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Bibliometric Analysis of Trends and Future Directions of Research and Development of Seed Orchards

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Abstract: Seed orchards are important seed resources for producing improved tree crops for future plantations, forest restoration, and forestry practices (i.e., gene conservation) and for transmitting current gene diversity to future generations. Seed orchards are a major sub-division in forest science. The establishment and management of a seed orchard involves many steps, from the selection of superior trees to the harvesting of a seed crop. Studying the trends and future directions of seed orchards using different analysis methods is critically important, especially to establish resistant forests via the production of climate-smart, biotic/abiotic-stress-resistant seedling materials. Published papers related to seed orchards should be analyzed to determine the current trends in this field and to contribute to its future directions. Bibliometric analysis has been used for different purposes in various scientific fields. However, it has not been performed for publications in seed orchards. This study was carried out to analyze the current trends of research on seed orchards and to determine the future directions of these orchards based on published papers. For these purposes, 1018 published papers were obtained from the Science Citation Index, Science Citation Index Expanded, and citation index databases of "Web of Science" using the keyword "seed orchard". The papers were published between 1980 and 2022 and were subjected to bibliometric analysis based on the most prolific contributors, references, countries, and keywords. CiteSpace software 6.1 R6 was applied to visualize information about seed orchard research. The average number of citations per publication was 13.05, and the 4 H-Index of the publication set was 48. The most prolific contributors with the strongest citation bursts, the highest centrality, and the greatest numbers of published papers were from Canada, Sweden, South Korea, Finland, and Czech Republic, while Canada (186 published articles), the USA (140), and Sweden (115), together with China, Brazil, and Germany, were active countries, especially based on citations from recent years. The "keywords" of the papers were the core of the research. "Mating pattern", "Swedish forestry", "fertility variation", "*Hymenoscyphus fraxineus*", "threatened Pacific sandalwood", "outbreeding depression", "climate change", "management", and "growth", together with others such as "genetic improvement" and "effective size", were active study areas and keywords, based on results of the analysis. They also guided the literature search and inventory and classification of early studies and served as predictors for future studies. The results of this study are discussed based on the trends and future directions of the research and development of seed orchards.

Keywords: forestry; genetic; management; seed; WoS

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Citation: Yardibi, F.; Kang, K.-S.; Özbey, A.A.; Bilir, N. Bibliometric Analysis of Trends and Future Directions of Research and Development of Seed Orchards. *Forests* **2024**, *15*, 953. https://doi.org/10.3390/f15060953

Academic Editor: Mulualem Tigabu

Received: 12 April 2024
Revised: 27 May 2024
Accepted: 28 May 2024
Published: 30 May 2024

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1. Introduction

A seed orchard is defined as a special plantation of assumed superior genotypes established for the production of seed crops. Typically, a seed orchard contains clones or seedlings from selected trees that are isolated to reduce pollination from outside sources, grown on even ground and widely spaced to facilitate cone harvesting, and managed for

an early, easily accessible, and abundant seed crop [1]. After World War II, establishing clonal seed orchards began immediately. For instance, clonal seed orchards of Scots pine (*Pinus sylvestris* L.) and Norway spruce (*Picea abies* (L.) Karst.) were established in Sweden in the 1950s. In Denmark, a Hybrid larch (*Larix* x eurolepis A. Henry) clonal seed orchard was established in 1946. Scots pine, Larch (*Larix* spp.), Black pine (*Pinus nigra* Arnold.), and spruce (*Picea* spp.) clonal seed orchards were established in Hungary in 1951. In New Zealand, a Radiata pine (*Pinus radiata* D. Don) clonal seed orchard was established in 1958. In the United States, Loblolly pine (*Pinus taeda* L.), Slash pine (*Pinus elliotti* Engelm.), and Shortleaf pine (*Pinus echinata* Mill.) clonal seed orchards were established. In Canada, a Douglas fir (*Pseudotsuga taxifolia* Carr.) clonal seed orchard was established in 1966, and in South Korea, the first clonal seed orchards of Japanese larch (*Larix kaempferi* (Lamb.) Carriére) and Korean pine (*Pinus koraiensis* (Sieb. et Zucc.)) were established in 1968 and 1969 [1]. However, the first book on seed orchards was published in 1922 [2].

In spite of many biological and environmental factors, there are two main types of seed orchards, named according to the way of propagation methods: clonal seed orchard and seedling seed orchard. The clonal seed orchard is a seed orchard raised from selected clones propagated by grafting, cutting, air-layering, tissue culture, or other methods of vegetative propagation. The seedling seed orchard, also called seed plantation, is a seed orchard raised from seedlings produced from selected parents through open- or control-pollination [1]. So, seed orchards are subjected to both vegetative and generative prorogation at the beginning of their establishment, and various publications due to many steps of orchards from selection of mother trees to crop harvest (i.e., seedling/graft prorogation for establishment, management practices such as fertilization, protection, soil treatments, tending). Many research papers have been published in national and international journals, and proceedings and books have addressed various aspects of seed orchards for a century. Directions of the trend of published papers may change based on the balance of supply and demand of wood and seed production. The balance can be getting the importance of seed orchard research on some forest tree species, such as fast-growing Pacific hardwood trees (i.e., *Acacia* spp., *Eucalyptus* spp., and *Cunninghamia* spp.), which have been used widely as natural and exotic in plantation forestry. Therefore, it can also be effective in a number of published papers and their present and future trends in seed orchards, which are improved seed sources for forest plantations. The papers can be analyzed to reveal trends and to guide future research to improve the design and management of seed orchards. One of the ways to summarize these publications is through bibliometric analysis. This is a predictive tool to indicate the likely research direction in the field of seed orchards. Bibliometric analysis measures the contributions of scientific articles to a field or specific topic. It reflects current scientific developments and can be used to predict the next scientific model. Bibliometric studies that summarize and analyze the current state of seed orchard studies are needed for research planning. A bibliometric analysis is a quantitative or inventorial analysis of a specific topic related to the keywords of a field based on a literature survey. It is also a research method for assessing the productivity of authors, countries, and institutions by revealing their global distribution, collaboration, knowledge structures development trends [3,4], depth topics, citations, citation times, and keyword co-occurrence based on Web of Science (WoS) database. While many bibliometric studies have been carried out in different scientific fields such as medicine, computing, geography, environmental science, social science, water management, and animal sciences for different purposes (e.g., [3–10]), limited studies have been carried out in forestry (e.g., [11,12]). In addition, published papers related to seed orchards have not yet been subjected to bibliometric analysis.

In this study, the annual numbers, citation trends, directions, authors and their countries, and keywords of seed orchard publications were subjected to bibliometric analysis based on 1018 publications in the WoS database between 1980 and 2022 to outline their contributions to the future directions and planning of potential studies on seed orchards and to examine bibliometric inventory of published papers on seed orchards to reflect on the development in this area and determine future research opportunities.

2. Materials and Methods

The bibliometric analysis had many steps, from the selection of keywords to analysis criteria (i.e., author, citations, country). The data for the bibliometric analysis were extracted from the well-known academic database present in the Science Citation Index, Science Citation Index Expanded, and citation index databases of Web of Science (WoS), considering that it provides comprehensive citation information in various academic disciplines [13]. The database is accessible and easy to search for researchers. It also has an English language advantage compared to national databases and other databases. The search criteria topic/keyword "seed orchard*" was chosen based on the purposes and topic of the present study to access publications about seed gardens from the Web of Science Core Collection (update: 14 March 2023). The keyword criteria "seed orchard*" was searched based on titles, abstracts, and author keywords in published papers of the database. The "*" sign was used to reach a more extensive literature database by expanding the scope of relevant keywords. The WoS category was chosen to limit the research to the field of "forestry". In order to make the analysis more general, only articles written in English were selected from the database. No time limit was set to carry out a complete literature review from the past to the present. Following the selection process, the related data were retained in the "Full Record and Cite References" format using the "Tab-delimited" configuration for subsequent analysis. The searching and screening processes are given in a flow chart in Figure 1. The recorded data were converted into Excel data, and deficiencies were checked. According to the defined criteria, 1058 studies were identified for the 42 years between 1980 and 2022. Two researchers independently searched and reviewed the identified documents. As a result of these reviews, studies that were found to be unrelated to the research topic were removed from the created database. In total, 92.83% (945) of the 1018 publications were articles.

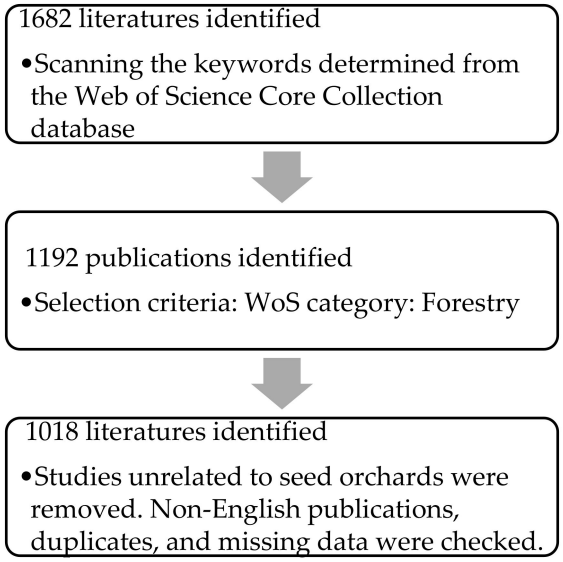

Figure 1. Flowchart of the data extracting process.

A total of 1018 publications were included in the analysis based on the most prolific contributors, references, countries, and keywords in the paper, while it was also extended in some studies by adding institutes and journals based on the purposes (e.g., [11]). In the next step, the publications were converted to a data file format suitable for CiteSpace and VOSviewer and subsequently analyzed. The study focused on previously published studies on seed orchards in the field of forestry. As this study involved a bibliometric analysis of existing published studies and did not involve human or animal subjects, no ethical review was required.

