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Bibliometric Mapping of School Garden Studies: A Thematic Trends Analysis

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Abstract: This paper analyzes the thematic trends in school garden studies over the past few decades, using a relational bibliometric methodology on a corpus of 392 articles and review articles indexed in the Web of Science Core Collection. The paper seeks to understand how researchers have studied the concept over the last few decades in various disciplines, spanning approximately eighty Web of Science categories. The results show that there is a critical mass of scientific research studying school gardens. The analysis shows the thematic trends in discussion journals, discussion terminology, and consolidates classic papers and some novel authors and papers. The studies and their theoretical trends lead to refocusing the analysis on the effects of school gardens beyond the educational, thanks to the contribution of authors from more than fifty countries engaged in the study of these activities. This work constitutes new challenges for this line of research, raising interdisciplinary research challenges between horticultural, environmental, technological, educational, social, food, nutritional, and health sciences.

Keywords: public health; well-being; eating behavior; education sciences; pro-environmental behavior; pro-social behavior

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Citation: Castillo, D.; Vega-Muñoz, A.; Salazar-Sepúlveda, G.; Contreras-Barraza, N.; Torres-Alcayaga, M. Bibliometric Mapping of School Garden Studies: A Thematic Trends Analysis. *Horticulturae* **2023**, *9*, 359. https://doi.org/10.3390/horticulturae9030359

Academic Editor: Luigi De Bellis

Received: 6 January 2023
Revised: 28 February 2023
Accepted: 28 February 2023
Published: 9 March 2023

1. Introduction

The school garden as an educational resource allows proximity to the natural environment by designing interdisciplinary experiences that contribute to the development of basic educational skills, such as cooperation, teamwork, communication and cognition [1], promoting healthy living by connecting students with healthy, whole food [2], and even bringing diverse environments between schools and neighborhoods [3].

In 1840, Fredrick Froebel was a pioneer in designing an educational program to teach through gardening, where several precursors such as Mentessori, Dewey, and Froebel, among others, set the basis to show the benefits of this teaching style. Today, several international organizations, such as the FAO and UNESCO, promote its development [4].

School gardens form part of many primary and secondary schools as a space for learning and experience for students [5]. Additionally, at the university level, they facilitate collaborative learning and the acquisition of social, emotional, and environmental competencies [1,5]. The presence of a school garden is also associated with better results in reading and science tests, independent of race and social class [3], being recognized as a contribution to the cognitive and affective–emotional development and as an influence on the prosocial behavior of children and adults [5]. Therefore, it is necessary to further knowledge about the development of the behavior of those who participate in educational programs of school gardens, the characteristics of these educational programs and their impact on learning, health, and well-being.

Additionally, from an emotional point in view, school gardens generate an active relationship with teachers and classmates, improving the academic performance and self-esteem of the participants, as well as engendering greater empathy for ecologically sustainable production and local biodiversity, considering an increase in 69% in the willingness to try fruits and vegetables, and a sense of well-being when sharing these experiences with the family by proposing healthy foods at home and being able to correctly identify fruits, with an observable increase from 52% to 94% that of vegetables from 43% to 86% [6–15].

1.1. Educational Programs around School Gardens

In recent years, primary, secondary, and higher education institutions have incorporated interaction with nature in their educational programs, having positive impacts on learning and education. Some school garden programs focus on hands-on inquiry to promote the learning of science concepts and other types of knowledge, in accordance with state-mandated learning objectives [16].

Research conducted by Petra and Kharleinz in 2019 on 300 primary and secondary school students found that students perceive educational environments associated with nature to be better for their learning [17]. On the other hand, a qualitative study of medicine degree students at a naturopathic college in Auckland, New Zealand, then continued access to a wide range of herbs and plants, was recognized as a practical resource for teaching and learning, because it aided coursework by providing students with outstanding opportunities such as making sensory/kinesthetic learning products, which were perceived to further student learning. The students also used the herb garden to provide clients in the student clinic with various infusions, integrating learning into actual hands-on activities [18].

From another dimension, another study conducted in the USA in marginalized schools indicated that school garden programs are effective in achieving educational objectives at a relatively low cost [19].

