragrant, melliferous, appear in May and give rise to an often-rich crop of fruit, false ellipsoidal drupes, similar to olives (Safdari & Khadivi, 2021), silvery on the outside and on the core yellowish-orange, floury, with a sweet taste, edible for man and wild animals. Small mammals, birds and fish are proven to play a role in seed dispersal.

*Elaeagnus angustifolia* L. is developing in a variety of soil types, from well - drained soils until those clay or poor (Gaskin et al., 2019), in salted and alkaline soil; it is a plant drought resistant, preferring sunny locations, but may tolerate and partial shade (Zhang et al., 2018a). It is worth emphasizing the remarkable ecological suitability of the species and its saddle relevance in various fields, from ecology (Nackley, 2012) to pharmacology (Syed et al., 2024). This provides a solid basis for subsequent discussion on its property and its various applications.

When it reaches its maturity, it does not exceed the height of 3-6 meters and it is excellent for cutting, it may be kept at one size low to form hedges (Morrow, 2016), standing out with trunk and branches covered with a brown bark that exfoliates, giving a special appearance in winter (Zare et al., 2023). It is an ideal species for rehabilitation and improving degraded soil, afforestation saline areas; it has an important role in protection against erosion in arid areas. As it tolerates well the air and soil contamination, it is often planted in industrial cities and locations. The species is sensitive to heavy metals and emissions (sulfur dioxide, ammonia compounds, acid hydrofluoric) as well, so it may be useful as a biomonitor species (Aksoy & Şahin, 1999). In Europe, species of *Elaeagnus* are planted in parks and gardens from where it can be permanently installed, even becoming invasive (Bartha & Csiszár, 2008).

In traditional medicine (Gaskin et al., 2019), *Elaeagnus angustifolia* L. was used for its antioxidant (Karkar & Şahin, 2022), anti-inflammatory, analgesic and antiseptic properties. In different cultures, it was used as treatment for gastrointestinal, respiratory disturbances and other chronic disease, having an important role in ethnopharmacology.

In the recent research it has been focused on its phytochemistry profile rich in bioactive primary and secondary compounds; numerous studied about *Elaeagnus angustifolia* L. provides a scientific validation for its traditional use, as a remedy for improving and treatment several symptom and conditions with different degrees of severity. Secondary metabolites of *Elaeagnus angustifolia* L. are numerous and belong to several classes: flavonoids, acids phenolics, steroids, alkaloids, glycosides, terpenes, amino acids, acids organic and other types of compounds (Liao et al.,2024). The plant also contains vitamins (tocopherol, vitamin C, thiamine B1), minerals (calcium,

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magnesium, potassium, iron and manganese), sugars (fructose, glucose), localized in different proportion in all plant's organs - fruits, flowers, leaves, branches young, bark or even root (Hamidpour et al., 2019), all being able to be subjected test in view obtaining from us phytopreparations and therapies.

Studies from the last decade have revealed the complexity interactions from these active principles and their effects on health human (Farzaei et al., 2015; Nazir et al., 2020). This review follows to synthesize these findings, providing a complete picture of the current state of knowledge about *Elaeagnus angustifolia* L. and potential or in pharmaceutical (Marvdashti et al., 2024) and therapeutic field. Moreover, the work is a Scientometric examination designed to develop a perspective amplified on the evolution in research, through analysis interpretative and theoretical depth of specialized literature related to *Elaeagnus angustifolia* L., with a special emphasis on the research conducted in the previous ten years.

The Scientometrics performs a quantitative exploration of academic literature, including books, articles and other ways of disseminating knowledge. Through the prism scientometry, various professional spheres could map the current panorama of the expertise, characteristics, progress and predominant trends. This methodology offers researchers, including outside the targeted specializations, the possibility of the depth and the amplitude of those fields of study.