The choice of appropriate software was determined by evaluating the features offered by the software and the adaptability of the network to accommodate these features. CiteSpace was used, as it is a popular software tool for in-depth bibliometric analysis (CiteSpace Advanced 6.1 R6 update 8 January 2023, software available at https://citespace.podia.com/) (15 January 2023). In the next step, VOSviewer 1.6.9 software was applied as a tool that provided a visual representation of the data for network analysis [14,15].

In this study, published studies on seed orchards were examined in detail and visualized according to the following aspects using bibliometric analysis and descriptive statistics: (1) the growth trends of publications on seed orchards over time and the main characteristics of these trends; (2) countries/regions and researchers; and (3) current research topics and analysis of keywords and co-citation documents on these topics, as other studies carried out bibliometric analysis for different purposes in large fields of science (i.e., [8,9,11,12,16,17]). Descriptive statistics were calculated and obtained using an Excel worksheet.

Visualization maps consisting of links and nodes representing analytical elements such as authors, countries, journals, references, and keywords were created. A link between two nodes represents a joint relationship, such as cooperation between authors, institutions, or countries [18]. The size and linkage numbers of a node reflected the total frequency of the co-occurrence of an item, while the thickness of a node and the color of its ring indicated the time periods of co-occurrence for that item. Three structural indicators were used to measure network integrity. Firstly, the modularity Q index was used to examine the sub-structuring of the network in smaller groups. Secondly, the average silhouette score was used to evaluate the homogeneity and quality of the generated clusters. Finally, centrality values were used to determine the effectiveness of communication between nodes within the network [19,20]. A purple color around a node represented high centrality (greater than 0.1). The centrality value varied between 0 and 1.

In addition to these structural metrics, the node analysis also considered temporal metrics. Another important metric is the research impact of citation bursts. It is commonly used to detect sudden changes in the literature [21]. A citation burst is a phenomenon that identifies keywords, authors, institutions, or publications that show significant changes in the literature during a specific period or timeline. A timeline view provides an overview of how a cluster has evolved over time and highlights the persistence of a particular trend [22]. Cluster analysis is employed to extract significant patterns and relationships from large and complex data sets. This powerful statistical method enables publications to be grouped on the basis of the similarity of their authors, keywords, or topics. As a result, the connections between research fields and important trends in the scientific literature can be illustrated more clearly. In these cluster analyses, log-likelihood ratio (LLR) tests were employed for the analysis of node clusters with the aim of extracting noun phrases from the article titles in CiteSpace. The correlation between annual numbers of publications and citations was estimated by Pearson correlation.

3. Results

3.1. Publication Output

In this study, 1018 publications published between 1980 and 2022 were downloaded from the WoS core collection in the field of seed orchards in forestry. The numbers of identified publications and citations for the period are shown in Figure 2. It was understood that the increase in the number of citations was faster than the increase in the number of publications, while they varied over the years. An increase in the number of publications was noticed to positively influence the number of citations each paper received (Figure 2). The Pearson correlation coefficient between publications and citations was positive, approximately 0.68, and significant ($p \leq 0.05$) over the years. However, the number of citations and papers analyzed was based only on the WoS database in this study. The papers could be published or cited in national journals and international/national proceedings or in other scopes such as forest genetics and forestry instead of the seed

orchard keyword or other databases. The present study did not focus on national databases and other international databases.

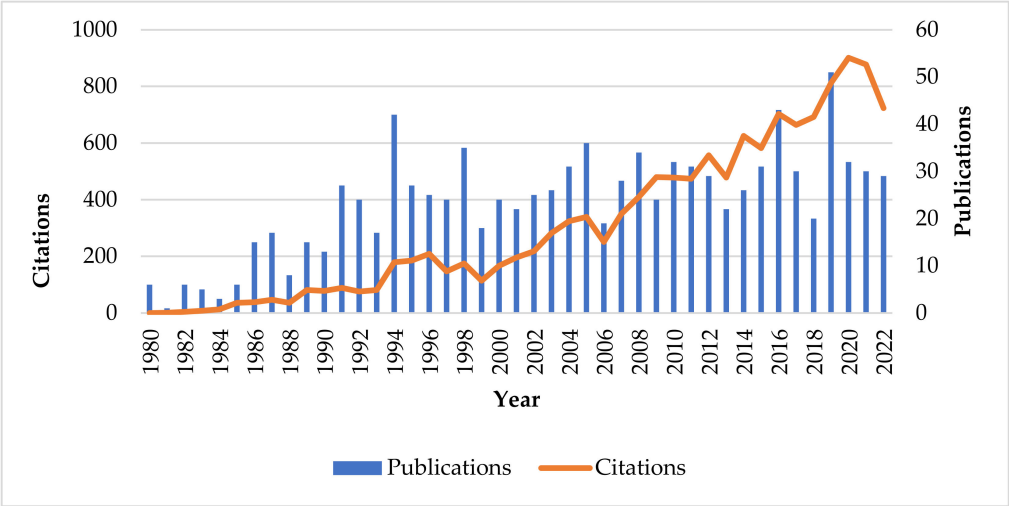

Figure 2. Distributions of the numbers of citations and publications by year for a total of 1018 publications.

The 1018 articles were cited a total of 13,288 times. The average number of citations per publication was 13.05. The H-Index of the publication set was 48, indicating that 48 publications were cited at least 48 times up to the search date without other databases.

3.2. The Most Prolific Contributors

The most prolific contributor authors section provided an overview of the most productive and influential contributors in the field. The ten authors who have been most prolific in publishing papers on seed orchards are listed in descending order in Table 1, which also lists the dates when these authors produced their first papers on this topic. There were large differences between the three most productive authors (El-Kassaby, Lindgren, and Kang) and the others in terms of the number of published papers. The most prolific author was El-Kassaby, with 58 papers. He published his first paper on seed orchards in 1984 (Table 1). However, author Lindgren was central to the field, with 40 published papers, and the highest centrality value (0.03) varied between 0 and 1 (Table 1). It indicated the importance of the content of the paper over the numbers.

Table 1. Top ten prolific authors with centrality values.

Count [1]	Centrality	Year [2]	Prolific Authors
58	0.02	1984	Elkassaby, YA
40	0.03	1981	Lindgren, D
15	0.01	2000	Kang, KS
9	0.01	1980	Adams, WT
8	0.02	1993	Nikkanen, T
8	0.01	1991	Burczyk, J
7	0.00	2012	Lstiburek, M
6	0.00	1985	Skroppa, T
6	0.00	2007	Almqvist, C
6	0.00	1995	Owens, JN

[1] is the total number of publications, and [2] is the year of the first publication by this author on seed orchards.

The citation bursts of authors who changed the literature with a sudden frequency during this period are given in Table 2. Author Lindgren had the highest strength at 9.84 and the longest period of the strongest citation bursts at 11 years (Table 2). However, H.

Liesebach from Germany was the most productive author, with five papers in the trend for 2021.

Table 2. Top five authors with the strongest citation bursts.

Authors	Year [1]	Strength	Beginning [2]	End [3]	1980–2022
El-Kassaby, YA	1984	6.92	1986	1993	
Nikkanen, T	1993	3.82	1994	2001	
Lindgren, D	1981	9.84	1998	2009	
Kang, KS	2000	7.39	2000	2007	
Lstibůrek, M	2012	4.19	2012	2015	

[1], [2], and [3] are first publication year and the beginning and end of the strongest citation bursts period, respectively.

The modularity value was divided into nearly perfect clusters, and the mean of the silhouette value was 0.9662, which suggested that the homogeneity of these clusters was sufficient. The 1018 academic works were divided into seven clusters (Table 3). As seen in Table 3, the largest cluster (#0 Douglas fir seed orchard) had 36 members and a silhouette value of 0.918. It could be related to the publication, which had one of the main topics of seed orchards, entitled "Reproductive phenology and its impact on genetically improved seed production in a Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) seed orchard" of El-Kassaby et al. [23]. Figure 3a shows the main clusters. The size of each node in the network is directly proportional to the author's productivity, as measured by citations (Figure 3a) and the number of links. In the cluster analysis, clusters were designated on the basis of the strengths of the silhouette scores, which ranged from 0 to 1. Clusters with low silhouette scores can't be shown in Table 3 or Figure 3b. Figure 4 provides a timeline visualization of the co-authorship networks of the authors and keywords. The node color indicates the mean duration of author collaboration, and the node size indicates the number of associations.

Table 3. Cluster summary of author analysis.

Cluster ID	Size [1]	Silhouette	Mean Year [2]
#0 Douglas fir seed orchard	36	0.918	2002
#1 reproductive phenology	21	0.997	1994
#3 individual ramet	11	0.989	1989
#10 scale insect	6	0.986	1987
#15 *Picea abies*	5	1.000	1994
#16 wood production	5	0.988	1998
#33 level	4	0.986	1980

[1] is the number of nodes, and [2] is the average year between the beginning and end.

Clusters 0, 1, and 3 were the largest, containing more than 10 authors. The most active author, El-Kassaby, was in cluster 1 (Table 3 and Figure 4). The change in clusters over time could be understood using the timeline view, which showed the strength of the authors and papers based on the number of citations and published papers in WoS. Examination of the distribution of the core authors provided a clearer indication of the progress of research and the main collaborations that developed over time [24]. The sizes of the bubbles in the network showed the extent of the collaboration. For example, the authors El-Kassaby, Lindgren, Kang, Nikkanen, and Lstibůrek had more collaborations than the others based on the size of bubbles and their number of linkages (Figure 4). Close collaborations between authors could be determined based on the density of the lines [12]. The larger nodal circles in the network also showed the greater numbers of articles published by authors such as El-Kassaby and Lindgren compared to the others (Figure 4). It was in accordance with the results of the most prolific contributors (Tables 1 and 2, Figure 3a). According to the cluster analysis, the fields of "reproductive phenology" and "Douglas-fir seed orchard"

have mainly been studied by seed orchard researchers and related researchers and authors as a part of current trends of seed orchards (Table 3 and Figure 4).

