Heliyon 10 (2024) e26824

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Global characteristics and trends of researches on watermelon: Based on bibliometric and visualized analysis

Yu-Ping Zheng *

Library of Henan University of Science and Technology, China

ARTICLE INFO

Keywords:
Watermelon
Bibliometric analysis
Visualized analysis
Bibliometrix

ABSTRACT

Watermelon is an important horticultural plant. A bibliometric analysis of the watermelon literature was carried out in order to analyze the research state, hotspots, and trends, as well as to highlight the overall watermelon research development from a holistic viewpoint. The summary of watermelon research is given via metrological analysis based on a set of indices using a newly built Bibliometrix R-package tool. This study gathered 6,632 documents indexed in the Core Collection of Web of Science (WoS) in the domain of watermelon from 1992 to 2022 using bibliometrix. The results indicated that the number of published articles showed an apparently upward trend. The United States was in the first place, with Plant Disease being the most productive journal. Levi A from the United States Department of Agriculture-Agricultural Research Service is the most prolific author, and Levi A is the most cited; The most frequently used keywords by authors are "growth", "resistance", "identification", "yield", "quality" "plants", "watermelon stomach" and "expression"; The most talked-about issues in this subject are resistance, yield, and quality, which highlight the crucial research areas. To effectively comprehend the turning moments for future research, it is useful to monitor the hotspots and frontiers of watermelon studies. The results highlight the future paths for study in the field of watermelon and provide useful information for researchers interested in the topic.

1. Introduction

Watermelon (*Citrullus lanatus*) is one of the world's most well-known tropical fruits that is widely grown around the world and accounts for 7% of the worldwide vegetable production, second only after tomato [1,2]. Due to the high-water content, watermelons are named because they provided plenty of water to the early African settlers in desert areas that were suffering from severe drought [3]. There are currently more than 1,200 different watermelon cultivars available, with a variety of sizes, colors, and seeds [3]. Watermelon breeding aims to produce hybrid varieties that can meet the consumer demand [4]. A variety of watermelon grafting methods have been documented and utilized to increase yields and resilience to biotic and abiotic stressors [5]. In addition, the fusarium wilt has occurred in a large area with the increase of watermelon planting area [6]. However, the comprehensive literature review of watermelon is relatively scarce. So, there is a need for the compendium of watermelon related scientific researches to reveal the whole research progress to guide the future research.

Bibliometric analysis is a statistical method that is frequently used in scientific research to examine the distribution and characteristics of published papers in sizable databases. It also offers ways to investigate potential connections between publications and can

* Address: No.263, Kaiyuan Road, Luolong District, Luoyang, China.
E-mail address: 9903294@haust.edu.cn.

https://doi.org/10.1016/j.heliyon.2024.e26824
Received 18 August 2023; Received in revised form 17 February 2024; Accepted 20 February 2024
Available online 21 February 2024

identify new research trends [7–9]. Traditional narrative reviews and bibliometric analysis are different, the latter is more objective and quantitative while the former is more subjective [10]. In an era of information overload and a huge growth number of publications [8,11], for deriving systematic findings, bibliometric analysis is becoming increasingly crucial [12]. For example, a comprehensive graphic description and representation of the bibliometric analysis for wastewater treatment and emerging contaminant from 1998 to 2021 have yet to be done [13], to determine the distribution of scientists and nations throughout the world as well as to evaluate the state, hotspots, and trend of the research of the area. The purpose of this study was to present a bibliometric analysis of studies that have been done on watermelon and their historical history. This was accomplished by searching the Web of Science (WOS) database between 1992 and 2022 for studies that were related to watermelon.

An in-depth analysis of the research information on watermelon were performed to reveal the specific information that was focused on this field and the current state of scientific research.

2. Materials and methods

2.1. Data collection

The literature data were gathered from Web of Science's Core Collection, which includes the databases SCI-EXPANDED, SSCI, AHCI, CPCI–S, CPCI-SSH, ESCI, CCR-EXPANDED, and IC, among the most often used databases in bibliometric analysis. The reference information of titles, authors, institutions of the papers' countries and keywords, publication years were employed for bibliometric analysis. The "topic" tag was selected in "Search" menu to hunt for the literature relevant to the research of watermelon. The publication date was set to "Timespan: 1992–2022". The titles, authors, keywords, and abstracts of literature obtained from the search results were checked to determine their relevance to watermelon. A total of 6,632 pieces of publications were selected and exported as a text-based format for further analysis.

2.2. Data analysis and visualization maps

Bibliometrics is often employed to evaluate systematically the current study characteristics and trends in a specific scientific field [14]. To carry out the required analysis, R (4.2.1 version) was used to import all valid data that had been obtained from the Core Collection of the Web of Science. Data extraction and visualization were carried out using the *bibliometrix* R package [15]. This package holds robust and extensive bibliometric analysis capabilities [16,17] which included author, institution, country and region analysis, journal cluster analysis, and temporal evolution. These results give a viewer with complete and extensive information on watermelon studies, as well as a deep and comprehensive grasp of the structure of watermelon scientific studies.

3. Results

3.1. Publication and citation trends

The publications on watermelon from 1992 to 2022 were used in this bibliometric analysis, all of them were research articles and in English. The country, key journals and institutions are analyzed to identify the key contributors and the most influential articles in this field. The quantity of yearly publications, to some extent, can represent the shifting of areas. Table 1 provided the descriptive statistics. In summary, 6,632 research articles were analyzed, which were written by 17,524 scholars, and 395 of those publications are single-authored, accounting for 5.9% of all documents, suggesting that certain works are completed independently. Fig. 1 displayed the quantity of publications per year of watermelon-related research, which showed that the quantity of research output increased steadily

Table 1
Descriptive statistics.

Description	Results
Main information about data	
Timespan	1992–2022
Sources (Journals, Books, etc.)	1778
Documents	6632
Document Average Age	10.6
Average citations per document	17.14
Document contents	
Keywords Plus (ID)	9562
Author's Keywords (DE)	11766
Authors	
Authors	17524
Authors of single-authored documents	305
Authors collaboration	
Single-authored documents	395
Co-authors per document	4.77
International co-authorships %	16.72

over that time.

Two primary units that indicate publication quantity and quality, respectively, are the number of publications and citations. To display the typical numbers for one article referenced by other papers in the local database, the average number of citations per output was employed. The average number of citations per publication over the past three decades has coincidently increased with the number of publications (Fig. 1). Between 1992 and 2014, the average number of citations per article rose in a wave-like fashion, but after 2015, it rose sharply. One reason for this pattern is that newer publications eventually replace older ones while current articles take longer to reach a high citation phase.