The research was spread extensively in research fields such as Environmental Sciences Ecology, Plant Sciences, Chemistry, Agriculture, Food Science Technology, Forestry, Pharmacology Pharmacy, Biochemistry Molecular Biology, Engineering, Energy Fuels, etc.

This bibliometric review differs from previous approaches that were based on sets limited by documents or were focusing exclusively on one discipline (Nazir et al., 2020) covering a variety of topics, thus the results of this bibliometric review provide a comprehensive basis for empirical future comparisons and emphasize the important directions for the studies further related to this species.

# 2. MATERIALS AND METHODS

The scientometrics investigation is based on the application of a series of bibliometrics indicators (Marchiori et al., 2021; Xu et al., 2021) which include variables quantitative (e.g. frequency publications on time intervals, relations between actors involved such as countries and quoters) and qualitative filters (topics, keywords, specialized journals) for the identification of new research directions and of the paradigm prevailing in the academic community (Oliveira et al., 2019) regarding the object of study *Elaeagnus angustifolia* L.

This section details the scientometric approaches adopted for the analysis of the study object *Elaeagnus angustifolia* L., with the aim of revealing the trends and essential characteristics of the specialized literature in this field. Scientometric investigation is fundamental to clarify research trajectories (Marchiori et al., 2021) and it identifies potential future directions by applying a series of bibliometric indicators (Xu et al., 2021). It should be noted that there was no comparable study in the period under review.

Innovation in the field of scientometrics resides in the application of bibliometric analysis (Eker et al., 2019), designed to satisfy the requirements of an epistemology that considers the historical evolution of a discipline. The use of scientometric tools, which includes quantitative variables (e.g. frequency of publications over time intervals, relationships between involved actors such as countries and citations) and qualitative filters (themes, keywords, specialized journals), facilitates

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the identification of new research directions and prevailing paradigm in the academic community (Oliveira et al., 2019).

The definition of scientometrics as the quantitative study of the evolution of science emphasizes its importance in evaluating the impact of research and in analyzing citation relationships to map fields of knowledge. Bibliometrics (Salinas-Ríos, 2022) focuses (Hood & Wilson, 2001) on the application of mathematical and statistical methodologies to written literature (Agada, 1987), while scientometrics (Hood & Wilson, 2001) deals with the quantitative aspects of scientific activity (Sengupta, 1992). This scientometric review aims at assessing publication patterns (Umeokafor et al., 2022), citation networks, co-authorship and research productivity, providing valuable insights into trends, influential papers and knowledge evolution in the field of *Elaeagnus angustifolia* L. species study. The methodology adopted for this study involved the stages of investigation design and information gathering, followed by a detailed bibliometric analysis and the development and mapping of collaborative networks (Farooq, 2023). The bibliometric analysis was performed using documents from the Web of Science Core Collection on the Clarivate Analytics platform and Scopus on the Elsevier platform. The query process included a full range of internationally recognized indexes: Science Citation Index (SCI), Social Science Citation Index (SSCI), Arts & Humanities Citation Index (AHCI), Conference Proceedings Citation Index (CPCI), Book Citation Index (BKCI), Emerging Sources Citation Index (ESCI), Current Chemical Reactions (CCR) and Index Chemicus (IC). The analysis period is from 2013 to 2023, and it should be noted that no similar studies were conducted during that time. The aim of this retrospective scientometric analysis is to investigate the characteristics and global trends of publications related to Elaeagnus angustifolia L., for the period 2013-2023. The study included an assessment of data on year of publication, author affiliation, country of origin, number of citations, type of journal, etc. The databases such as PubMed, Scopus, Google Scholar and Web of Science were used for data collection (Table 1), exploring various applications of *Elaeagnus angustifolia* L. in ethnomedicine, phytochemistry, pharmacological and biological activities, toxicology and agronomy. The data collection period was January 1, 2013 to December 31, 2023, using the search terms "Elaeagnus angustifolia L." or "oleaster", without language restrictions. References from the selected papers were also reviewed to identify additional relevant studies. Articles were evaluated in their entirety, including both publications and abstracts presented at conferences.