One of these ways is the methodologies and learning developed in the school gardens, enabling significant and multidisciplinary learning [1,20]. This has been seen since the first recorded study in 1902, where there were several open topics and with great opportunities on the relationship between gardens and education [21]. Some research has established that the benefits of using school gardens in the learning and teaching process have a direct effect on academic performance, positive results of diet in students, and an increase in the intention of students to perform physical activity and develop psycho-social skills. A stratified, purposeful sample of 21 New York City elementary and middle schools participated in this study throughout the 2013/2014 school year, when schools with integrated and sustained gardens were studied; patterns emerged on how school gardens improve school performance and group integration processes [22]. However, several studies have pointed out the importance of studying the impact of learning and teaching in the use of school gardens [23–27]. In turn, studies have indicated that those students who undergo active teaching methodologies such as those used in school gardens demonstrate better performance in learning and knowledge than students exposed to traditional teaching methodologies [28–30]. A study conducted on a sample of 360 secondary school students in Slovenia aged 15–18 years old to test the effectiveness of experimental instruction in a school garden compared with traditional classroom instruction in the subject of biotechnology showed that experimental instruction yielded significantly better performance scores than traditional instruction. The experimental instruction group achieved higher scores in both cognitive domains in knowledge and application [28]. It can also be observed that the use of the garden methodology generates a better predisposition and behavior to care for the environment [31,32]. One of these cases is the project carried out at the University of Arizona, in conjunction with the Community Food Bank of Southern Arizona, which, in 2014, conducted a program where more than 50 teacher interns were placed in 16 establishments and where the beneficiary students narrated how the activities brought them closer to a more sustainable behavior, as manifested through the students' own narratives and the observations of the teacher interns [31]. This has generated an approach towards new pedagogical practices oriented towards protecting non-human organisms and nature as a whole (biocentric), generating new challenges for teachers to develop competencies, evaluation systems, and a contextual pedagogy [1,33–35]. This has led to specialized curricular designs of educational programs incorporating gardens as a new form of pedagogical activity that contributes to knowledge and learning [22,36,37] and the curricula of teacher training centers [38].

1.2. School Gardens in Health and Well-Being

Another topic related to school gardens is their value in promoting a strategy to increase vegetable consumption. School gardens stimulate the consumption of vegetables to the extent that their installation, especially in primary and secondary education, can be integrated into the school curriculum. The latter ensures that teachers integrate the school garden into the academic activities of the students, including the preparation and consumption of the cultivated vegetables. In fact, since the late 1980s, especially in the United States, studies and publications have analyzed the impact of school gardens on increasing vegetable consumption [6,39–41]. The specialized literature of the last thirty years consolidates the association between the promotion of school gardens with vegetable consumption and better nutrition of children and youth [42]. This is relevant because bibliographic evidence confirms that the intake of vegetables and fruits by adolescents is low, and many exhibit unhealthy eating behaviors. Therefore, school gardens develop food literacy and are a key object to improve adolescent nutrition [43]. School gardens stimulate food literacy to the extent that they subjectively develop knowledge, skills, and behaviors. In addition, they show food and health options related to emotions and the food culture that includes vegetables [44].

From the improvement in nutrition, school gardens also become a visible intervention that subjectively contributes to promoting comprehensive and mental health among the child and youth population [40,45]. In addition, school gardens are recognized as one strategy to improve nutritional health in schools through changes in eating behaviors. Therefore, gardening, cooking, and nutrition interventions in schools can translate into significant improvements in dietary intake, which is the foundation of health [46].

Third, childhood obesity has become a global concern, especially in the population between 6 and 17 years of age, to the extent that a low proportion of children and adolescents consumes the recommended daily servings of fruits and vegetables [47]. However, currently, it is confirmed that a school curriculum based on horticulture, gardening, and school gardens can improve children's attitudes towards the consumption of fruits and vegetables, whose preference can contribute to nutritional education that prevents obesity at an early age, based on the daily link with school gardens. In other words, school gardens have cognitive, affective, reactive, and metacognitive effects [48,49].

Finally, for many children today, the easiest and most readily available outdoor environment is their schoolyard. However, school grounds are organized according to their neatness, maintenance simplicity, safety, and security. Thus, school spaces that incorporate lawns, wildflowers, and vegetated areas have been shown to promote physical activity [16]. In this context, school gardens are stimulating displays that provide opportunities to relax and to promote physical activity. In other words, they contribute to improving health and preventing obesity [26].

Faced with such a diversity approach, this paper analyzes the way in which the concept of school gardens has been studied in recent decades. Considering an analysis of thematic trends that include the benefits of school gardens from an interdisciplinary and unidisciplinary perspective.

2. Materials and Methods

A set of articles was used as a homogeneous citation base, avoiding the impossibility of comparing indexing databases that use different calculation bases to determine journals' impact factors and quartiles [50–54], relying on the core Web of Science (WoS) collection [55], selecting only articles and review, from a search vector on school garden TS = (school NEAR/0 garden), with which the query was performed in the WoS Advanced Search module, without restricted temporal parameters, performing the extraction on 26 December 2022. The advanced search field tag TS (Topic) searches for a topic term in the following fields within a record: Title, Abstract, Author Keywords, and Keywords Plus®, and proximity operator NEAR/0 find records where the terms joined by the operator are within zero words of each other (adjacent words) [55].