3.2. Contribution of countries

There are 103 nationsfor 6632 papers selected for analysis in this study. The network statistics were utilized to map the global distribution of these nations further. Fig. 2 depicted the scientific output of countries throughout the world. Colors were assigned to countries depending on the number of scientific publications published in the WOS database. Production is described by a color scale ranging from dark blue, which represented the most productive nations, to grey, which represented countries where no scientific production on the examined issue has been reported. For example, >41 denoted nations that published 41 or more papers over the time period indicated in the dataset. The United States and China have contributed the most, with 164 cooperative research projects, followed by the United States and Israel, the United States and Korea, with 52 and 38 publications, respectively. In other words, China and the United States have the highest level of academic and scientific collaboration in scientific literature (Fig. 2). Table 2 illustrated specific information on the top ten nations by categorizing statistical data as single-authored publications (SCP) or multi-authored publications (MCP). The United States ranks the top among these nations, with 1,778 (26.81%) articles, 1,161 of which are single-authored and 167 of which are multi-authored works. China is ranked the second with 1,249 (18.83%) publications, of which 1,025 are single-authored and 224 are multi-authored studies. Brazil, India, and Turkey are placed the third, fourth, and fifth, respectively, with 304 (4.58%), 292 (4.40%), and 280 (4.22%) research publications. The fact that the top ten nations produced more SCP than MCP is intriguing, indicating that the level of research collaboration in these countries is lower.

3.3. Most influential research journals

Watermelon research studies have been published in 1,778 publications, spanning 199 topic areas according to WoS categorization codes. Source impact and Bradford law were employed to examine the influence of the most important research journals. Table 3 listed the top 10 research journals based on the total publications, publication beginning year, total citations, and h-index. In comparison, Table 4 displayed the top 10 research journals based on classification from Bradford law, which classified academic journals into three groups with zone 1 encompassing core research journals to publish material relevant to growth and development, plant disease. This is also known as a nuclear zone since it contributes the most researches. Of 1,778 research journals, 33 are in zone 1, 247 are in zone 2, and 1,498 are in zone 3 (Supplemental Table 1). The tree map of the top 10 subject categories (Fig. 3) showed that Plant Sciences (1742, 28%) was the most popular topic, followed by Horticulture (1,479, 24%), Agronomy (884, 14%), Food Science & Technology (644, 10%), and Agriculture Multidisciplinary (348, 6%).

3.4. Most popular keywords

Authors employ keywords to provide a clear, representative, and short description of the study content, therefore keyword analysis may be used to find popular topics and themes in a research area [18,19]. To efficiently identify active research hotspots in scientific disciplines and sectors [20], the word cloud of author keywords (Fig. 4A) is naturally displayed to identify the most common study subjects [21]. This word cloud depicted the top 50 author keywords from all papers collected. The greater the keyword collection, the

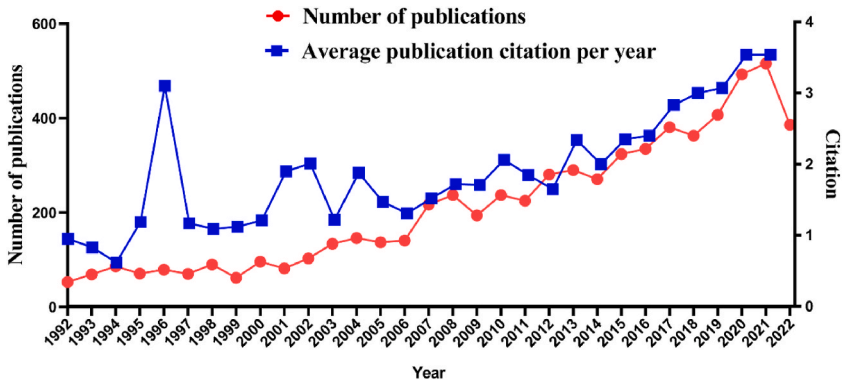

Fig. 1. The number of publications and average publications citation per year of the research on watermelon from 1992 to 2022 in the Web of Science Core Collection.

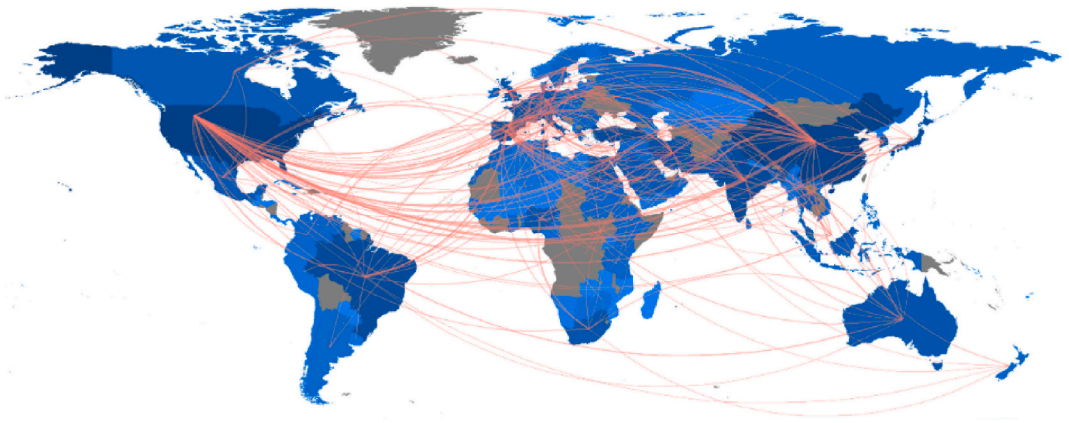

Fig. 2. Countries with the research collaboration.

Table 2
List of nations (countries with the most corresponding authors).

Country	Articles	SCP	MCP	Freq	MCP-Ratio
USA	1778	1611	167	0.268	0.094
China	1249	1025	224	0.188	0.179
Brazil	304	272	32	0.046	0.105
India	292	267	25	0.044	0.086
Turkey	280	251	29	0.042	0.104
Spain	271	227	44	0.041	0.162
Korea	240	190	50	0.036	0.208
Japan	213	198	15	0.032	0.07
Iran	125	92	33	0.019	0.264
Italy	116	72	44	0.017	0.379

Table 3
The top 10 journals by source impact.

Source titles	*h*-index	g-index	TC	NP	PY-start
Plant Disease	34	47	4016	250	1992
Phytopathology	33	61	3914	232	1992
Hortscience	28	48	3593	553	1993
Scientia Horticulture	28	55	3397	113	1997
Food Chemistry	23	35	2710	35	1998
Journal of Agricultural and Food Chemistry	22	42	1986	42	1996
PLoS One	22	40	1745	55	2009
Archives of Virology	19	30	1047	55	1992
Frontiers in Plant Science	19	35	1322	63	2015
Crop Protection	17	24	675	43	1992

Note: The total number of citations (TC), the number of publications (NP), and the year of first publication (PY-start).