Parameters	WoS	Purpose	PubMed	Google Scholar
Rank	2013 - 2023			
Data	January 12, 2024			
Document Type	Article, book, book chapter, review article, conference proceedings			
Words	Elaeagnus angustifolia L.			
Results	203	188	50	650

**Table 1.** Results of parameter search in databases

Source: Authors' processing

In our scientometric analysis, we went through the following stages:

- Investigating the presence of a scientometric study dedicated to research on *Elaeagnus* angustifolia L.

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Initiating the process involved performing a search using the combination of terms "*Elaeagnus angustifolia* L. and scientometric analysis" in the four databases listed previously (Fig. 1): PubMed, Scopus, Google Scholar and Web of Science. The results of this search did not reveal the existence of such a study.

- Collection of data on the volume of publications, citations and co-citations associated with *Elaeagnus angustifolia* L. from PubMed, Scopus, Google Scholar and Web of Science.

By querying the databases with the terms "*Elaeagnus angustifolia* L.", we identified 650 entries in Google Scholar, 50 in PubMed, 188 in Scopus and 203 in Web of Science (Fig. 1).

- we decided to focus scientometric analysis efforts on data from Scopus and Web of Science.

- Explore the research directions highlighted by the most cited papers, as well as the significant contributions of top authors or countries.

- Subsequently, we used VOSviewer to aggregate data on citations, annual publications, journals, reference authors, nations and organizations with the most relevant contributions, predominant themes, and key terms. VOSviewer, in its version 1.6.20, was selected as a high-performance network analysis tool (Van Eck & Waltman, 2010), used to generate maps based on network data, examine frequently cited documents, perform keyword co-occurrence analysis, and perform a co-citation analyzes of references (Yu et al., 2020). In addition, software was implemented to assess the intensity of interactions between authors, affiliations, and nations within the presented research (Mc Allister et al., 2022).

Figure 1 illustrates a sequential methodology for literature collection and review. The present research was based on publicly available information, thus eliminating the need to obtain approval from an ethics committee.



Figure 1. Flowchart of literature collection and analysis

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Selection criteria included articles indexed in Web of Science and Scopus, published between 2013 and 2023, in any language, with complete metadata (Xiaobei et al., 2022). Articles from other databases or published outside the specified range were excluded. Descriptive and bibliometric analyzes were performed using VOSviewer, which allowed the evaluation of different bibliometric indicators. The results of the analysis, including collaborations, authors, citations, institutions, topics of interest and types of journals, are presented in the form of descriptive tables.

# **3. RESULTS**

## 3.1. Annual productions

During the last decade, a corpus of 203 papers focused on *Elaeagnus angustifolia* L. was identified in the Web of Science. According to Figure 2, which illustrates an average annual rate of expansion of 10%, an incremental growth of publications can be distinguished, increasing from 12 papers (representing 5.91% of the total) in 2013 to 22 papers (10.84%) in 2023. The period between 2018 and 2022 marked an intensification of publications, in contrast to a decline observed between 2015 and 2017, and a similar decrease in 2023.

The average annual growth rate in scientific production was 10.20%, with a maximum appreciation of 80% in 2018 and a devaluation of -24.14% in 2023. The 203 papers in Web of Science, from the interval 2013-2023, accumulated 2423 citations.



Figure 2. The trend of publication production and citations of articles on Elaeagnus angustifolia L. research from 2013 to 2023 by authors based on information from WoS and Scopus / date January 12, 2024

Parallel to this, an investigation of the Scopus database revealed a total of 188 relevant papers published during the same ten-year period. Figure 2 also indicates a gradual growth trend, from 15 papers (7.98%) in 2013 to 18 papers (9.57%) in 2023. A period of accelerated ascent was identified between 2019 and 2022, while between 2015 and 2017 a reduction occurred, similar to year 2023. The average annual rate of advancement of scientific production was estimated at 4.85%, with a peak of 50% in 2020 and a maximum retraction of -36.84% in 2015. In total, the works of Scopus received 2742 citations during the analyzed period.