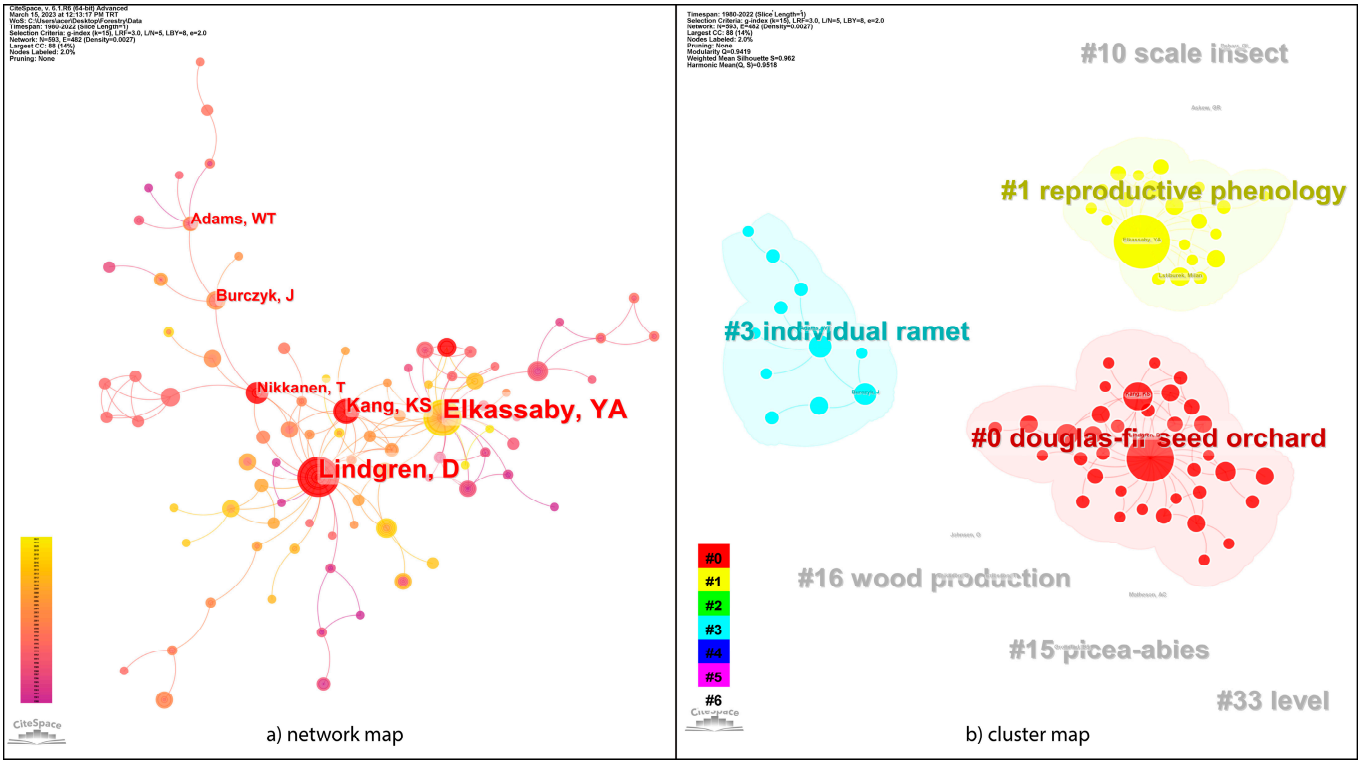

Figure 3. The network map (**a**) and cluster map (**b**) of authors related to seed orchards from 1980 to 2022.

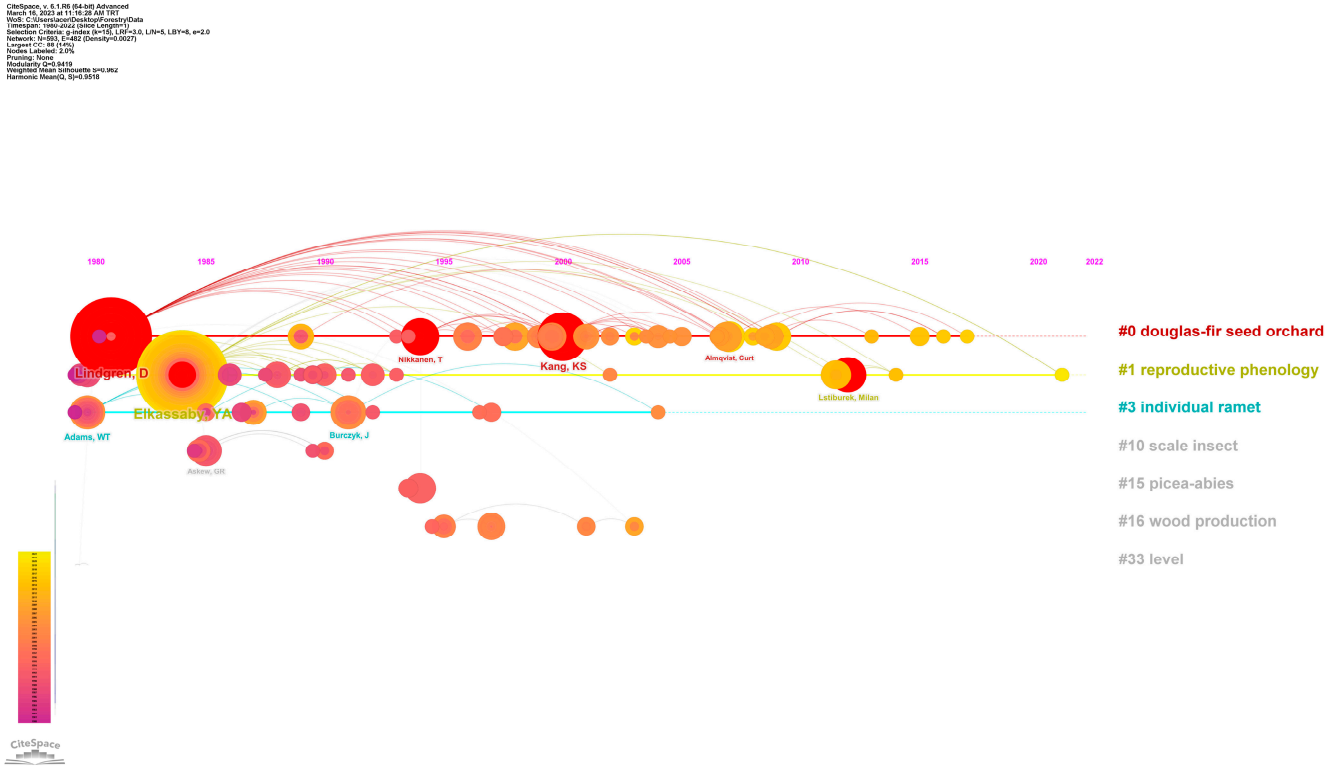

Figure 4. Timeline view of author analysis.

3.3. Analysis of Research Contributions by Country

The network consisted of 76 nodes and 206 linkages, where each node represented a country. The density of the network was 0.0723 (Table 4). A visualization of the country network structures is shown in Figure 5. Maps based on bibliographic data from WoS were created for each year based on the co-occurrence of authors and keywords. Sweden had the most centrality, with a value of 0.45. Some countries are not visible in Figure 5 because of their low centrality values and small cluster sizes.

Table 4. The most active countries.

Count [1]	Centrality	Year [2]	Countries
186	0.23	1980	Canada
140	0.24	1982	USA
115	0.45	1986	Sweden
69	0.32	1986	Australia
60	0.16	1994	China
56	0.16	1988	Finland
38	0.01	2000	Japan
31	0.15	1992	France
30	0.00	1998	India
29	0.03	1998	South Korea
29	0.00	1986	Poland
24	0.04	2002	Brazil
24	0.20	1991	Germany
24	0.14	1996	Denmark
23	0.03	2002	Turkey

[1] and [2] are the number of published papers and the year of the first publication on seed orchards in WoS, respectively.