Table 4
Rankings of journals (Bradford law).

Sources	Rank	Freq	cumFreq	Zone
Hortscience	1	553	553	Zone 1
Plant Disease	2	250	803	Zone 1
Phytopathology	3	232	1035	Zone 1
Scientia Horticulture	4	113	1148	Zone 1
Frontiers in Plant Science	5	63	1211	Zone 1
Archives of Virology	6	56	1267	Zone 1
PLoS One	7	55	1322	Zone 1
Horttechnology	8	51	1373	Zone 1
European Journal of Plant Pathology	9	50	1423	Zone 1
Crop Protection	10	43	1466	Zone 1

Fig. 3. Tree map of the top 10 subject categories.

more frequently it appeared in a dataset [22]. The keyword "growth" (total frequency of 350) was the most popular (except for the phrase "watermelon"), indicating that growth is one of the most attention-attracting topics of watermelon study. Furthermore, the terms resistance (344), identification (308), yield (301), quality (237), plants (226), watermelon stomach (194), and expression (179) have all contributed significantly to the literature. The identical set of most popular keywords from Fig. 4A are shown in Fig. 4B together with their percentage domination over the entire number of keywords related to watermelon. Watermelon is the fruit with the most representation (7%) followed by others, such as yield (4%), identification (4%), growth (5%), and resistance (5%).

3.5. Authors analysis and thematic evolution

Fig. 5 is visually depicted how the output of renowned authors have changed through the periods. The circle's diameter represented the number of publications, and its blackness represented the total number of citations per year (TC/Y) [23]. In the last 30 years, the top 10 authors produced 699 publications in the field of watermelon research; the majority of these articles were produced from 2008 to 2020 (Supplementary Table 2). With 134 publications, Levi A from the Agricultural Research Service of the United States Department of Agriculture is rated #1. TC/Y stands for total citations per year since publication. For instance, if the total cost of Levi A's output in 2008 was 462, the appropriate TC/Y would be 299/(2024-2019) = 28. 875. It's important to note that Levi A's works from 2008 likewise have the greatest TC/Y (59.8), followed by Xu Y's (6 papers) and Zhang HY's (5 papers) creations from 2017 with the second and third highest TC/Y, respectively (50.429 and 49.714). It suggests that, to some extent, Levi A (2019), Xu Y (2017), and Zhang HY (2017) have greater effect than other experts. The researchers with successive publications in recent years are among the top 10 authors published, as indicated in Fig. 5. This illustrates their significant contributions to the watermelon study from a different angle. Additionally, it is clear from Table 5 that Levi A is the most well-known researcher in this field because he has the greatest h-index, TC, and NP values.

The keywords, journals, and countries were further examined, a novel three-fields (Fig. 6) plotted the relationships between keywords (left), journals (middle), and nations (right) in the watermelon research [24]. Papers on *Citrullus lanatus* were largely published in Hortscience, with the bulk of them written by scholars from the United States. Similarly, the bulk of watermelon research, primarily written by Chinese scientists, were published in the journal of Scientia Horticulture. The vast majority of publications on watermelon were published in Hortscience, Phytopathology, Plant Disease, and Scientia Horticulture. The chart showed that *Citrullus lanatus*, *Cucurbitaceae*, grafting, and watermelon were the key study areas, with the majority of contributions coming from the United States, China, and Spain.

3.6. Co-occurrence network of keyworks

The co-occurrence network of the top 50 high frequency terms of watermelon literature was displayed in Fig. 7 using the R software, which is called Bibliometrix. As can be observed, the co-occurrence network's Cluster 1 (Blue Cluster) and Cluster 2 (Green

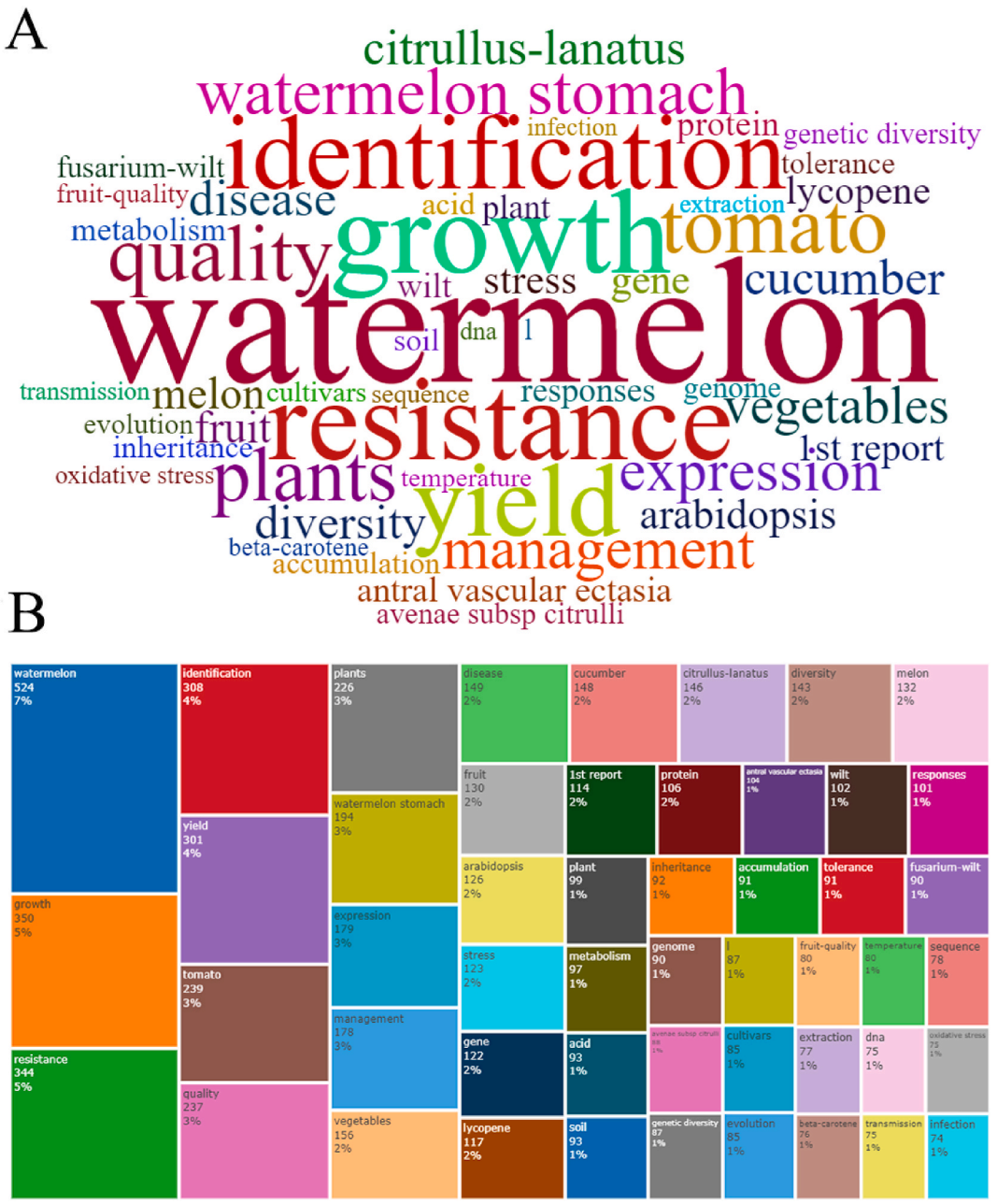

Fig. 4. Word cloud and tree map representations of the top 50 author keywords. (A) fifty author keyword clouds; (B) 50 author keywords mapped out as a tree. Labels are often single words, and the font size and color of each label indicate how frequently it is used.