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The most active 10 regions, 10 research fields and 10 organizations of those who researched *Elaeagnus angustifolia* L. and published are listed in Table 2.

203 p	WoS ublications		Scor 188 publ	ous ications	
	No Publications	% of total		No Publication s	% of total
		Affiliatio	ons		
Chinese Academy of Sciences	14	6.89	Chinese Academy of Sciences	8	4.26
University of Chinese Academy of Sciences	10	4.92	University of Chinese Academy of Sciences	7	3.72
Islamic Azad University	9	4.43	Islamic Azad University	7	3.72
Shandong Normal University	9	4.43	Ministry of Education of the People's Republic of	6	3.19
Tabriz University of Medical Sciences	8	3.94	Shandong Normal University	6	3.19
Colorado State University	6	2.95	Selçuk University	6	3.19
Northwest Af University China	6	2.95	Northwest A&F University	6	3.19
University of Tabriz	6	2.95	Tabriz University of Medical Sciences	6	3.19
Selcuk University	5	2.46	University of Tabriz	6	3.19
Alborz Univ Med Sci	4	1.97	Research Center of Saline and Alkali Land of State Forestry Administration	4	2.13
		Countries/R	egions		
CHINA	54	26.6	China	53	28.19
IRAN	49	24.13	Iran	48	25.53
TURKEY	30	14.77	Turkey	35	18.62
USA	20	9.85	United States	10	5.32
INDIA	9	4.43	Russian Federation	10	5.32
ITALY	6	2.95	Germany	6	3.19
HUNGARY	5	2.46	Italy	5	2.66
PAKISTAN	5	2.46	French	5	2.66
RUSSIA	5	2.46	Algeria	5	2.66
ALGERIA	4	1.97	Tunisia	4	2.13
		Research A	reas		
Environmental Sciences Ecology	38	18.71	Agricultural and Biological Sciences	116	61.70
Plant Sciences	31	15.27	Environmental Science	46	24.47
Chemistry	25	12.31	Biochemistry Genetics and Molecular Biology	28	14.89
Agriculture	24	11.82	Chemistry	2.3	12.23
Food Science Technology	24	11.82	Medicines	21	11.17

#### **Table 2** The most active regions, research areas and publication organizations

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Forestry	19	9.35	Pharmacology Toxicology and Pharmaceutics	20	10.64
Pharmacology Pharmacy	17	8.37	Engineering	14	7.45
Biochemistry Molecular Biology	14	6.89	Chemical Engineering	13	6.91
Engineering	14	6.89	Energy	10	5.32
Energy Fuels	8	3.94	Social Sciences	5	2.66
		Langua	ge		
English	201	99.01	English	172	91.49
Russian	1	0.49	Chinese	10	5.32
Turkish	1	0.49	Persian	3	1.60
			Russian	2	1.06
			Turkish	1	0.53

Source: Authors' processing according to: <u>https://www.webofscience.com/</u>, https://www.scopus.com/

## 3.2. Keywords

In the analysis process, the keywords provided by the authors were considered (Chang et al., 2015), and a criterion was that the minimum number of occurrences of the keywords should be 5.

In Web of Science of the 1474 keywords, 54 meet the threshold. For each of the 54 keywords, the total strength of co-occurrence links with other keywords will be calculated. The keywords with the highest total link strength will be selected (Fig. 3A). The number of keywords to be selected is 54.

In terms of frequency, the most frequent keyword was *Elaeagnus angustifolia* L., along with oleaster, Russian olive, vegetation, diversity, growth, antioxidant activity, plants. Fig. 4A shows the top 100 words cloud.