A bibliometric analysis of a set of articles obtained for the topic under study was carried out using five fundamental bibliometric laws, in two phases:

Phase 1: Bibliometric analysis of scientific production

1. Exponential science growth or Price's law, through the exponential adjustment degree (by the coefficient of determination, R^2) of the annual growth of publications (in this case, published articles per year), using Microsoft Excel trend line adjustment. As a measure of a strong interest among the scientific community, this confirmed that a critical researcher mass was developing this knowledge topic [56,57].
2. Publication concentration in authors or Lotka's law, recognizing that in any knowledge field, most of the articles come from a small proportion of prolific authors, who, being identified, can be studied in isolation, estimated by the square root of total authors, which is verified by adjustment to the power law, using Microsoft Excel trend line adjustment between authors publishing and published articles, by the coefficient of determination, R^2 [58].
3. Hirsch index (h-index), specifying a set of "n" articles with "n" or more citations, determined by the intersection of ordered pairs between the curves: citations received by each published article (in decreasing order) and the count of published articles (cumulative) [59] and cross-citation analysis Sainaghi et al. [60], which observes the citation network between a specific article set, and therefore how some articles of this set are the basis for the creation of new knowledge (subsequent articles).

Phase 2: Bibliometric analysis of scientific production areas

4. Publication concentration in journals or Bradford's law, distributing the journals in thirds according to the decreasing number of documents published in them, establishing a nucleus of journals with the highest concentration that covers at least 33% of the total published records (in this case, published articles) [61,62].
5. Keyword concentration or Zipf's law, highlighting the most commonly used keywords in the article set, estimated by the square root of total words, which is verified by the adjustment to power law [63]. Using Microsoft Excel trend line adjustment between Keywords Plus (KWP) frequency of publishing and published articles, using the coefficient of determination, R^2.

Finally, VOSviewer software was used to perform the processing and visualization of the dataset, as well as the co-occurrence, performing a fragmentation analysis with clustered visualization outputs. Identifying: only authors (solo), dyads, triads, and clusters of these, countries producing collaboratively or autonomously, and thematic clusters [64,65].

3. Results

The 392 articles (including 27 review articles) were published between 1902 and 2022, with the oldest article entitled "Conference on School Gardens", published in the journal *Nature* (see the Supplementary Material, Table S1). However, the annual scientific production in this topic has only achieved recurrent presence since 1999: we studied the exponential publication growth between that year and 2022, showing good results (R^2 of approximately 80%), even considering that the year 2022 does not have complete records, as shown in Figure 1 below. Studies around the school garden concept have exhibitewd a growth form expected in terms of documented scientific knowledge production [56,57], and therefore, it is possible to develop a bibliometric analysis.

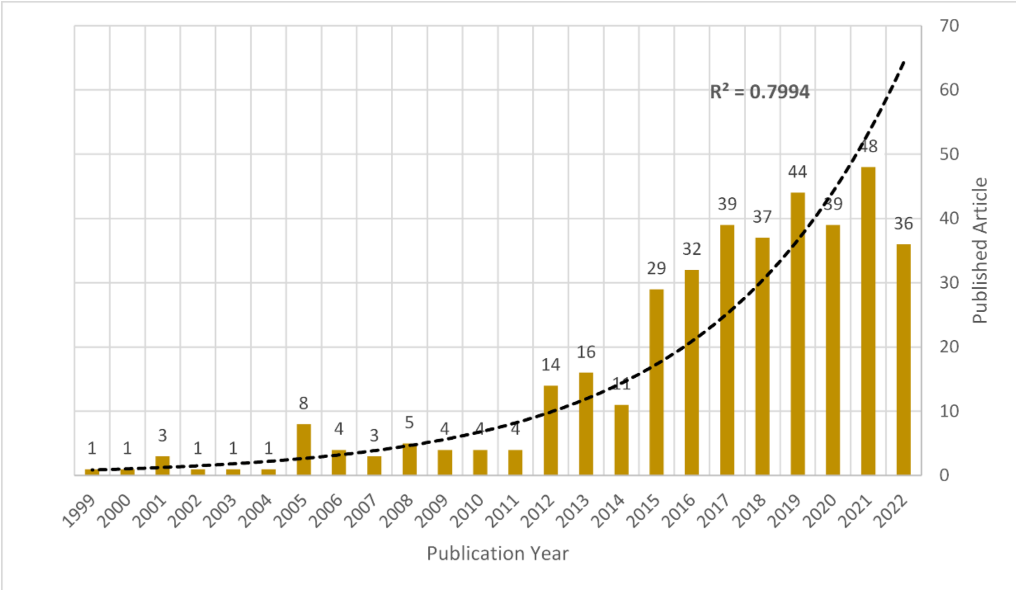

Figure 1. Publications on school gardens between 1999 and 2022. Bars: data series; dashed line: exponential data series trend.

3.1. Relational Scientific Production Results

The number of authors who have produced this knowledge (392 articles) totaled 1243 (extracted by VOSviewer from the Author Full Names data field of each record), although 1076 of these only contributed to one paper. Thus, according to Lotka's law, the number of authors with the greatest contribution to generating this knowledge is estimated at 35 (square root of 1243), but given the discrete article count, only the 23 authors contributing four or more articles were identified as prolific (Figure 2).