Cluster) significantly overlaped, demonstrating their tight relationship in terms of study themes. The co-occurrence network's lines that connect two circles show the connections between two keyworks. Generally speaking, the closer the link between two keyworks is, the thicker the line is, and the stronger their association [25]. Six phrases were identified as the main topics of the watermelon research hotspots by the significant keyword occurrence network: "watermelon", "identification", "resistance", "growth", "yield" and "watermelon stomach." (Fig. 7). In cluster 1, "watermelon" was the most often used keyword. Watermelon resistance was the main topic of cluster 1, along with the identification of specific genes or types. In cluster 2, "growth" was the most often used keyword. This cluster, which was related to "quality", "yield", "stress", and "responses", particularly discussed the growth and development of watermelon.

3.7. Co-occurrence network of authors

The most pertinent author cooperation network should be considered firstly with regard to the analysis at the level of the authors.

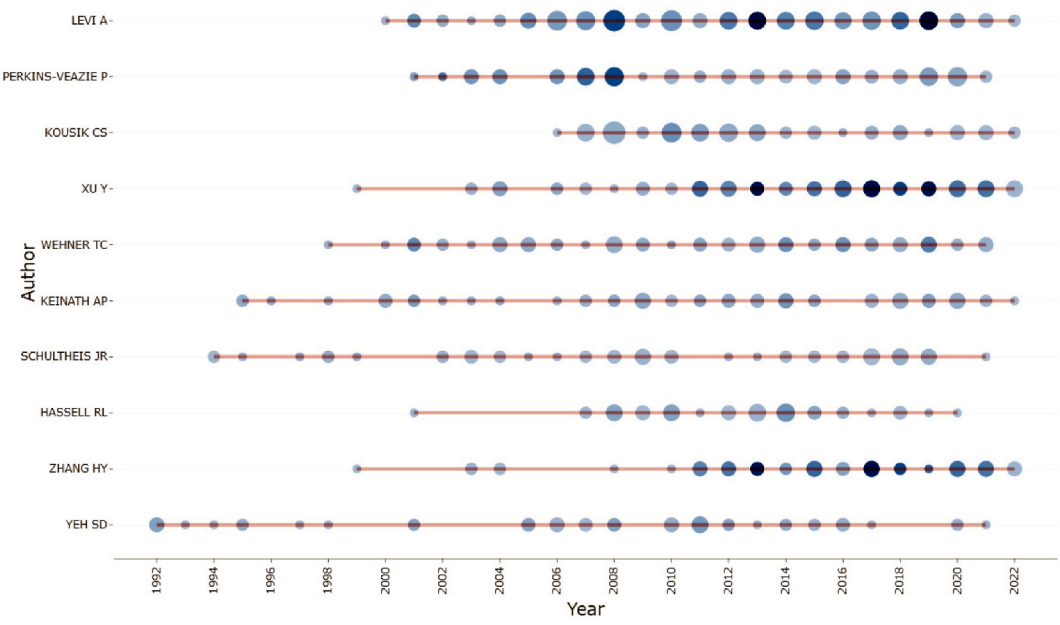

Fig. 5. The output of the top ten authors throughout time.

Table 5
Top 10 influential authors in the watermelon research Feld.

Author	*h*-index	g-index	TC	NP	PY-start
LEVI A	30	54	3313	134	2000
PERKINS-VEAZIE P	19	45	2066	82	2001
KOUSIK CS	13	20	485	80	2006
XU Y	28	50	2543	74	1999
WEHNER TC	20	32	1206	68	1998
KEINATH AP	19	31	1027	57	1995
SCHULTHEIS JR	9	17	333	55	1994
HASSELL RL	11	19	379	28	2006
ZHANG HY	21	45	2031	50	1999
YEH SD	21	32	1083	49	1992

The author cooperation network (Fig. 8) as a consequence had 13 clusters. Each color in this network denoted a specific cluster or group of authors that are working together. The cooperation network reveals that there are closed groups, which are visible in the graph. In actuality, this number of nodes was selected since a higher number would result in a considerably higher number of individual authors, making the network impossible to understand. The identical hue denoted the identical cluster. Links among authors indicated that there were frequent research partnerships on watermelon, particularly amongst authors in the same cluster. The biggest clusters, as shown in Fig. 8, are the green and yellow clusters. Levi A and Xu Y are the most well-known researchers in this field, according to authors from the green and yellow cluster, to which the most productive author belongs, who mostly examined germplasm resources and fruit ripening of watermelon [26–28].

4. Discussion

Focused bibliometric studies are essential for presenting the trend analysis of research in a certain topic or research area and for giving key bibliometric indexes like the most prolific authors, journals, and nations over time [29]. In the current study, watermelon-related articles were examined using bibliometric techniques through R 4.2.1, laying the groundwork for further investigation in this area.