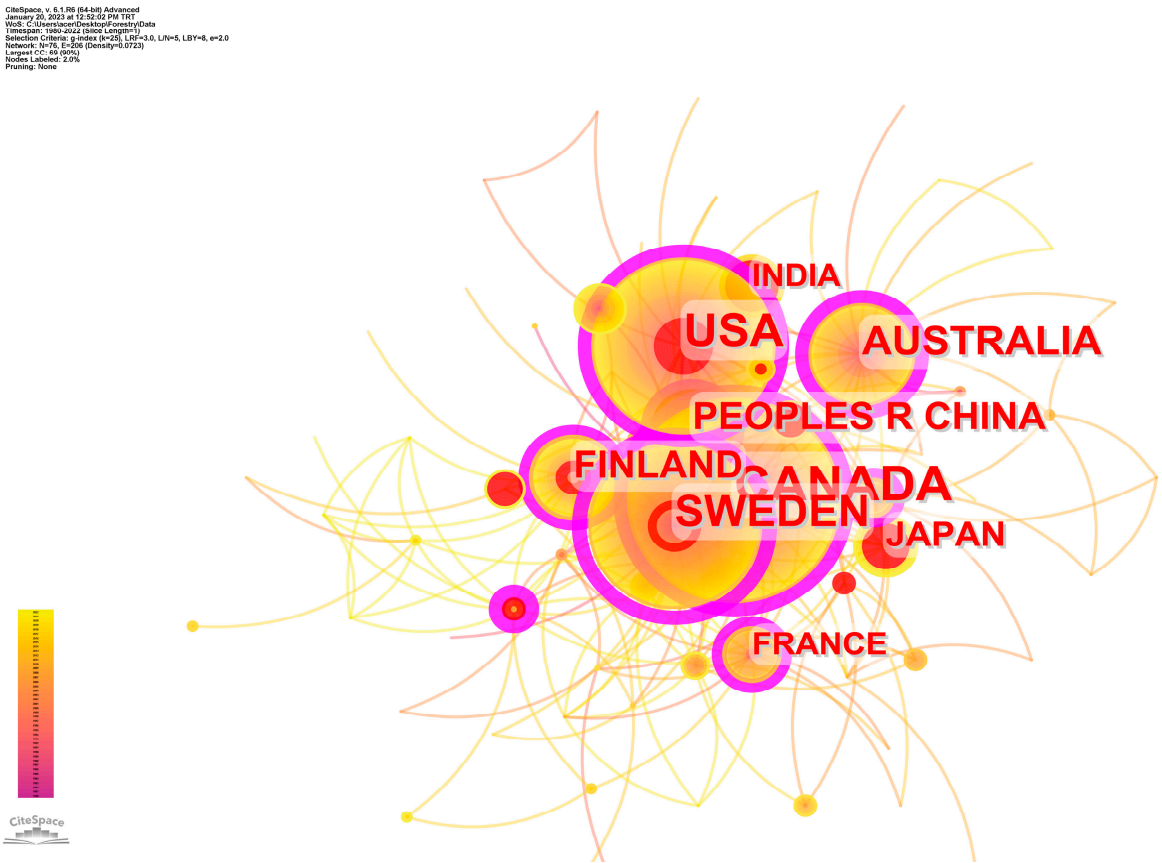

Figure 5. Visualization of country network structures.

As seen in Table 4, the greatest contribution was made by Canada, with 186 articles, followed by the USA with 140 and Sweden with 115. The number of articles could be related to the published language and the years. However, international bibliometric databases were generally focused on papers written in English. This meant that countries whose main language was not English were underrepresented. It can be said that Sweden had the highest centrality value (0.45), which meant that it was a linkage country (also called a base/key country) for other countries. Australia, Canada, the USA, China, France, Germany, Finland, and Denmark were also linkage countries because of their higher centrality values (Table 4 and Figure 5).

Much of the research was not published in English. Some of this research gained entry to the database if it was published in the USA, but similar work published in other countries such as Sweden, China, and Russia was missed because it was written in the languages of those countries. This was despite the fact that these countries had large areas of forest and likely published a body of papers on seed orchard research. For example, Sweden was rather English-oriented and was slightly favored compared to, e.g., France and Brazil.

The strongest citation bursts of the top twelve countries are given in Table 5. Canada (15.42) and the USA (13.32) had higher strength values and longer citation burst periods than other countries. It is interesting that China, Brazil, and Germany had higher numbers of citations in recent years. This shows that these countries have mainly focused on seed orchard studies in recent years based on the WoS papers.

Table 5. Top twelve countries with the strongest citation bursts.

Countries	Year [1]	Strength	Beginning [2]	End [3]	1980–2022
Canada	1980	15.42	1980	1994	
USA	1982	13.32	1982	1998	
Norway	1989	3.98	1989	1995	
Sweden	1986	6.13	1999	2001	
Finland	1988	4.58	1999	2003	
South Korea	1998	6.64	2001	2007	
India	1998	4.92	2004	2012	
Japan	2000	4.39	2004	2014	
Czech Republic	2009	5.23	2009	2016	
China	1994	6.54	2016	2022	
Brazil	2002	5.79	2016	2022	
Germany	1991	4.43	2020	2022	

[1], [2], and [3] are the first publication year and the beginning and end of the strongest citation burst period, respectively.

Modularity Q reached 0.4516. This indicated that the structure was reasonable and sufficient and meant that the clusters were partially nested and not fully separated. The silhouette score showed that the result validation reached 0.8706 > 0.4. The studies of the countries had five main clusters (Table 6 and Figure 6).

Table 6. Summary of clusters of studies of countries.

Cluster ID	Size [1]	Silhouette	Mean Year
#0 fertility variation	19	0.782	1998
#1 genetic variation	17	0.947	2004
#2 South Africa	14	0.857	1998
#3 *Pinus sylvestris*	13	0.932	2005
#4 supporting domestication	6	0.832	2007

[1] is the number of linkage clusters/nodes.

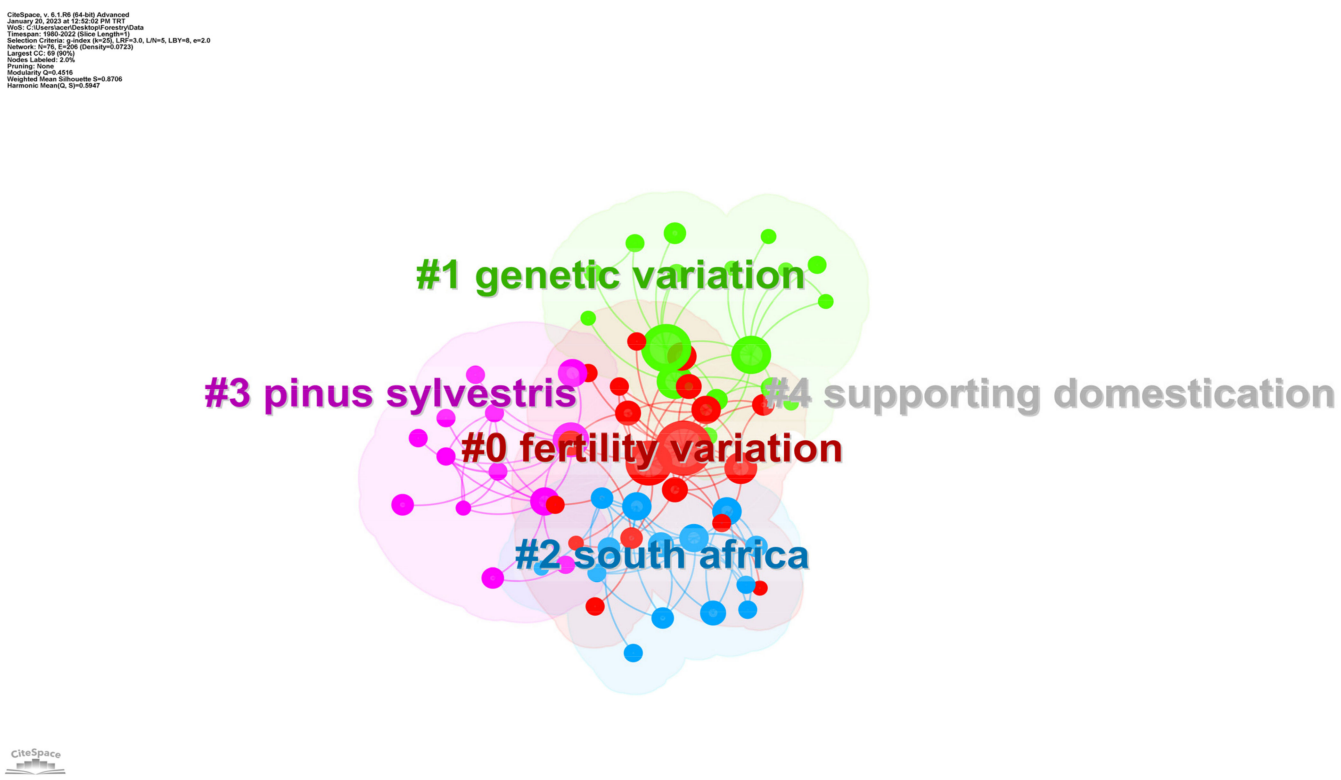

Figure 6. Clusters of studies of countries.

The results presented in Table 6 and Figure 6 indicated that "fertility variation", "genetic variation", and "*Pinus sylvestris*" were activated/refreshed by the scientists and researchers of the countries.

3.4. Analysis of Keywords

The network had 714 nodes, where each node represented a keyword. There were 3962 linkages. The word "seed orchard" occurred in 234 articles and had the highest centrality (0.37), followed by "growth", which occurred in 136 articles and had a centrality of 0.21 (Table 7). A network map of current trends based on keyword analysis is presented in Figure 7 for some of the keywords. The sizes of the nodes and words in Figure 7 represent the weights of the nodes. Larger nodes and words indicate higher importance.

Table 7. List of top 21 keywords with centrality.

Count [1]	Centrality	Year	Keywords	Count	Centrality	Year	Keywords
234	0.37	1986	seed orchard	30	0.05	1994	scots pine
136	0.21	1991	growth	29	0.08	1989	*Picea abies*
68	0.13	1991	population	28	0.05	1990	pollination
52	0.08	1991	douglas fir	28	0.08	1999	tree improvement
51	0.06	1996	genetic diversity	26	0.02	1990	pollen contamination
48	0.12	1995	genetic gain	25	0.01	2002	number
44	0.07	1989	selection	24	0.03	1993	clonal seed orchard
43	0.07	1986	*Pinus sylvestris*	24	0.02	1992	tree
42	0.07	1993	genetic variation	22	0.06	1993	Norway spruce
40	0.05	1990	mating system	22	0.01	1999	fertility variation
39	0.12	1991	loblolly pine	21	0.03	1991	cone
38	0.08	1991	diversity	20	0.02	2008	gene flow
31	0.02	2001	relatedness	-	-	-	-

[1] is the number of published papers.