Within the Scopus database, out of a total of 3206 key terms, 101 reached a predefined level of relevance. For each of these 101 terms, the intensity of co-occurrence connections with other key terms will be assessed. Those terms with the highest degree of interconnectivity will be preferred for selection, as illustrated in Figure 3B. The set number of key terms to be included in the final analysis is 101.

Relative to the frequency of occurrence, the predominant key term was "*Elaeagnus angustifolia* L.", followed by terms such as "nonhuman", "elaeagnaceae", "plant extract", "human", "controlled study", "medicinal plant", "unclassified drug", and "antioxidant activity". The graphical representation of these terms, in the form of a word cloud for the top 100 most used terms, is shown in Fig. 4B.

## 3.3. Co-Authorship Analysis

The investigation on co-authorship reveal a perspective on dynamics collaboration between researcher and entities (Isfandyari-Moghaddam et al., 2023), which is fundamental to the progress of partnerships in scientific and technologic field (Mohammadamin et al., 2012). Co-authorship represents a formal acknowledgment of plural contribution, where many authors or organizations are recognized as having an intake in the development one technical or scientific work. Patterns of academic cooperation continue to be examined and interpreted through the lens of co-authorship analysis, even in the face of controversy regarding its meaning and analysis.

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Figure 3. Co-occurrence map of all keywords: A - by examining keywords from WoSdatabases and B - by examining keywords from Scopus database

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Figure 4. Words for the first 100 most used terms: A - by examining keywords from WoSdatabases and B - by examining keywords from Scopus databases

The analysis of the network' structure of the of co-authors is done through assigned nodes, which represent either individual authors, or organizations, or countries, which collectively participate in the act of co-authorship. They were analyzed using VOSviewer, version 1.6.20.

Analyzing the co-authorship map based on the data from the Web of Science databases, a total of 840 authors were identified, of which 20 met the minimum criterion of having published at least three papers. VOSviewer software revealed that not all 20 entities in the coauthorship network are interconnected, and the largest group of interconnected papers consists of 7 articles.

In terms of intensity of connections, Chen Min (with 8 papers, 61 citations, and a total link strength score of 18) stood out as having the highest presence. Li Lingyu (with 3 papers, 30 citations and a total link strength score of 18) was second in terms of influence, followed by Zhang Mingjing (with 3 papers, 24 citations and a link strength score of 8 total links) in third place.

On the co-authorship map for works with *Elaeagnus angustifolia* L. as their subject, indexed in the Scopus databases, 775 authors were identified, of which 18 met the condition of having at least three publications. It was observed that of the 18 elements of the co-authorship network, not all are connected to each other, and the largest connected group is composed of 4 authors.

Regarding the strength of connections, Mahdavi Reza, Nikniaz Leila, Nikniaz Zeinab and Ostadrahimi Alireza (each with 4 papers, 74 citations and a score of 12 for total strength of links) share the top spot in terms of influence. In addition, the diameter of each node in the coauthorship map was proportional to the number of coauthorship links joining them to other nodes.

In the context of the institutional co-authorship analysis, it is worth emphasizing that 22 of the 314 entities have reached the criterion of being co-authors of at least three documents, according to data from Web of Science. The density map indicates the central placement of organizations with the highest total link strength. The Chinese Academy of Sciences was distinguished by the most extensive total linkage strength, rated 9. This is followed by the University of the Chinese Academy of Sciences with the second highest linkage intensity, with a value of 8, and the University of Medicale Alborz, with a total strength links of 7.

In the similar Scopus peer review, of the 460 organizations, only 8 met the threshold of three publications. The Department of Obstetrics and Gynecology of the Faculty of Medical Sciences, Alborz University of Medical Sciences occupies the central position on the density map, with the most prominent total link strength, rated at 9. This is seconded by the Department of Food Science

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and Technology, Faculty of Nutrition, Tabriz University of Medical Sciences, with a score of 3, and by the Tabriz Health Services Management Research Center, Tabriz University of Medical Sciences, also with a score of 3.