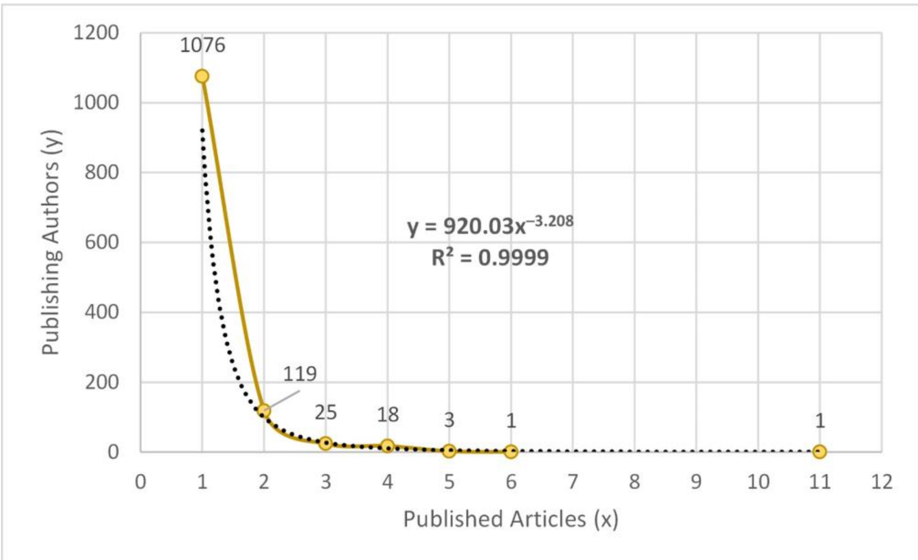

Figure 2. Relationship between scientific production level and authors.

As shown in Figure 3, between solitary authors (five) and dyads (two), the presence of two clusters stands out: the first, in green, including the authors with the highest scientific production level; and the other, in blue and red, congregating nine prolific authors, where the double coloration is due to the segregation made by VOSviewer for the author Schreinemachers, Pepijn, given his lower level of centrality in that cluster.

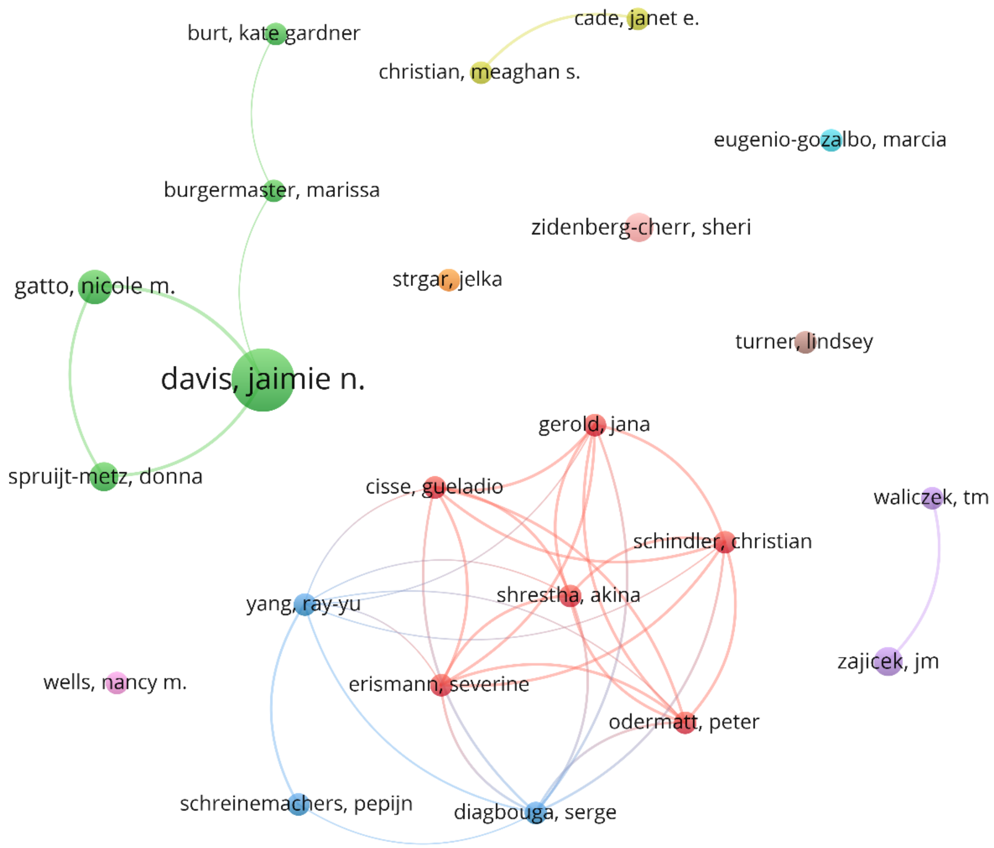

Figure 3. Prolific co-authorship graph. The colors indicate the cluster.

Table 1 details what is shown in Figure 3, indicating the specific background of each prolific author.