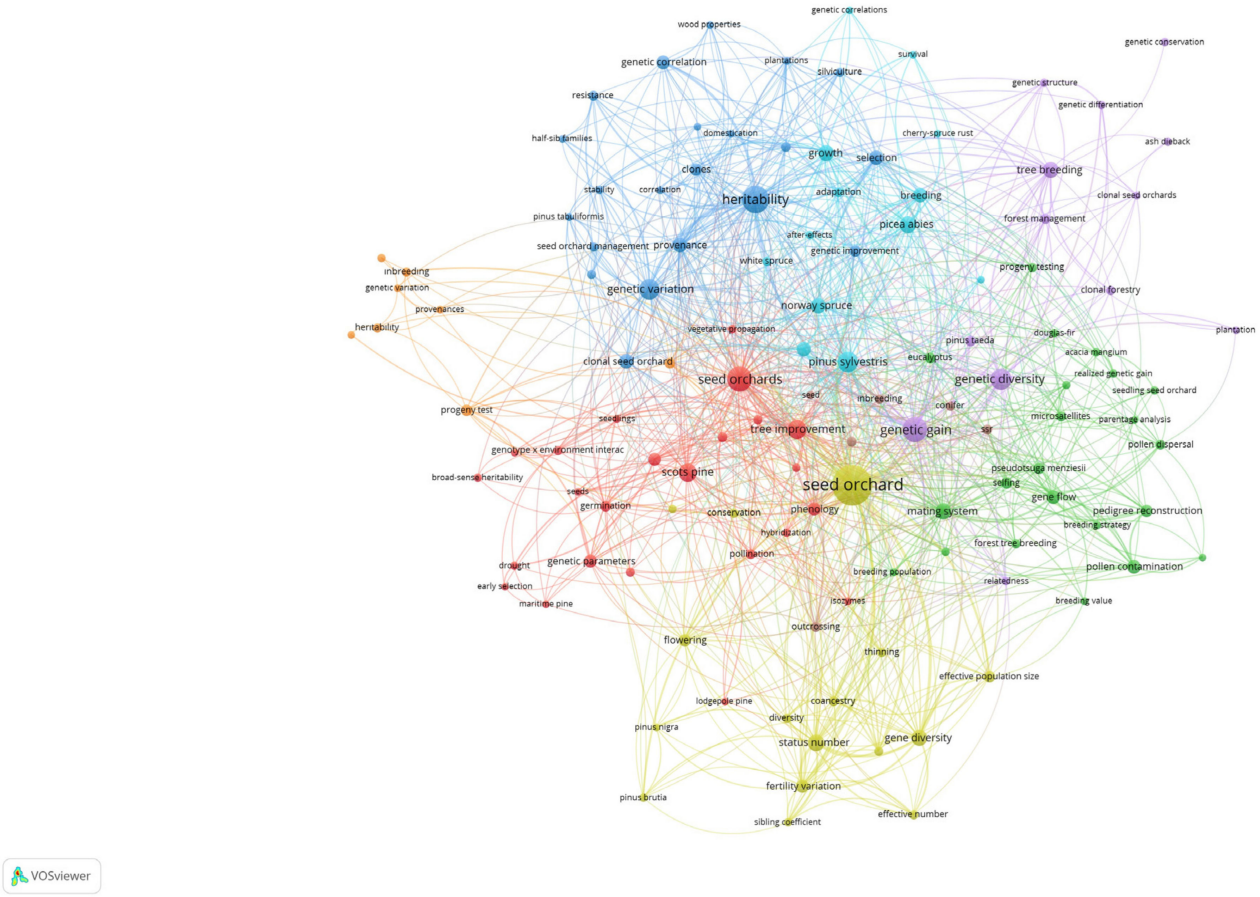

Figure 7. Network map of trends based on keyword analysis.

The "keywords" were reflections of the published papers. They were also guides in the literature search, in the inventory and classification of the published studies, and in the direction and planning of future studies. However, the authors generally avoided extraction from title to keyword. Most of the national papers were published in their mother tongues with English abstracts and keywords, while bibliometric analysis focused on English and WoS papers. This gave keywords importance.

The strongest citation bursts of the top 21 keywords are given in Table 8. The keywords "climate change", "management", and "growth" were actively studied topics in current seed orchard research. Results of keywords analysis (Table 8) with the strongest citation bursts showed limited studies were carried out in some aspects of seed orchards (i.e., molecular markers, ecology). However, some keywords could include various sub-keywords and divisions such as management (i.e., soil treatment, fertilization), gene flow (i.e., pollen contamination, molecular genetics), or pine by different *Pinus* ssp. The content of the papers could not be performed in the analysis. Results of keyword analysis (Tables 7 and 8) showed that publications were focused mainly on American and Euro-Asian trees such as Douglas fir, Scots pine, Loblolly pine and Norway spruce belong to *Pinacea*. Moreover, some keywords had long periods of more than 10 years, such as cone and loblolly pine, opposite to growth, which has a 1-year period (Table 8). However, interest in these topics fluctuated and diverged over the years. Modularity Q reached 0.4251, and the silhouette score was 0.7546. The keywords of the countries had five main clusters (Figure 8). However, presenting all active and past keywords is not possible in the table and figure (Table 8 and Figure 8) due to their low size and strength values.

Table 8. Top 21 keywords with the strongest citation bursts.

Keywords	Year [1]	Strength	Beginning [2]	End [3]	1980–2022
pine	1990	4.85	1990	1994	
cone	1991	5.80	1991	2007	
fruitfulness	1991	4.04	1991	1996	
sitka spruce	1993	4.86	1993	1996	
pollination	1990	4.23	1994	1996	
status number	2001	4.58	2001	2009	
loblolly pine	1991	4.14	2001	2014	
number	2002	7.80	2002	2009	
gene diversity	1991	3.99	2002	2008	
genetic gain	1995	4.29	2003	2006	
diversity	1991	4.33	2004	2009	
microsatellite marker	2005	4.01	2005	2010	
trait	1994	4.6	2007	2011	
gene flow	2008	4.56	2008	2017	
pedigree reconstruction	2010	4.27	2010	2015	
performance	2010	4.03	2010	2020	
Pinus sylvestris	2004	4.33	2012	2017	
success	2005	4.16	2014	2017	
climate change	2000	4.41	2017	2022	
management	2017	4.22	2017	2022	
growth	1991	3.91	2019	2020	

[1], [2], and [3] are the first publication year and the beginning and end of the strongest citation burst period, respectively.

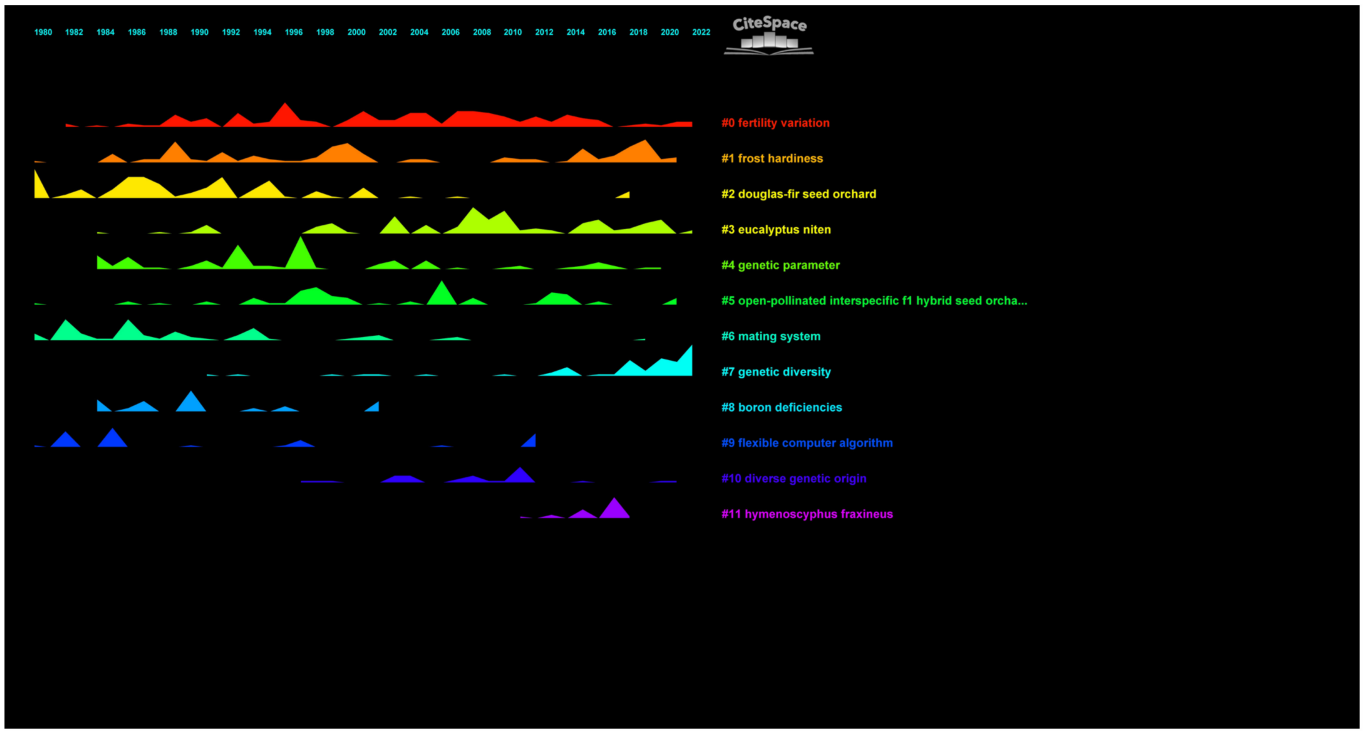

Figure 8. Timeline view of the co-occurrence network of some keywords in the clusters.