Therefore, this methodology was effective in facilitating a visual and intuitive analysis of the involvement and relationships between major research institutions.

# **3.4**. Co-occurrence analysis

Co-occurrence analysis involves examining the frequency with which two or more entities appear together in a set data (Qiu et al., 2014) (Fig. 5). The central tool in this type of analysis is the co-occurrence matrix, which organizes the entities on the vertical and horizontal axes, and the meeting point between a row and a column indicates the frequency of their co-occurrence (Xiaobei et al., 2022). In the field of bibliometrics, this methodology is applied to explore potential links between two bibliographic works (Sedighi, 2016) that are cited together in the same academic paper. Co-occurrence analysis techniques in bibliometrics have refined considerably over the past twenty years.

Web of Science provides a set of additional keywords for research papers, thereby helping to improve researchers' ability to access more detailed and relevant information. These "KeyWords Plus" include terms and phrases extracted from the titles of cited references, providing a broader view of the knowledge structure of a domain, and facilitating the interconnection between various research areas, as illustrated in Fig. 5A. The frequency with which these keywords appear also highlights emerging trends in each field, often being more descriptive than terms attributed directly by authors. Therefore, "KeyWords Plus" can provide a more accurate description of the content of an article.

In the co-occurrence map, each node represents a keyword, and the size of the node reflects the frequency of co-occurrence of the keyword in the data set - the larger a node, the more frequently the term co-occurred. Lines between nodes represent co-occurrence links, and their thickness indicates the intensity of co-occurrence. The color of the different nodes and corresponding clusters suggests groups of terms that are frequently associated in the literature, indicating specific research subfields or themes.

Based on the colors in the image, it appears that there are several distinct groups that reflect different research themes in the *Elaeagnus angustifolia* L. field of study. For example, nodes colored in red represented a theme related to the plant's biological responses (such as stress, gene expression, accumulation), while nodes in blue represented research on the antioxidant properties of the plant. The green ones refer to the study of the compounds in the fruits and seeds of the plant, and the yellow ones indicate aspects related to ecology and biodiversity.

Analyzing and interpreting this map allows researchers to understand not only the major themes of interest, but also how these themes are interconnected, thus facilitating the identification of new potential directions for research.

On the other hand, keyword indexing is an information organization methodology that uses natural language to classify and identify essential terms in the title of a paper, as happens in the Scopus database. Significant terms are those words that show a high correlation with the central ideas of the document. These terms, present as "Index Keywords" in Scopus records, come from subject headings of the source database, not generated by Scopus itself, as illustrated in Fig. 5B. Five clusters can be observed.

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Figure 5. Map of co-occurrence analysis: A - by examining WoSdatabases and B - by examining Scopus databases

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We notice that *Elaeagnus angustifolia* L. is centrally positioned and is a large node, which indicates a high frequency of co-occurrence of this term with other keywords. The nodes related to *"Elaeagnus angustifolia* L." could suggest topics directly related to the plant in question, such as "antioxidants", "phenol", and "antioxidant activity", thus showing a research focus on the properties and chemical composition of the plant.

Nodes and links are colored differently, indicating thematic clustering. For example, the red cluster represented studies related to ecology and biology, such as plant cultivation, salinity, and ecological stress. The blue cluster can include research on medicinal uses and animal experiments, such as "controlled study", "animal tissue", and "nonhuman". The green cluster focuses on the study of plants in the context of traditional medicine and phytotherapy, with terms such as "herbal medicine", "medicinal plant" and various other plants.

By analyzing the distribution and density of links, we can deduce which research areas are of increased interest and the interconnections between different sub-disciplines. This map can be particularly useful for researchers in identifying emerging trends, potential collaborations, and directing future research.