Table 1 reflects the country/territory of the prolific authors' affiliation. For the 1243 authors in total, the geography of production differed, registering affiliations belonging to 56 countries, of which only 39 are consistently connected (in addition, the 17 disconnected countries/territories produce knowledge autonomously without any international collaboration), among which the scientific production generated in the USA stands out, contributing 160 documents. In terms of centrality, the UK, with 20 countries or territories, and Germany, with 19 international collaboration connections, stand out. However, the levels of citations in Jordan (78 citations on average), Pakistan (52 citations on average), and Switzerland (42 citations on average) are notable. National/territorial co-authorship relationships are shown in Figure 4.

Table 1. Prolific authors (over four publications).

Author	Documents	Citations	Average Citations	Total Link Strength [1]	Cluster	Country Affiliation
Davis, Jaimie N.	11	348	32	65	Green	USA
Gatto, Nicole M.	6	259	43	22	Green	USA
Spruijt-Metz, Donna	5	82	16	21	Green	USA
Zajicek, JM	5	225	45	9	Dyad	USA
Zidenberg-Cherr, Sheri	5	70	14	18	Solo [2]	USA
Burgermaster, Marissa	4	24	6	21	Green	USA
Burt, Kate Gardner	4	36	9	6	Green	USA
Cade, Janet E.	4	131	33	17	Dyad	UK
Christian, Meaghan S.	4	131	33	17	Dyad	UK
Cisse, Gueladio	4	62	16	40	Red/blue	Switzerland
Diagbouga, Serge	4	63	16	39	Red/blue	Burkina Faso
Erismann, Severine	4	62	16	40	Red/blue	Switzerland
Eugenio-Gozalbo, Marcia	4	29	7	11	Solo	Spain
Gerold, Jana	4	62	16	40	Red/blue	Switzerland
Odermatt, Peter	4	62	16	40	Red/blue	Switzerland
Schindler, Christian	4	62	16	40	Red/blue	Switzerland
Schreinemachers, Pepijn	4	49	12	30	Red/blue	Thailand
Shrestha, Akina	4	62	16	40	Red/blue	Switzerland and Nepal
Strgar, Jelka	4	13	3	9	Solo	Slovenia
Turner, Lindsey	4	70	18	14	Solo	USA
Waliczek, TM	4	171	43	8	Dyad	USA
Wells, Nancy M.	4	94	24	37	Solo	USA
Yang, Ray-Yu	4	51	13	35	Red/blue	Taiwan

[1] Document-by-document count of the connection with other authors; [2] only in terms of prolific.

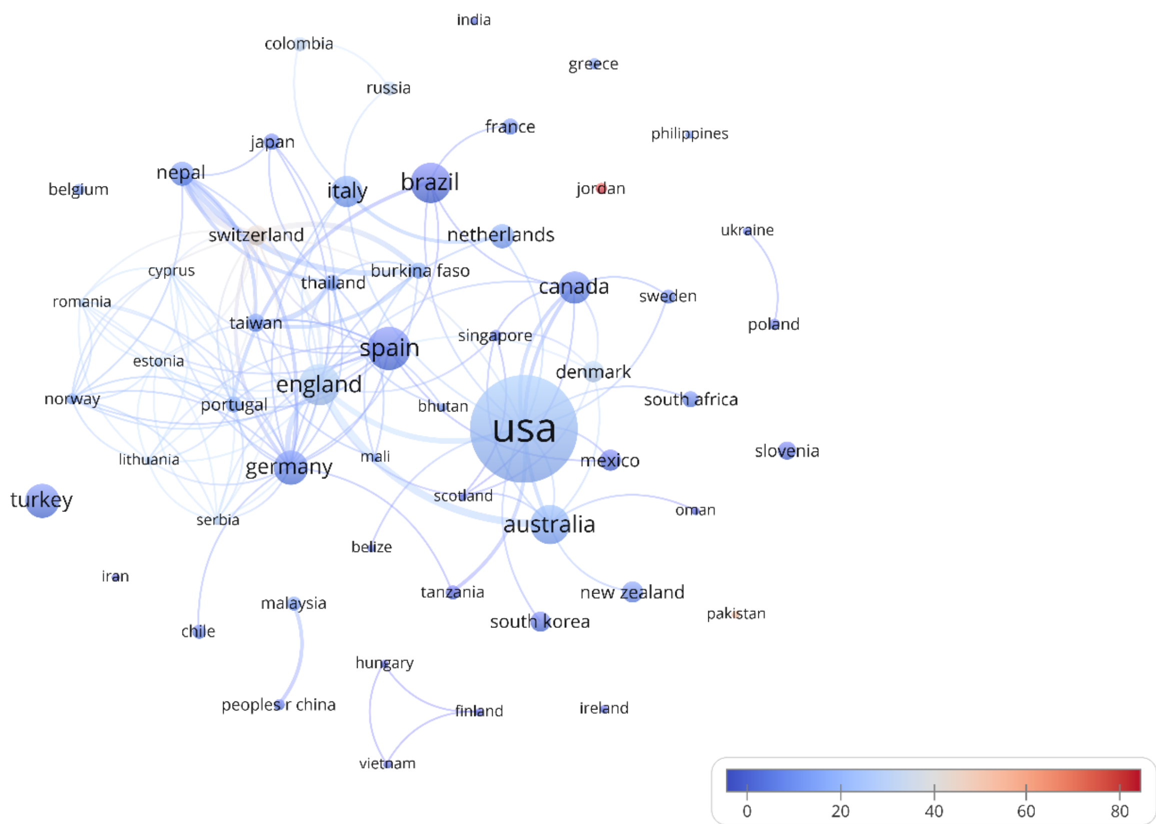

Figure 4. National/territorial co-authorship graph.