"Mating pattern", "Swedish forestry", "fertility variation", "frost tolerance", and "outbreeding depression", together with others, were active and past keywords according to the timeline and cluster's analysis (Figure 8). However, the keywords are changeable. They should be checked periodically.

3.5. Data Analysis by Reference

The 1018 published studies on seed orchards were cited 23,275 times. The network shown in Figure 9a had a total of 1358 nodes and 4726 linkages. The modularity value was 0.868, meaning that the network was divided into separate clusters. The mean silhouette value was 0.9603, which suggested that the homogeneity of these clusters was suitable. Figure 9b shows the largest clusters. Each network node represents a keyword or study topic, and its size is proportional to its degree. It can be seen that there were a few keywords centered around topics such as "mating pattern", "Swedish forestry", "fertility variation", and "threatened Pacific sandalwood", among others (Figure 9b). The top 10 articles, according to their citation frequency, are listed in Table 9. According to the analysis, the paper of Lindgren and Mullin [25] was the most cited paper that included innovative theory. The importance of innovative theory was also emphasized via Kang and Lindgren's article [26] published in an un-WoS database journal (Table 9 and Figure 9a).

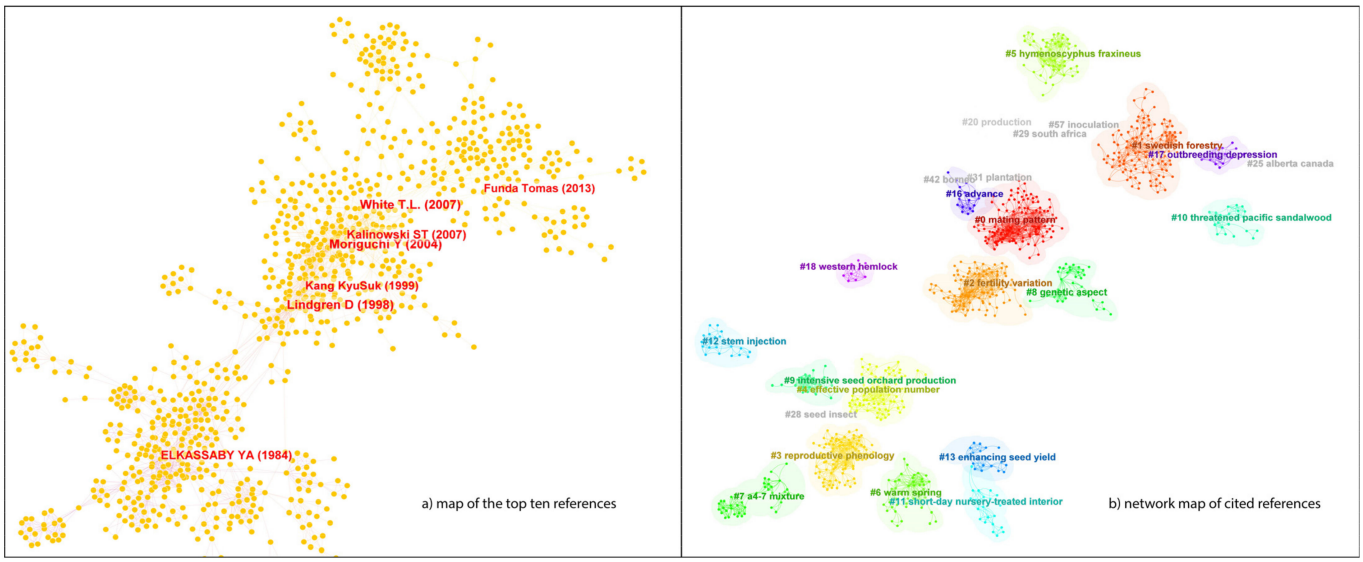

Figure 9. Visualization map of the top ten cited references (**a**) and cluster map of cited references (**b**) related to seed orchards from 1980 to 2022.

Table 9. List of top ten cited publications with centrality.

#	Count [1]	Centrality	Year	Cited Publication
1	23	0.11	1998	Lindgren D, 1998, CAN J FOREST RES, V28, P276, DOI 10.1139/cjfr-28-2-276
2	22	0.07	2007	White TL, 2007 FOREST GENETICS, V0, P0
3	22	0.22	2004	Moriguchi Y, 2004, CAN J FOREST RES, V34, P1683, DOI 10.1139/X04-029
4	19	0.11	1984	El-Kassaby YA, 1984, SILVAE GENET, V33, P120
5	19	0.04	2007	Kalinowski ST, 2007, MOL ECOL, V16, P1099, DOI 10.1111/j.1365-294X.2007.03089.x
6	18	0.23	1999	Kang KS, 1999, FOREST GENETICS, V6, P191
7	16	0.12	2012	Funda T, 2012, P21, V0, P0, DOI 10.1079/PAVSNNR20127013
8	15	0.08	1985	Ritland K, 1985, THEOR APPL GENET, V71, P375, DOI 10.1007/BF00251176
9	15	0.05	2001	Kang KS, 2001, NEW FOREST, V21, P17, DOI 10.1023/A:1010785222169
10	15	0.10	2003	Kang KS, 2003, FORESTRY, V76, P329, DOI 10.1093/forestry/76.3.329

[1] is the number of cited references.

In Table 10, the most representative references with respect to burst strength and burst duration are illustrated based on the results of clustering by the beginning time of the burst marked in bold. According to the analysis, the paper by Funda and El-Kassaby [27] was an actively cited publication in recent years (Table 10). Additionally, Moriguchi Y's article [28] also had a recent intense citation burst. It was titled "Gene flow and pollen contamination in a seed orchard of *Cryptomeria japonica* D. Don", and they used six microsatellite markers

in their study [28], which was carried out molecular markers. The paper of Lindgren and Mullin [25] had the highest strength value (11.42) and the longest citation bursts period (Table 10). Some references had the strongest citation bursts in the published year (i.e., [25]). The results emphasized the importance of paper content, such as innovation, basis, and originality. Paper types such as research articles and reviews were not performed in the present study.

Table 10. The top ten references with the strongest citation bursts.

References	Year [1]	Strength	Beginning [2]	End [3]	1980–2022
El-Kassaby YA, 1984, SILVAE GENET, V33, P120	1984	10.35	1986	1992	
Ritland K, 1985, THEOR APPL GENET, V71, P375, DOI 10.1007/BF00251176,	1985	7.93	1986	1993	
El-Kassaby YA, 1986, SILVAE GENET, V35, P240	1986	8.15	1988	1992	
Lindgren D, 1998, CAN J FOREST RES, V28, P276, DOI 10.1139/cjfr-28-2-276,	1998	11.42	1998	2006	
Kang KS, 1999, FOREST GENETICS, V6, P191	1999	9.7	2001	2007	
Moriguchi Y, 2004, CAN J FOREST RES, V34, P1683, DOI 10.1139/X04-029	2004	10.52	2005	2012	
White TL, 2007, FOREST GENETICS, V0, P0	2007	10.13	2008	2015	
Kalinowski ST, 2007, MOL ECOL, V16, P1099, DOI 10.1111/j.1365-294X.2007.03089.x,	2007	8.74	2008	2015	
El-Kassaby YA, 2009, GENET RES, V91, P111, DOI 10.1017/S0016672309000070X,	2009	8.25	2011	2014	
Funda T, 2012, P21, V0, P0, DOI 10.1079/PAVSNNR20127013,	2012	8.57	2017	2022	

[1], [2], and [3] are the publication year and the beginning and end of the strongest citation burst period, respectively.

4. Discussion

Bibliometric analysis helps to better visualize the organization and dynamics of scientific domains, to better understand a particular scientific field, and to provide predictions regarding future trends [29]. Several parameters, such as leading countries, organizations, and journals, and the contributions of various authors, citations, and keywords, have been analyzed with the help of bibliometric mapping [7–9,12,30,31]. Bibliometric analysis has been used for different purposes in various scientific fields (i.e., [3,11,12,20,21,32,33]). However, this analysis has not been carried out for seed orchards. The present study could be accepted as the first investigation of seed orchards in the field of forestry using bibliometric analysis. Therefore, it was not possible to compare our results with other bibliometric studies of publications based on seed orchard research.

The sustained increase in the number of papers demonstrates the effort invested in seed orchard research since the 1980s (Figure 2). This increase could also reflect the greater number of established orchards that have reached seed-bearing age over the recent decades. The readership of these publications, as evidenced by the number of citations, also steadily increased over the last forty years. The increase in the number of citations was greater than the increase in the number of published papers (Figure 2). This was an expected result, as one published paper can cite many papers. The average annual growth rate of the publications was approximately 4%. However, when calculating the citation growth rate, the initial citation value was zero, which led to division by zero in the growth rate formula, resulting in an infinite value. When calculated for the 40 years from 1982, when the citation value was 6, to 2022, there was an annual increase of 13.13% in the number of citations in the relevant field. These numbers could be related to the establishment years of the orchards [1], the number of orchards, the sizes of the orchards, or the ability of authors (i.e., budget and number of members) to give accurate data to researchers for publications.