As was already indicated, researches on watermelons have advanced swiftly and formed a bountiful crop during the previous three decades. It has evolved into a vibrant area of research in recent years, a natural byproduct of agricultural prosperity in many nations. Since 1992, there has been an almost linear growth in the number of publications and the average number of citations per article. While various bibliometric evaluations of well-established scientific domains have noted this trend [30–32]. However, it should be mentioned that the results of this study indicated a low degree of collaboration among authors in the area, as previously reported; So, it is strongly recommended that various geographies with diverse cultures enhance cooperation [33]. Author collaboration should be

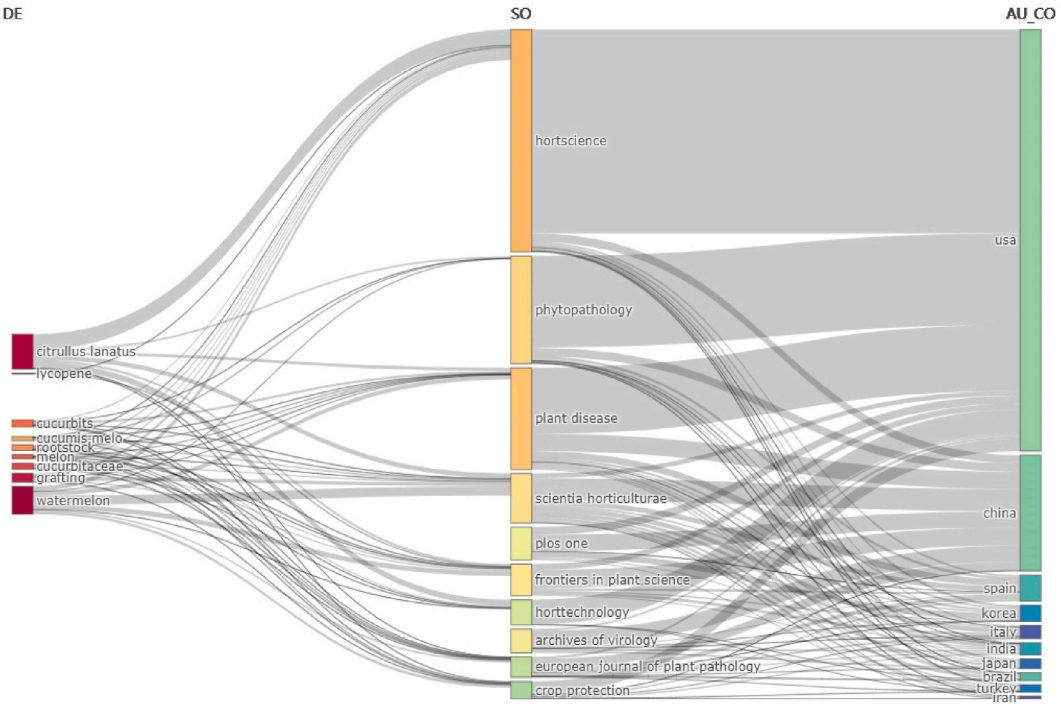

Fig. 6. Top 10 keywords, journals, and countries plotted over three fields.

prioritized since it adds to scholarly advancement [34]. Highly collaborative conduct is increased in recent years and has become a typical practice in most scientific areas [35]. It is worth mentioning that the United States was not only the most productive country, but also the country with the most citations, demonstrating that the United States is the dominant country in this subject. China came in second in terms of article count, followed by Brazil, India, and Turkey. In other words, the United States and China have contributed more to publications than any other country.

The keywords were examined in order to better grasp the research topic. The word cloud results showed that the terms "resistance", "identification", "yield", and "quality" are relevant. It has been observed that low temperatures stimulate SA production, which may work in conjunction with redox signaling to control watermelon resistance [36,37]. Additionally, new biotechnology techniques have been widely applied in watermelon plant breeding and disease resistance because to the rapid advancement of molecular biology [38]. "Identification" is a term that has been reported frequently, taking Zhang's findings on the genome-wide discovery of SAUR genes in the watermelon genome as an example [39]. Additionally, certain watermelon microRNAs and their target genes have been discovered [40]. Another significant study area is the production and quality of watermelons. Research by Mohamed Dhamir examined the effects of rootstock on watermelon seed output and quality [41]. Overall, the frequency with these keywords have been used to demonstrate their significance and further support the accuracy of the results analysis. The top four prolific authors were determined to be Levi A, Perkins-Veazie P, Kousik CS, and Xu Y. The most prolific author in this field was Levi A, whose research focused on watermelon genetic resources and disease or pest resistance. For example, Levi A explored the watermelon response to southern root-knot nematode (*meloidogyne incognita*) [42,43], fusarium wilt [44] and genetic resources diversity among watermelon accessions [45]. The second-most productive author was Perkins-Veazie P, and their research hotspots were comparable. They both focused on watermelon genetic resources and soilborne illness [46,47].

The analysis of the watermelon research area from a bibliometric perspective in this study will have management implications for academics and researchers and may aid in researchers' efforts to get a comprehensive grasp of this field in the face of the challenge of more papers being published, might aid researchers in this endeavor [48]. The results demonstrate about the nations in this region, the leading journals, significant authors, research trends, and hotspots in this region. The results also showed that researchers can swiftly pinpoint the information they are looking for. For example, it may assist researchers in selecting a journal that is appropriate for them when submitting their paper based on the journal analysis, and it can also assist authors in locating a prospective cooperator based on the author's analysis. Furthermore, researchers may immediately identify research hotspots that might direct their research. In general, this work can serve as a resource for scholars.

This study has several limitations that should be considered. To begin, only journal articles from the WOS core collection database are analyzed. Despite being one of the world's largest databases, WOS does not contain all watermelon publications. Other bibliometric methods by using more datasets should be focused on except the WoS in the future. Extending the study to include conference papers, theses, and dissertations might also be an attempt to enhance the analysis [23]. Besides, this study focused on demonstrating a broad viewer of the field rather than an in-depth analysis of the details. Future research might employ alternative methodologies, such