For a deeper interpretation of the role and interaction between prolific authors and highly scientifically productive countries/territories in school garden studies, we incorporated the Hirsch index or h-index as a factor to weight the impact of these 23 authors and 56 countries/territories. Figure 5 shows the h-index calculation, with 38 articles with 38 or more citations; Table 2 lists these articles.

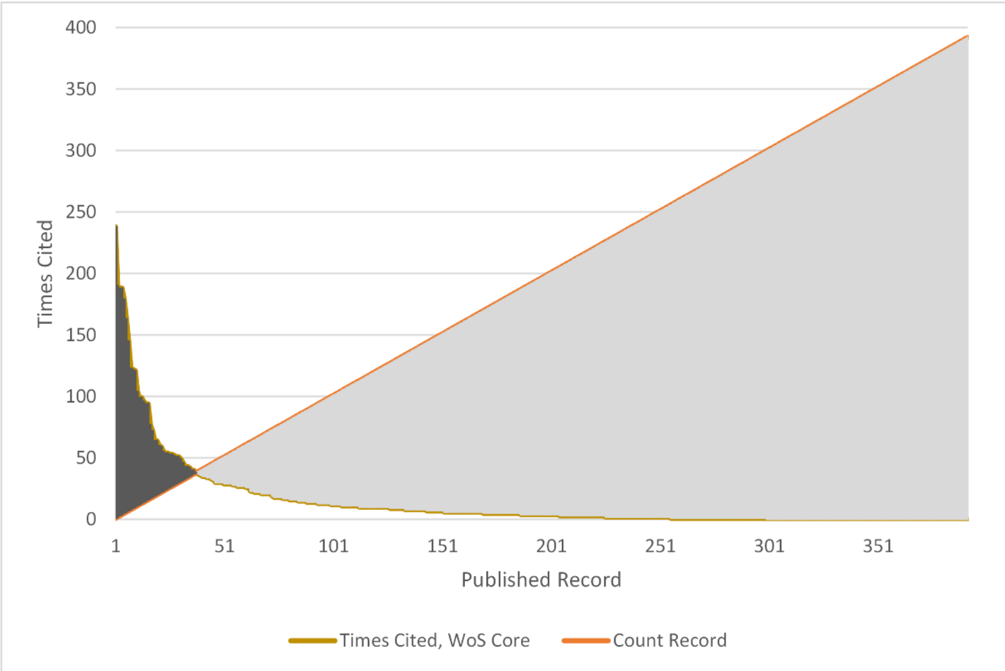

Figure 5. h-index estimation.

Table 2. h-index articles (38 or more citations).

Authors	Prolific Authors	Article Title	Journal ISO Abbreviation	Country/ Territory	Times Cited, WoS Core	Publication Year	WoS Index
Blair [66]	No	The Child in the Garden: An Evaluative Review of the Benefits of School Gardening	*J. Environ. Educ.*	USA	238	2009	SSCI
Parmer et al. [67]	No	School Gardens: An Experiential Learning Approach for a Nutrition Education Program to Increase Fruit and Vegetable Knowledge, Preference, and Consumption among Second-grade Students	*J. Nutr. Educ. Behav.*	USA	190	2009	SCIE; SSCI
McAleese et al. [68]	No	Garden-based nutrition education affects fruit and vegetable consumption in sixth-grade adolescents	*J. Am. Diet. Assoc.*	USA	188	2007	SCIE
Robinson-O'Brien et al. [6]	No	Impact of Garden-Based Youth Nutrition Intervention Programs: A Review	*J. Am. Diet. Assoc.*	USA	188	2009	SCIE; SSCI
DeCosta et al. [69]	No	Changing children's eating behaviour—A review of experimental research	*Appetite*	DNK	179	2017	SCIE; SSCI
Hawkes et al. [70]	No	Double-duty actions: seizing programme and policy opportunities to address malnutrition in all its forms	*Lancet*	England; USA; CHE	163	2020	SCIE; SSCI
Ozer et al. [16]	No	The effects of school gardens on students and schools: conceptualization and considerations for maximizing healthy development	*Health Educ. Behav.*	USA	145	2007	SSCI