There were 31 years between the first publishing (1981) and last publishing (2012) years of the ten most prolific authors. Some authors had similar centrality values despite large differences in their numbers of published papers (Table 1). The top five authors with the strongest citation bursts (Table 2) were also among the ten most prolific authors (Table 1). As presented in Table 2, the periods of the strongest citation bursts of these five authors (Table 2) ranged from 3 (Lstibůrek) to 11 (Lindgren) years. The authors generally had citation bursts a few years after first publishing (Table 2). However, self-citation and the availability of papers (i.e., open access) by researchers were not taken into consideration in the analysis. The results of the most prolific contributors emphasized the importance of innovative methods, new ideas, and theoretical framework for the lifespans of the papers, such as [25,34], and provided a guide for future studies (Tables 1 and 2).

Cluster analysis helps us understand the main features of science mapping [35]. Figure 3a shows that the most massive clusters accorded well with the productivity and citation bursts of the authors (Tables 1 and 2). A total of 1018 academic papers were divided into seven clusters (Table 3 and Figure 3b). The clusters were designated on the basis of the strengths of the silhouette scores, which ranged from 0 to 1, and clusters with low silhouette scores can't be shown in Table 3 or Figure 3b. "Douglas-fir seed orchard", which was the youngest, and "reproductive phenology" had larger cluster sizes (36 and 21) than the others (Table 3 and Figure 3b). They may be correlated with the basic field of seed orchards or characteristics of the species (i.e., the sizes of natural and exotic distribution areas and commercial importance of the species). Basic fields have been refreshed by researchers. Fields such as reproductive phenology (Table 3 and Figure 4), which was a main topic in the seed orchard field, can be changed by many abiotic and biotic factors such as species, climate, and altitude. They may also be related to the basic steps in the establishment and management of seed orchards. Therefore, some fields need to be examined continually. Future studies can be expected in basic fields of seed orchards, such as reproductive phenology.

Figure 4 provides a timeline visualization of the co-authorship networks of the authors and keywords. The authors El-Kassaby and Lindgren had larger and longer clusters (Figure 4). Close collaboration between authors can be determined based on the density of the lines [12] and the number of sub-clusters.

The network consisted of 76 nodes and 206 linkages, where each node represented a country. However, some countries are not visible in Figure 5 because of their low centrality values. Canada, the USA, and Sweden were the most productive and central countries in the field of seed orchards, while Sweden had the most centrality, with a value of 0.45, which meant that it was a linkage country for other countries (Table 4). The home countries of the authors were not taken into consideration in the analysis. International bibliometric databases were generally focused on papers written in English. This gave an advantage to countries whose mother tongue was English. The number of papers might also be related to the amount of forest area and the importance given to forestry in each particular country, as well as the number of forestry organizations such as faculties and research institutes in each country. In addition, scientific rules, such as those of WoS papers and Ph.D. theses (i.e., [36,37]), and publishing project results supported by foundations in the database could have important impacts on the number of papers and the centrality of countries. The centrality of countries could change in the future.

Canada, the USA, and Sweden were the countries that made the greatest contributions to this field based on their higher numbers of papers (Table 4).

Of the strongest citation bursts, those of Canada and the USA were the longest at 14 and 16 years, while those of Sweden were the shortest at 3 years, with a strength value of 6.13 (Table 5). Increases in the number of strong citation bursts in China, Brazil, and Germany showed that these countries have mainly focused on seed orchard studies in recent years, based on WoS papers (Table 5). This could be due to innovation and the scope of the published papers. It is interesting that China, Brazil, and Germany had higher numbers of citations recently than in the early years. This shows that these countries have

mainly focused on seed orchard studies in recent years, based on WoS papers (Table 5). The results indicated that the strength value, depending on the citation bursts of countries, could change in the future.

Some fields of seed orchards, such as "fertility variation" and "genetic variation", have been activated/refreshed based on clusters of countries (Table 6 and Figure 6). The results also had linkages to the results of the keyword analysis (Table 7 and Figure 7). The results of the keywords analysis (Figure 8) accorded well with keywords such as "fertility variation" in recent papers (i.e., [38–40]). It is expected that researchers publishing work on seed orchards will use different keywords to describe their work in future publications. They may include phrases such as "climate change" if this forms a key consideration in their research. We found that some keywords are interchangeable, for example, Scots pine/*Pinus sylvestris*, flowering/strobili, and pine/*Pinus*. If only one of the interchangeable words is entered into a search, some publications that use the other keyword could be overlooked.

The analysis databases were generally focused on papers written in English, and this resulted in a bias against inclusion in the databases for non-English-language publications. However, this could be rectified by carrying out a national analysis of publications written in the mother tongues of non-English-speaking countries, and it could be balanced by a national analysis.

Citation burst detection reflected dynamic changes in keywords over time in this field, which reflected an explosion of information that has attracted researchers' attention [41]. The number of citations for some keywords increased over a short period, such as climate change and management, allowing us to detect some exciting trends (Table 8). "Cone", which was a main seed orchard crop, had the highest strength value (5.80) and the longest citation burst period at 16 years, while some keywords (i.e., pollination and growth), which began in the 1990s, had long lifespans (Table 8). "Climate change" and "management" were active keywords at the time of the analysis (Table 8). They could be related to a current problem and a basic field of seed orchards. However, their fates cannot be estimated in the future. The timeline of the keywords in the clusters helped to study the periodic visibility of keywords. "Mating pattern", "Swedish forestry", "fertility variation", and "outbreeding depression", together with others, were active and past keywords according to the timeline and clusters (Figure 8). These results accorded well with the results of the cluster map of the cited references (Figure 9b). However, they could not be stable. For instance, the "threatened Pacific sandalwood" keyword could be related to fast-growing Pacific tree species, which have been used widely in plantation forestry harvested by seed crops from improved seed sources (i.e., seed orchards) in the whole world, such as *Acacia* spp., *Eucalyptus* spp., *Cryptomeria* spp., and *Cunninghamia* ssp. to supply forest product demand. It also accorded well with the active keyword "*Eucalyptus niten*" in Figure 8 and recent papers in seed orchards of these species (i.e., [28,42]). However, they could be checked periodically to give future directions in the seed orchard field.

The 1018 published studies on seed orchards were cited 23275 times. They had 1358 nodes and 4726 linkages (Figure 9a). A cluster map of the cited references is shown with the largest clusters (Figure 9b). They accorded well with the results in Tables 9 and 10. The top ten cited articles were generally co-authored papers that included new and innovative methods. Kang had three papers in the top ten cited articles (Table 9). One of these papers included innovative methods and had the highest centrality (0.23) despite not being published in a WoS database journal. This indicated the importance of innovative methods and ideas in the papers. It also accorded well with Lindgren's paper, which had the highest strength value (11.42) and the longest citation burst (Table 10).

5. Conclusions

Bibliometric analysis is an interdisciplinary science that qualitatively and quantitatively analyzes all knowledge in publications through mathematical and statistical methods [43]. An examination of the publications produced in recent decades that emerged from the bibliometric search of seed orchard-related papers demonstrates that significant

advances have been made in the development and management of seed orchards. The increased number of publications in recent years indicates there is continued interest and investment in seed orchard research, which we expect will continue into the future.

Based on our bibliometric analysis, we comprehensively reviewed the papers published in WoS in the field of seed orchards from 1980 to 2022 (update: 14 March 2023), giving a total of 1018 publications. According to the results of this study, some potential trends and future directions in seed orchard research may include the following:

(1) Different methods are used for bibliometric studies to explore the breadth and depth of research areas. However, WoS data were considered for bibliometric analysis in this study. Books and national and international papers published in other databases were ignored in this study. National and international bibliometric analysis should be performed at regular intervals to identify new international and national trends and directions in seed orchard research and to incorporate new keywords that are relevant to this area of research.
(2) The results of this study may explore new breeding strategies to optimize the genetic improvement of seed orchard crops based on new fields instead of previously studied fields, such as alternative breeding designs and methods. They may serve as a guide for future studies on seed orchards.
(3) New fields allow the establishment and management of seed orchards with crops that are resistant to climate change, which was not hit strongly in the analysis.
(4) Studied keywords and aspects are presented in Tables 6–8 and Figures 6–8, which are opposite to invisible keywords such as soil treatment, protection, and fertilization in the results of the analysis. Potential future research may focus on identifying optimal management practices, such as irrigation, fertilization, pest control, genetic tending, and biotechnology, to improve seed orchard productivity and sustainability, which were not visible in the analysis, and new fields related to seed orchards may be identified depending on the results.
(5) Advances in technology, such as unmanned aerial vehicles, remote sensing, and artificial intelligence, which were not visible in the analysis of keywords in the study, may be innovative and potential opportunities to contribute to the seed orchard practices in future studies.

Overall, the future of seed orchard research will likely continue to evolve and improve as new technologies, breeding strategies, and management practices are developed and implemented via periodic bibliometric analysis.