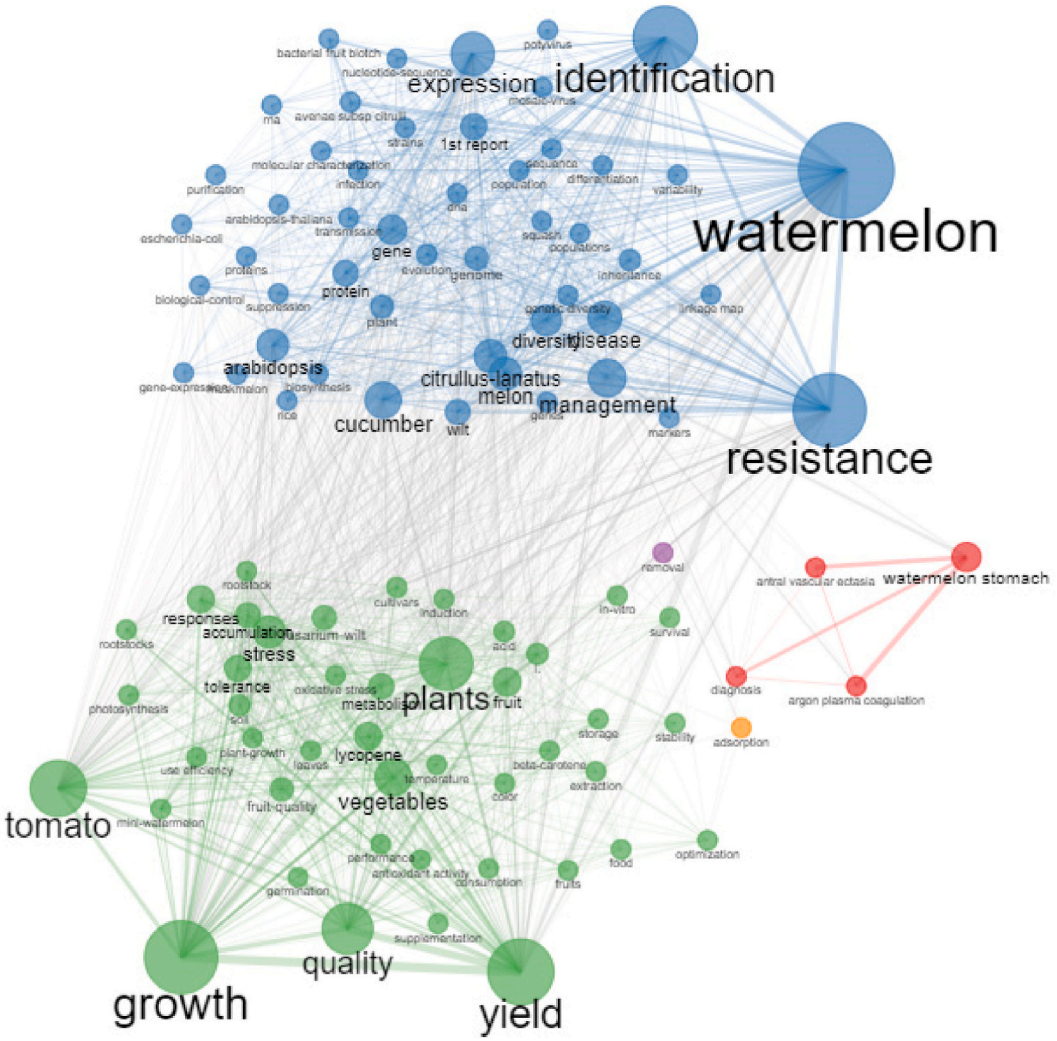

Fig. 7. examination of keyworks' cogitations. Clusters 1, 2, and 3 are represented by the colors blue, green, and red, respectively. The relationships between two keyworks are shown by lines between two circles; the closer the relationship, the thicker the line9.

as social network and factor analysis, to explore ongoing tendencies of the research.

Although the great research progress about the watermelon have been achieved, there still some areas needed to be enhanced according to the bibliometric analysis results of retrieved articles. In the future research, researchers should pay more attention to the following directions:

(1) The international cooperation should be strengthened. The genetic resource is very important for the watermelon breeding. Through the exchanges of the materials based on the cooperation, the key breakthrough may be acquired.
(2) Artificial intelligence should be attracted more attentions. Artificial intelligence methods have been widely applied to horticultural cultivation and breeding because of their ability to solve nonlinear and complex data structures. It is promising to develop some smart method to aid the research of watermelon.
(3) The evaluation of nutrition value and the development of nutrition reinforcement cultivars should be focused. The present research topics are mainly about the yield and quality. People are eager to get more healthy and valuable cultivars, this area is with great promise.

5. Conclusions

The yearly publications, marked journals, marked nations, popular keywords, and their temporal evolution in watermelon research from 1992 to 2022 were examined using bibliometric analysis. The number of papers on watermelon research has expanded dramatically during the last 30 years. Plant Disease was the most cited journal and placed #1 among all journals. The most often used

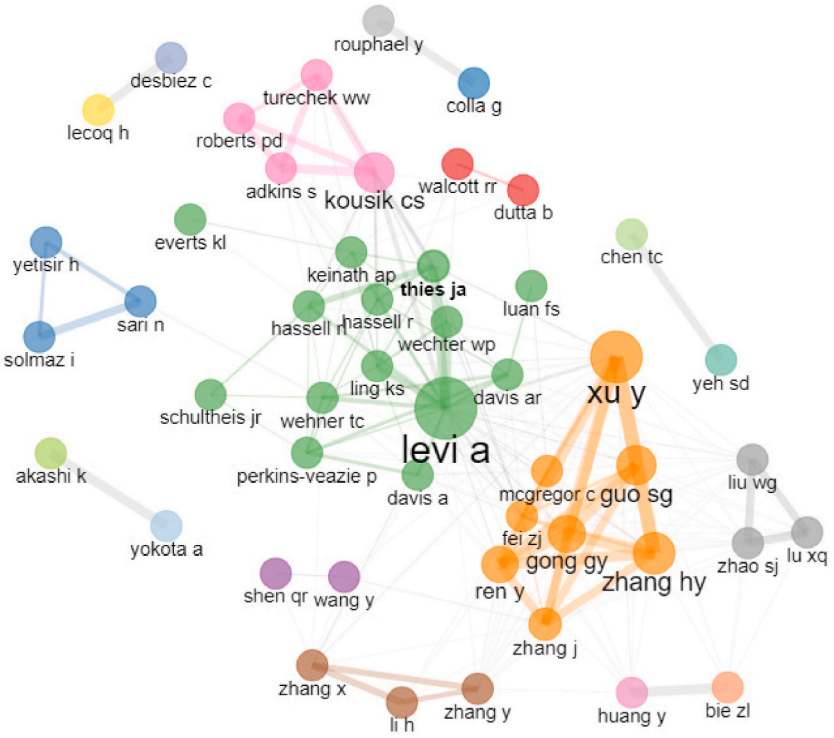

Fig. 8. Co-citation analysis of authors. The relationships between two writers are shown by lines between two circles; the tighter the link, the thicker the line.

keywords are "growth", "resistance", "identification", "yield", "quality", "plants", "watermelon stomach", and "expression". The research showed that watermelon research was heavily promoted and developed in the United States and China, but there have only been a few studies on the topic from African nations. Thus, emerging nations must further encourage their cooperation and contact with developed nations. Additionally, because the bibliometric data are continually updated and modified, the results could alter over time. Despite the narrow range of the search results, the results can serve as a useful illustration of the chronological patterns in watermelon research. The findings give scholars useful information to pinpoint knowledge gaps, suggest areas for next research, and advance this subject.

Funding

This work was funded by the Henan Federation of Social Sciences [SKL-2023-1713]. The funding bodies had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Data availability statement

Data included in article/supplementary material/referenced in article.

CRediT authorship contribution statement

Yuping Zheng: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:Yu-Ping Zheng reports financial support was provided by Henan Federation of Social Sciences.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e26824.

References

[1] R.C. Fierascu, E. Sieniawska, A. Ortan, I. Fierascu, J.B. Xiao, Fruits by-products – a source of valuable active principles. a short review, Front. Bioeng. Biotechnol. 8 (2020) 319, https://doi.org/10.3389/fbioe.2020.00319.