Table 2. *Cont.*

Authors	Prolific Authors	Article Title	Journal ISO Abbreviation	Country/ Territory	Times Cited, WoS Core	Publication Year	WoS Index
Morgan et al. [71]	No	The impact of nutrition education with and without a school garden on knowledge, vegetable intake and preferences and quality of school life among primary-school students	*Public Health Nutr.*	AUS; England	123	2010	SCIE; SSCI
Williams et al. [72]	No	Impact of Garden-Based Learning on Academic Outcomes in Schools: Synthesis of Research Between 1990 and 2010	*Rev. Educ. Res.*	USA	122	2013	SSCI
Davis et al. [73]	Yes	LA Sprouts: A Gardening, Nutrition, and Cooking Intervention for Latino Youth Improves Diet and Reduces Obesity	*J. Am. Diet. Assoc.*	USA	121	2011	SCIE; SSCI
Al-Khashman et al. [74]	No	The investigation of metal concentrations in street dust samples in Aqaba city, Jordan	*Environ. Geochem. Health*	JOR	104	2007	SCIE
Ohly et al. [75]	No	A systematic review of the health and well-being impacts of school gardening: synthesis of quantitative and qualitative evidence	*BMC Public Health*	England	99	2016	SCIE; SSCI
Hayes-Conroy et al. [76]	No	Veggies and visceralities: A political ecology of food and feeling	*Emot. Space Soc.*	USA	99	2013	SSCI
Russo et al. [77]	No	Edible green infrastructure: An approach and review of provisioning ecosystem services and disservices in urban environments	*Agric. Ecosyst. Environ.*	RUS; COL; ITA	96	2017	SCIE; SSCI
Klemmer et al. [78]	Yes	Growing minds: The effect of a school gardening program on the science achievement of elementary students	*HortTechnology*	USA	94	2005	SCIE; SSCI
Graham et al. [79]	No	Use of school gardens in academic instruction	*J. Nutr. Educ. Behav.*	USA	94	2005	SCIE
Savoie-Roskos et al. [80]	No	Increasing Fruit and Vegetable Intake among Children and Youth through Gardening-Based Interventions: A Systematic Review	*J. Acad. Nutr. Diet.*	USA	77	2017	SCIE; SSCI
Berezowitz et al. [81]	No	School Gardens Enhance Academic Performance and Dietary Outcomes in Children	*J. Sch. Health*	USA	72	2015	SCIE; SSCI
Gatto et al. [82]	Yes	LA Sprouts: A Garden-Based Nutrition Intervention Pilot Program Influences Motivation and Preferences for Fruits and Vegetables in Latino Youth	*J. Acad. Nutr. Diet.*	USA	64	2012	SCIE; SSCI
Langellotto et al. [83]	No	Gardening Increases Vegetable Consumption in School-aged Children: A Meta-analytical Synthesis	*HortTechnology*	USA	64	2012	SCIE; SSCI
Bontrager Yoder et al. [84]	No	Farm to Elementary School Programming Increases Access to Fruits and Vegetables and Increases Their Consumption Among Those with Low Intake	*J. Nutr. Educ. Behav.*	USA	60	2014	SCIE; SSCI

Table 2. *Cont.*

Authors	Prolific Authors	Article Title	Journal ISO Abbreviation	Country/Territory	Times Cited, WoS Core	Publication Year	WoS Index
Christian et al. [85]	Yes	Evaluation of the impact of a school gardening intervention on children's fruit and vegetable intake: a randomised controlled trial	*Int. J. Behav. Nutr. Phys. Act.*	England	59	2014	SCIE; SSCI
Skinner et al. [86]	No	Intrinsic Motivation and Engagement as Active Ingredients in Garden-Based Education: Examining Models and Measures Derived from Self-Determination Theory	*J. Environ. Educ.*	USA	55	2012	SSCI
Davis et al. [87]	Yes	Sustenance and sustainability: maximizing the impact of school gardens on health outcomes	*Public Health Nutr.*	USA; AUS	54	2015	SCIE; SSCI
Robinson et al. [88]	Yes	Growing minds: The effects of a one-year school garden program on six constructs of life skills of elementary school children	*HortTechnology*	USA	54	2005	SCIE; SSCI
Christian et al. [89]	Yes	Family meals can help children reach their 5 A Day: a cross-sectional survey of children's dietary intake from London primary schools	*J. Epidemiol. Community Health*	England	53	2013	SCIE; SSCI
Graham et al. [90]	No	California teachers perceive school gardens as an effective nutritional tool to promote healthful eating habits	*J. Am. Diet. Assoc.*	USA	53	2005	SCIE
Bhutta et al. [91]	No	Meeting the challenges of micronutrient malnutrition in the developing world	*Br. Med. Bull.*	PAK	52	2013	SCIE
Wells et al. [92]	Yes	School gardens and physical activity: A randomized controlled trial of low-income elementary schools	*Prev. Med.*	USA	51	2014	SCIE; SSCI
Al-Khashman [93]	No	Assessment of heavy metals contamination in deposited street dusts in different urbanized areas in the city of Ma'an, Jordan	*Environ. Earth Sci.*	JOR	51	2013	SCIE
Jaenke et al. [94]	No	The Impact of a School Garden and Cooking Program on Boys' and Girls' Fruit and Vegetable Preferences, Taste Rating, and Intake	*Health Educ. Behav.*	AUS; England	49	2012	SSCI
Smith et al. [95]	No	Impact of hands-on science through school gardening in Louisiana public elementary schools	*HortTechnology*	USA	46	2005	SCIE
French et al. [96]	No	School-based research and initiatives: fruit and vegetable environment, policy, and pricing workshop	*Prev. Med.*	USA	43	2004	SCIE; CPCI-S
Guitart et al. [97]	No	Color me healthy: Food diversity in school community gardens in two rapidly urbanising Australian cities	*Health Place*	AUS	43	2014	SCIE; SSCI
Waliczek et al. [98]	Yes	The effect of school gardens on children's interpersonal relationships and attitudes toward school	*HortTechnology*	USA	42	2001	SCIE
Kingsley et al. [13]	No	You feel like you're part of something bigger: exploring motivations for community garden participation in Melbourne, Australia	*BMC Public Health*	AUS	40	2019	SCIE; SSCI