## 3.5. Analysis of citations

This analysis is based on observing which article cited by another article (or which authors of articles cite the authors of the author's articles). VOSviewer allows the identification and graphical representation of connections between scientific papers based on the frequency with which they are cited together. Through the created citation maps, researchers can discover the influential works, the connections between different topics or authors, and the collaboration structure in a field see Fig. 6. This analysis helps to understand how knowledge is disseminated and developed, indicating the most cited and, by implication, possibly the most influential works in a field of study.

Fig. 6A illustrates a citation map generated by VOSviewer, using data from Web of Science. Each node on the citation map represents a scientific document, and is labeled with the name of the lead author and the year of publication. The size of the nodes reflects the frequency with which each document has been cited; the larger a node is, the more citations that document has received. Lines connecting nodes represent citations between documents, and their thickness indicates the number of mutual citations. Different node colors indicate different clusters or groups of papers that are often cited together, thus suggesting that they may address similar topics or belong to the same research subfield. The cluster with the most closely connected nodes may represent a central research topic or a group of studies with significant impact in their field such as the one labeled "Çakmakçı (2015)" or "Singh (2016)", suggests that these works are influential and have played a key role in disseminating knowledge in their field.

We also observe different groups of studies, reflecting specific subfields of interest, such as plant health effects, optimization of agricultural processes, or studies related to specific plant bioactive components.

This citation map, created with VOSviewer based on Scopus data, helps the user visualize how the documents in their research database are interconnected.

For example, we can see the group "Hamidpour 2017" which may represent a highly cited research topic or a specific field of study, while other groups ("Farzaei, 2015"; "Niknam, 2016"; etc.) may represent other related fields or topics. Analysis of these connections and clusters can provide insight into how different studies are related to each other and trends in the literature, as well as potential emerging research directions.

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Visual analysis of the citation map can provide researchers with a quick understanding of the structure and evolution of the scientific network, identifying the main actors and the links between them, which can guide further research or literature reviews.



Figure 6. Map of citations: A - by examining WoSdatabases and B - by examining Scopus databases

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## 4. DISCUSSIONS

The scientometric analysis performed on the literature on *Elaeagnus angustifolia* L. during the period 2013-2023 reveals a significant expansion of the field, with an annual growth rate that reflects a growing interest in this species from the scientific community. This upward trend, recorded in both the number of publications and citations, underlines the continued importance and relevance of the species in various fields of research.

The increase in the number of publications and citations associated with *Elaeagnus angustifolia* L. highlights not only the importance of the species in traditional fields such as pharmacology and ethnobotany, but also in emerging fields including ecology and environmental rehabilitation. The scientometric analysis indicates a diversification of research, with studies covering aspects ranging from bioactive properties and medicinal applications to ecological benefits and agricultural potential.

Analysis of co-citations and bibliographic linkages suggests that while there is a solid core of research focused on the antioxidant and medicinal properties of *Elaeagnus angustifolia* L., there are also less explored areas such as its impact on the soil microbiome and its use potential in agroforestry systems. Thus, future research directions may include more detailed exploration of the ecological interactions between *Elaeagnus angustifolia* L. and other species in both natural and human-managed systems, as well as more in-depth studies of its potential in phytoremediation of polluted soils.

The co-authorship and co-citation analysis highlights the international and multidisciplinary collaborations surrounding research on *Elaeagnus angustifolia* L., indicating a global network of knowledge that transcends geographic and disciplinary boundaries.

The obtained results reveal a remarkable geographic diversity in research on *Elaeagnus angustifolia* L., with China (Mamat et al., 2023; Huojiaaihemaiti et al., 2022a; Ma et al., 2021), Iran (Zarban et al., 2023; Asri et al., 2023) and Turkey (Gecer, 2023; Sevindik et al., 2023; Yavuz et al., 2022) among the most active regions. This distribution reflects not only the richness of biodiversity and the traditional importance of the species in these areas, but also the increased investment in research and development. The variable regional interest emphasizes the potential of *Elaeagnus angustifolia* L. in addressing specific environmental and health problems, as well as the importance of international collaborations in exploring this potential.