[2] S.G. Guo, J.G. Zhang, H.H. Sun, J. Salse, W.J. Lucas, The draft genome of watermelon (*Citrullus lanatus*) and resequencing of 20 diverse accessions, Nat. Genet. 45 (2013) 51–58, https://doi.org/10.1038/ng.2470.

[3] B. Burton-Freeman, M. Freeman, X.H.Q. Zhang, A. Sandhu, I. Edirisinghe, Watermelon and l-citrulline in cardio-metabolic health: review of the evidence 2000-2020, Curr. Atherosclerosis Rep. 23 (2021) 81, https://doi.org/10.1007/s11883-021-00978-5.

[4] A. Wahyudi, J. Kartahadimaja, A.B. Setyawan, N.A. Mustakim, F.A. Askhary, B.J. Katfar, Evaluation of yields on new varieties of hybrid watermelon, IOP Conf. Ser. Earth Environ. Sci. 1012 (1) (2022) 012070, https://doi.org/10.1088/1755-1315/1012/1/012070.

[5] F. Ulas, A. Aydın, A. Ulas, H. Yetisir, Grafting for sustainable growth performance of melon (*cucumis melo*) under salt stressed hydroponic condition, Eur. J. Sustain. Dev. 8 (2019) 201–210, https://doi.org/10.14207/ejsd.2019.v8n1p201.

[6] A.P. Keinath, T.W. Coolong, J.D. Lanier, P.S. Ji, Managing fusarium wilt of watermelon with delayed transplanting and cultivar resistance, Plant Dis. 103 (2019) 44–50, https://doi.org/10.1094/PDIS-04-18-0709-RE.

[7] M. Zhong, M. Lin, Bibliometric analysis for economy in COVID-19 pandemic, Heliyon 8 (9) (2022) e10757, https://doi.org/10.1016/j.heliyon.2022.e10757.

[8] C. Michels, U. Schmoch, The growth of science and database coverage, Scientometrics 93 (2012) 831–846, https://doi.org/10.1007/s11192-012-0732-7.

[9] L. Zhang L, J. Ling, M. Lin, Carbon neutrality: a comprehensive bibliometric analysis, environmental science and pollution research, Environ. Sci. Pollut. Res. 30 (16) (2023) 45498–45514, https://doi.org/10.1007/s11356-023-25797-w.

[10] L. Bornmann, R. Mutz, Growth rates of modern science: a bibliometric analysis based on the number of publications and cited references, J. Assn. Inf. Sci. Tec. 66 (2015) 2215–2222, https://doi.org/10.1002/asi.23329.

[11] M. Pautasso, Publication growth in biological sub-fields: patterns, predictability and sustainability, Sustainability 4 (2012) 3234–3247, https://doi.org/10.3390/su4123234.

[12] M.W. Neff, E.A. Corley, 35 years and 160,000 articles: a bibliometric exploration of the evolution of ecology, Scientometrics 80 (2009) 657–682, https://doi.org/10.1007/s11192-008-2099-3.

[13] Y. Chen, M. Lin, D. Zhuang, Wastewater treatment and emerging contaminants: bibliometric analysis, Chemosphere 297 (2022) 133932, https://doi.org/10.1016/j.catena.2020.104798.

[14] M.E. Mohadab, B. Bouikhalene, S. Safi, Bibliometric method for mapping the state of the art of scientific production in Covid-19, Chaos, Solit. Fractals 139 (2020) 110052, https://doi.org/10.1016/j.chaos.2020.110052.

[15] M. Aria, C. Cuccurullo, bibliometrix: an R-tool for comprehensive science mapping analysis, J. Inf. 11 (2017) 959–975, https://doi.org/10.1016/j.joi.2017.08.007.

[16] N. Niknejad, W. Ismail, M. Bahari, R. Hendradi, A.Z. Salleh, Mapping the research trends on blockchain technology in food and agriculture industry: a bibliometric analysis, Environ. Tech. Inno. 21 (2021) 101272, https://doi.org/10.1016/j.eti.2020.101272.

[17] R. Rodríguez-Soler, J. Uribe-Toril, J.P. Valenciano, Worldwide trends in the scientific production on rural depopulation, a bibliometric analysis using bibliometrix R-tool, Land Use Pol. 97 (2020) 104787, https://doi.org/10.1016/j.landusepol.2020.104787.

[18] L. Zhang, J. Ling, M. Lin, Artificial intelligence in renewable energy: a comprehensive bibliometric analysis, Energy Rep. 8 (2022) 14072–14088, https://doi.org/10.1016/j.egyr.2022.10.347.

[19] L. Zhang, L. Ling, M. Lin, Risk management research in East Asia: a bibliometric analysis, Inter. J. Intell. Com. Cyber. 16 (3) (2023) 574–594, https://doi.org/10.1108/IJICC-10-2022-0276.

[20] J.E. Lngulsrud, K. Kai, S. Kadowaki, S. Kurobane, M. Shiobara, The assessment of cross-cultural experience: measuring awareness through critical text analysis, Int. J. Intercult. Relat. 26 (2002) 473–491, https://doi.org/10.1016/S0147-1767(02)00030-5.

[21] B. Pham-Duc, H. Nguyen, C. Le Minh, L.H. Khanh, T. Trung, A bibliometric and content analysis of articles in remote sensing from vietnam indexed in scopus for the 2000-2019 period, Ser. Rev. 46 (2020) 275–285, https://doi.org/10.1080/00987913.2020.1854155.

[22] A. Nasir, K. Shaukat, I.A. Hameed, S. Luo, T.M. Alam, F. Iqbal, A bibliometric analysis of corona pandemic in social sciences: a review of influential aspects and conceptual structure, IEEE Access 8 (2020) 133377–133402, https://doi.org/10.1109/ACCESS.2020.3008733.

[23] J.G. Shi, K.F. Duan, G.D. Wu, R. Zhang, X.W. Feng, Comprehensive metrological and content analysis of the public–private partnerships (PPPs) research field: a new bibliometric journey, Scientometrics 124 (2020) 2145–2184, https://doi.org/10.1007/s11192-020-03607-1.

[24] Z.H. Munim, M. Dushenko, V.J. Jimenez, M.H. Shakil, M. Imset, Big data and artificial intelligence in the maritime industry: a bibliometric review and future research directions, Marit. Pol. Manag. 47 (2020) 577–597, https://doi.org/10.1080/03088839.2020.1788731.

[25] K. van Nunen, J. Li, G. Reniers, K. Ponnet, Bibliometric analysis of safety culture research, Saf. Sci. 108 (2018) 248–258, https://doi.org/10.1016/j.ssci.2017.08.011.

[26] S. Guo, S. Zhao, H. Sun, X. Wang, S. Wu, T. Lin, et al., Resequencing of 414 cultivated and wild watermelon accessions identifies selection for fruit quality traits, Nat. Genet. 51 (2019) 1616–1623, https://doi.org/10.1038/s41588-019-0518-4.