Author Contributions: F.Y. and A.A.Ö. conducted data collection, data analysis, and drafting and prepared the figures and tables. K.-S.K. and N.B. revised the manuscript, checked bibliographic data, and edited the final version of the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Acknowledgments: The authors have to thank the anonymous reviewers, who made valuable comments that helped improve the manuscript.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Kang, K.S.; Bilir, N. *Seed Orchards (Establishment, Management and Genetics)*; OGEM-VAK Press: Ankara, Turkey, 2021. Available online: https://www.ogemvak.org.tr/ (accessed on 15 January 2022).
2. Gardner, V.R.; Bradford, F.C.; Hooker, H.D. *Fundamentals of Fruit Production*; MacGraw-Hill: New York, NY, USA, 1922.
3. Chen, C.; Dubin, R.; Kim, M. Emerging trends and newdevelopments in regenerativemedicine: A scientometric update (2000–2014). *Expert Opin. Biol. Ther.* **2014**, *14*, 1295–1317. [CrossRef] [PubMed]

4. Yardibi, F.; Firat, M.Z.; Teke, E.C. Trend topics in animal science: A bibliometric analysis using CiteSpace. *Turk. J. Vet. Anim. Sci.* **2021**, *45*, 833–840. [CrossRef]
5. Aispuro, G.P.; Jácome, I.B.R.; Zamora, C.A.M.; Mejía, C.G.-O.; Mader, C.; Rangel, C.C.; Sosa, A.M.; Flores-Vázquez, M.; Zavala, O.J.A.; Ramos-Zúñiga, R.; et al. Bibliometric analysis: Six decades of scientific production from a Nationwide Institution: Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado (ISSSTE) from Mexico. *Healthcare* **2023**, *11*, 1725. [CrossRef] [PubMed]
6. Liao, H.; Tang, M.; Luo, L.; Li, C.; Chiclana, F.; Zeng, X.J. A bibliometric analysis and visualization of medical big data research. *Sustainability* **2018**, *10*, 166. [CrossRef]
7. Ankrah, J.; Monteiro, A.; Madureira, H. Bibliometric analysis of data sources and tools for Shoreline change analysis anddetection. *Sustainability* **2022**, *14*, 4895. [CrossRef]
8. Siao, H.-J.; Gau, S.-H.; Kuo, J.-H.; Li, M.-G.; Sun, C.-J. Bibliometric analysis of environmental, social, and governance management research from 2002 to 2021. *Sustainability* **2022**, *14*, 16121. [CrossRef]
9. Folharini, S.; Vieira, A.; Bento-Gonçalves, A.; Silva, S.; Marques, T.; Novais, J. Bibliometric analysis on wildfires and protected areas. *Sustainability* **2023**, *15*, 8536. [CrossRef]
10. Mingaleva, Z.; Chernova, O.; Mitrofanova, I.V. Bibliometric analysis of research trends in water management aimed at increasing the sustainability of the socio-economic development of a region. *Water* **2023**, *15*, 3688. [CrossRef]
11. Gao, W.; Qiu, Q.; Yuan, C.; Shen, X.; Cao, F.; Wang, G.; Wang, G. Forestry big data: A review and bibliometric analysis. *Forests* **2022**, *13*, 1549. [CrossRef]
12. Xie, J.; Zhang, G.; Li, Y.; Yan, X.; Zang, L.; Liu, Q.; Chen, D.; Sui, M.; He, Y. A bibliometric analysis of forest gap research during 1980–2021. *Sustainability* **2023**, *15*, 1994. [CrossRef]
13. Hou, L.X.; Liu, R.; Liu, H.C.; Jiang, S. Two decades on human reliability analysis: A bibliometric analysis and literature review. *Ann. Nucl. Energy* **2021**, *151*, 107969. [CrossRef]
14. Van Eck, N.; Waltman, L. Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics* **2010**, *84*, 523–538. [CrossRef] [PubMed]
15. VOSviewer. Visualizing Scientific Landscapes. 2023. Available online: https://www.vosviewer.com/ (accessed on 18 January 2023).
16. Uribe-Toril, J.; Ruiz-Real, J.L.; Haba-Osca, J.; de Pablo Valenciano, J. Forests' first decade: A bibliometric analysis overview. *Forests* **2019**, *10*, 72. [CrossRef]
17. Kişi, N. Bibliometric analysis and visualization of global research on employee engagement. *Sustainability* **2023**, *15*, 10196. [CrossRef]
18. Sabé, M.; Sulstarova, A.; Chen, C.; Hyde, J.; Poulet, E.; Aleman, A.; Downar, J.; Brandt, V.; Mallet, L.; Sentissi, O.; et al. A century of research on neuromodulation interventions: A scientometric analysis of trends and knowledge maps. *Neurosci. Biobehav. Rev.* **2023**, *152*, 105300. [CrossRef] [PubMed]
19. Chen, C. Cite space II: Detecting and visualizing emerging trends and transient patterns in scientific literature. *J. Am. Soc. Inf. Sci. Technol.* **2006**, *57*, 359–377. [CrossRef]
20. Yardibi, F.; Firat, M.Z. A bibliometric analysis of publications during the last decade on growth performance in animal science. *J. Anim. Prod.* **2021**, *62*, 99–108. [CrossRef]
21. Yardibi, F.; Chen, C.; Firat, M.Z.; Karacaoren, B.; Suzen, E. The trend of breeding value research in animal science: Bibliometric analysis. *Arch. Fuer Tierz.* **2023**, *66*, 163–181. [CrossRef]
22. Zhang, J.; Ji, C.; Zhai, X.; Ren, S.; Tong, H. Global trends and hotspots in research on acupuncture for stroke: A bibliometric and visualization analysis. *Eur. J. Med. Res.* **2023**, *28*, 359. [CrossRef]
23. El-Kassaby, Y.A.; Fashler, A.M.K.; Sziklai, O. Reproductive phenology and its impact on genetically improved seed production in a Douglas-fir seed orchard. *Silvae Genet.* **1984**, *33*, 120–125.
24. Kim, J.; Perez, C. Co-Authorship Network Analysis in Industrial Ecology Research Community. *J. Ind. Ecol.* **2015**, *19*, 222–235. [CrossRef]
25. Lindgren, D.; Mullin, T.J. Relatedness and status number in seed orchard crops. *Can. J. For. Res.* **1998**, *28*, 276–283. [CrossRef]
26. Kang, K.S.; Lindgren, D. Fertility variation among clones of Korean pine (*Pinus koraiensis* S. et Z.) and its implications on seed orchard management. *For. Genet.* **1999**, *6*, 191–200.
27. Funda, T.; El-Kassaby, Y.A. Seed orchard genetics. *CAB Rev.* **2012**, *7*, 1–23.
28. Moriguchi, Y.; Taira, H.; Tani, N.; Tsumura, Y. Variation of paternal contribution in a seed orchard of *Cryptomeria japonica* determined using microsatellite markers. *Can. J. For. Res.* **2004**, *34*, 1683–1690. [CrossRef]
29. Aksoy, U.; Küçük, M.; Versiani, M.A.; Orhan, K. Publication trends in microCT endodontic research: A bibliometric analysis over a 25 year period. *Int. Endod. J.* **2021**, *54*, 343–353. [CrossRef]
30. Alam, B.F.; Nayab, T.; Ali, S.; AlSheikh, R.; Khan, A.M.; Al Hinai, M.T.; Farooq, I. Current scientific research trends on Salivary Biomarkers: A Bibliometric Analysis. *Diagnostics* **2022**, *12*, 1171. [CrossRef] [PubMed]
31. Tian, Y.; Gama-Arachchige, N.S.; Zhao, M. Trends in seed priming research in the past 30 years based on bibliometric analysis. *Plants* **2023**, *12*, 3483. [CrossRef]
32. Sweileh, W.M. Bibliometric analysis of peer-reviewed literature on climate change and human health with an emphasis on infectious diseases. *Glob. Health* **2020**, *16*, 44. [CrossRef] [PubMed]

33. Vlase, I.; Lähdesmäki, T. A bibliometric analysis of cultural heritage research in the humanities: The Web of Science as a tool of knowledge management. *Humanit. Soc. Sci. Commun.* **2023**, *10*, 84. [CrossRef]
34. Lindgren, D. For. Genet Intern Rapport. Sveriges Lantbruksuniversitet, Institutionen foer Skoglig Genetik och Vaextfysiologi. 1981. Available online: https://www.slu.se/institutioner/skoglig-genetik-vaxtfysiologi/ (accessed on 12 February 2023).
35. Chen, C. Science mapping: A systematic review of the literature. *J. Data Inf. Sci.* **2017**, *2*, 1–40. [CrossRef]
36. Kang, K.S. Genetic Gain and Gene Diversity of Seed Orchard Crops. Ph.D. Thesis, Swedish University of Agricultural Science, Umeå, Sweden, 2001. Available online: https://www.upsc.se (accessed on 10 June 2023).
37. Prescher, F. Seed Orchards-Genetic Considertions on Function, Management and Seed Procurement. Ph.D. Thesis, Swedish University of Agricultural Science, Umeå, Sweden, 2007. Available online: https://pub.epsilon.slu.se (accessed on 18 May 2023).
38. Bilir, N.; Kang, K.S. Fertility variation, seed collection and gene diversity in natural stands of Taurus cedar (*Cedrus libani*). *Eur. J. For. Res.* **2021**, *40*, 199–208. [CrossRef]
39. Wang, F.; Zhang, S.; Zhu, P.; Chen, L.; Zhu, Y.; Yang, C.; Liu, R.; Li, F.; Huang, X.; Yang, H. The effects of fertility and synchronization variation on seed production in two Chinese fir clonal seed orchards. *Sci. Rep.* **2023**, *13*, 627. [CrossRef] [PubMed]
40. Park, J.M.; Kim, Y.J.; Gu, D.E.; Woo, Y.; Cho, G.; Kang, K.S. Clonal fertility and heritability in strobilus production, and gene diversity of seed crops in a second-generation seed orchard of *Pinus thunbergii*. *Silvae Genet.* **2023**, *72*, 105–113. [CrossRef]
41. Zhou, L.; Zhang, L.; Zhao, Y.; Zheng, R.; Song, K. A Scientometric Review of Blockchain Research. *Inf. Syst. E-Bus. Manag.* **2021**, *19*, 757–787. [CrossRef]
42. Kamalakannan, R.; Varghese, M.; Suraj, P.G.; Arutselvan, T. Options for converting a clone trial of *Eucalyptus camaldulensis* into a clonal seed orchard considering gain, fertility and effective clone number. *J. For. Res.* **2016**, *27*, 51–57. [CrossRef]
43. Moed, H.F. Bibliometric indicators reflect publication and management strategies. *Scientometrics* **2000**, *47*, 323–346. [CrossRef]

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