The research fields listed, such as *Environmental Sciences and Ecology* (Karimian & Farashi, 2021; Katz et al., 2020; Zhang et al., 2018), *Plant Sciences* (Incedayi & Erol, 2023; Ma et al., 2021; Liu et al., 2020), *Chemistry* (Huojiaaihemaiti et al., 2022b; Sun et al., 2021), *Agriculture* (Dubovyk et al., 2016), *Pharmacology* (Mamashli et al., 2022; Jalalvand et al., 2021; Torbati et al., 2016), and *Medicine* (Mahboubi, 2018; Alami et al., 2021) illustrate the broad spectrum of scientific interest in *Elaeagnus angustifolia* L. This thematic diversity highlights the multifunctional role of the species, from its importance in conserving biodiversity and combating soil erosion, to its potential in the development of new medical (Gecer, 2023) therapies. The presence of prominent institutions in research on the species of interest, such as the Chinese Academy of Sciences and the University of Chinese Academy of Sciences, reflects the significant investment in research and development and emphasizes the central role these organizations play in advancing scientific knowledge about it. The contribution of these organizations, along with those of Iran and Turkey, points to the importance of research infrastructure and academic collaborations in the dissemination and progress of knowledge about *Elaeagnus angustifolia* L. These thematic and collaborative connections are critical to addressing complex research questions and developing new insights and innovative solutions.

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## **5. CONCLUSIONS**

This work represents the first scientometric and bibliometric study of *Elaeagnus angustifolia* L. in Web of Science and Scopus, databases recognized for their accuracy in documenting the scientific literature. This rigorous selection of the data source guarantees an accurate analysis and maximum relevance of the presented information.

The present study makes an essential contribution to the existing literature by applying a comprehensive scientometric analysis, which illustrates not only the volume and frequency of research, but also the thematic connections and international collaborations in this field; it emphasizes the interdisciplinarity and diversity of applications of the species, from medicine to ecology and agriculture, these being only a few main areas of interest.

The study also identified possible research limitations and gaps.

The main limitation is the reliance on databases that, although comprehensive, do not always include the "grey" literature or publications in languages other than English, which may omit relevant studies, especially from regions where *Elaeagnus angustifolia* L. is native. Another limitation is represented by methodological variations between different databases, which can influence the consistency and comparability of the data. Although significant progress has been made in understanding *Elaeagnus angustifolia* L., scientometric analysis suggests that there are still areas that require further attention. Research is comparatively underrepresented on its effects on biodiversity, relationships with other species in the environments it lives in, and its potential in relation to climate change.

We consider as research gaps on the species of interest insufficient studies on the complex ecological interactions of the species in natural and human-managed ecosystems. Therefore, a potential course of action would be to investigate the function of *Elaeagnus angustifolia* L. in phytoremediation and in agroforestry systems, given its adaptability to varied soil conditions, including saline and alkaline. Another noted gap is given by the lack of research in the field of medical cosmetics.

Integrating the scientometric and bibliometric analyzes about *Elaeagnus angustifolia* L., it is evident that the species continues to offer a vast field of scientific exploration, with the potential to contribute significantly both to the advancement of scientific knowledge and to the solution of global challenges in the fields of health, agriculture, and environmental conservation. The perspectives emphasize the importance of continuing and expanding interdisciplinary and international research to fully explore the potential of *Elaeagnus angustifolia* L. for the benefit of humanity and the planet.

The study's conclusion highlights the ongoing interest in *Elaeagnus angustifolia* L. research, given its variety of applications, the species' widespread interest, and the necessity of an integrated approach that combines ecological, pharmacological, and agricultural studies to better understand the species' interactions with its environment and its many health and environmental benefits.

Considering this, the study may serve as a starting point for future research and emphasize the significance of carrying out more studies in this topic by offering a strong foundation for comprehending the intricacy and interconnection of domains related to *Elaeagnus angustifolia* L.

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