[27] S. Wu, X. Wang, U. Reddy, H. Sun, K. Bao, L. Gao, et al., Genome of 'Charleston Gray', the principal American watermelon cultivar, and genetic characterization of 1,365 accessions in the U.S. National Plant Germplasm System watermelon collection, Plant Biotechnol. J. 17 (2019) 2246–2258, https://doi.org/10.1111/pbi.13136.

[28] M. Zhou, S. Guo, S. Tian, J. Zhang, Y. Ren, G.M. Gong, et al., Overexpression of the watermelon ethylene response factor *ClERF069* in transgenic tomato resulted in delayed fruit ripening, Hortic. Plant J. 6 (2020) 247–256, https://doi.org/10.1016/j.hpj.2020.05.004.

[29] N. Donthu, S. Kumar, D. Mukherjee, N. Pandey, W.M. Lim, How to conduct a bibliometric analysis: an overview and guidelines, J. Business Res. 133 (2021) 285–296, https://doi.org/10.1016/j.jbusres.2021.04.070.

[30] H. Liao, M. Tang, L. Luo, C. Li, F. Chiclana, X.J. Zeng, A bibliometric analysis and visualization of medical big data research, Sustainability 10 (2018) 166, https://doi.org/10.3390/su10010166.

[31] W.M. Sweileh, K. Wickramage, K. Pottie, C. Hui, B. Roberts, A.F. Sawalha, S.H. Zyoud, Bibliometric analysis of global migration health research in peer-reviewed literature (2000–2016), BMC Publ. Health 18 (2018) 777, https://doi.org/10.1186/s12889-018-5689-x.

[32] Y.Z. Yi, D.Y. Chen, B.F. Li, Global regulatory T-Cell research from 2000 to 2015: a bibliometric analysis, PLoS One 11 (2016) e162099, https://doi.org/10.1371/journal.pone.0162099.

[33] X. Wei, X. Li, S. Song, X. Wen, C. Zhao, X. Wu, K. Liu, Z. Shao, Trends and focuses of hantavirus researches: a global bibliometric analysis and visualization from 1980 to 2020, Arch. Publ. Health 80 (2022) 218, https://doi.org/10.1186/s13690-022-00973-5.

[34] J. Wang, H. S, Zhang Cross-cultural learning: a visualized bibliometric analysis based on bibliometrix from 2002 to 2021, Mobile Inf. Syst. 2022 (2022) 1–11, https://doi.org/10.1155/2022/7478223.

[35] L. G, Kiser No more first authors, no more last authors if we really want transdisciplinary research, we must ditch the ordered listing of authors that stalls collaborative science,says, Nature 561 (2018) 435, https://doi.org/10.1038/d41586-018-06779-2.

[36] F. Cheng, J. Lu, M. Gao, K. Shi, Q. Kong, et al., Redox signaling and CBF-responsive pathway are involved in salicylic acid-improved photosynthesis and growth under chilling stress in watermelon, Front. Plant Sci. 7 (2016) 1519, https://doi.org/10.3389/fpls.2016.01519.

[37] F. Zhu, Z. Wang, Y. Fang, J. Tong, J. Kang, K. Yang, Study on the role of phytohormones in resistance to watermelon fusarium wilt, Plants 11 (2022) 156, https://doi.org/10.3390/plants11020156.

[38] X.D. Li, M.N. An, Z.H. Xia, X.J. Bai, Y.H. Wu, Transcriptome analysis of watermelon (*Citrullus lanatus*) fruits in response to *Cucumber green mottle mosaic virus* (CGMMV) infection, Sci. Rep. 7 (2017) 16747, https://doi.org/10.1038/s41598-017-17140-4.

[39] N. Zhang, X. Huang, Y. Bao, B. Wang, H. Zeng, W. Cheng, M. Tang, Y. Li, J. Ren, Y. Sun, Genome-wide identification of *SAUR* genes in watermelon (*Citrullus lanatus*), Physiol. Mol. Biol. Plants 23 (2017) 619–628, https://doi.org/10.1007/s12298-017-0442-y.

[40] M.C.M. Zakeel, M.I.S. Safeena, T. Komathy, *In silico* identification of microRNAs and their target genes in watermelon (*Citrullus lanatus*), Sci. Hortic. 252 (2019) 55–60, https://doi.org/10.1016/j.scienta.2019.02.012.
[41] M.D. Kombo, N. Sari, Rootstock effects on seed yield and quality in watermelon, Hortic. Environ. Biotechnol. 60 (2019) 303–312, https://doi.org/10.1007/s13580-019-00131-x.
[42] J.A. Thies, J.J. Ariss, R.L. Hassell, S. Olson, C.S. Kousik, A. Levi, Grafting for management of southern root-knot nematode, *meloidogyne incognita*, in watermelon, Plant Dis. 94 (2010) 1195–1199, https://doi.org/10.1094/PDIS-09-09-0640.
[43] J.A. Thies, J.J. Ariss, C.S. Kousik, R.L. Hassell, A. Levi, Resistance to southern root-knot nematode (*Meloidogyne incognita*) in wild watermelon (*Citrullus lanatus var. citroides*), J. Nematol. 48 (2016) 14–19, https://doi.org/10.21307/jofnem-2017-004.
[44] S.E. Branham, A. Levi, W.P. Wechter, QTL mapping Identifies novel source of resistance to fusarium wilt race 1 in citrullus amarus, Plant Dis. 103 (2019) 984–989, https://doi.org/10.1094/PDIS-09-18-1677-RE.
[45] A. Levi, C.E. Thomas, A.P. Keinath, T.C. Wehner, Genetic diversity among watermelon (*Citrullus lanatus and Citrullus colocynthis*) accessions, Genet. Resour. Crop Evol. 48 (2001) 559–566, https://doi.org/10.1023/A:1013888418442.
[46] A. Attavar, L. Tymon, P. Perkins-Veazie, C.A. Miles, Cucurbitaceae germplasm resistance to verticillium wilt and grafting compatibility with watermelon, Hortscience 55 (2020) 141–148, https://doi.org/10.21273/HORTSCI14631-19.
[47] P. Devi, P. Perkins-Veazie, C. Miles, Impact of grafting on watermelon fruit maturity and quality, Horticulturae 6 (2020) 97, https://doi.org/10.3390/horticulturae6040097.
[48] W. Yang, X. He, Z. Wang, L. Lu, G. Zhou, J. Cheng, X. Hao, Research focus and theme trend on fulminant myocarditis: a bibliometric analysis, Front. Cardiovasc. Med. 9 (2022) 935073, https://doi.org/10.3389/fcvm.2022.935073.