Table 2. *Cont.*

Authors	Prolific Authors	Article Title	Journal ISO Abbreviation	Country/Territory	Times Cited, WoS Core	Publication Year	WoS Index
Taylor et al. [99]	No	Food Availability and the Food Desert Frame in Detroit: An Overview of the City's Food System	*Environ. Pract.*	USA	40	2015	ESCI
Soylak et al. [100]	No	Lead concentrations of dust samples from Nigde City-Turkey	*Fresenius Environ. Bull.*	TUR	38	2000	SCIE

Table 2 details what is shown in Figure 5, indicating the specific details of each h-index article.

To complement the explanation in Figure 5, Table 2 provides the details of each item with respect to the h-index analysis.

Additionally, there are cross-citation interactions between this subset of 38 highly cited articles. Thus, the older articles have served as a reference for the articles depicted in Figure 6.

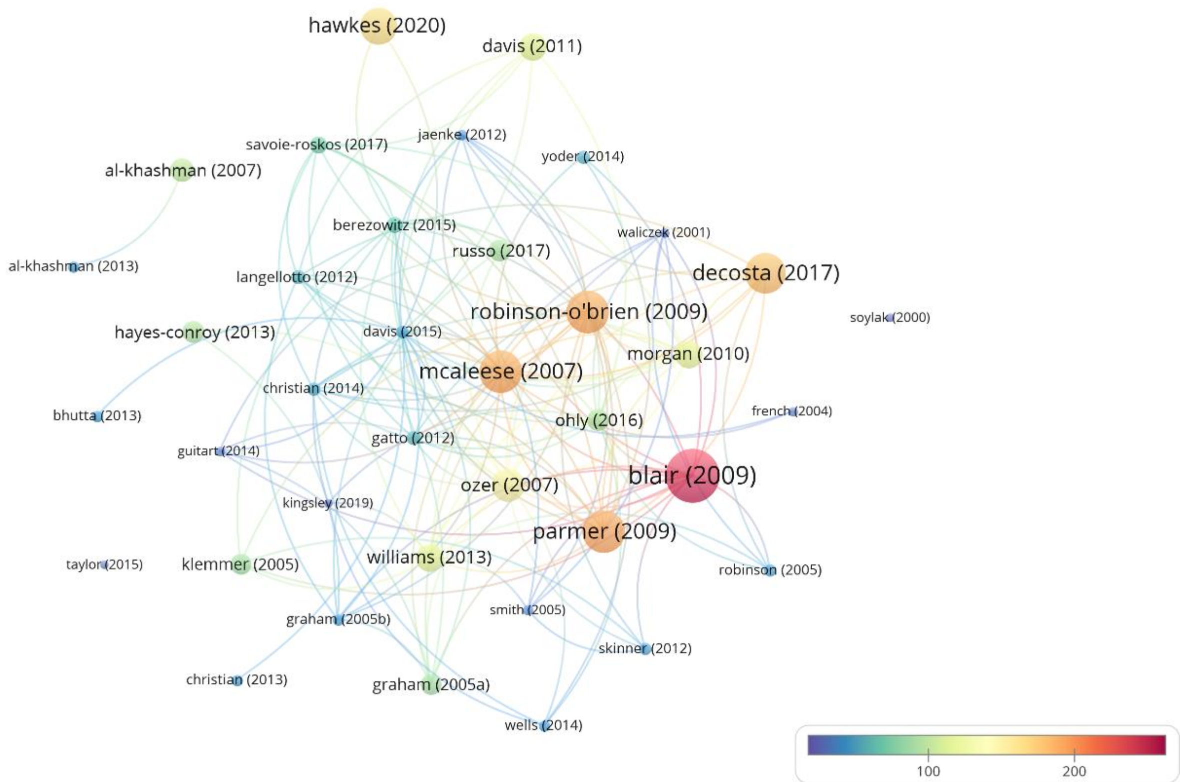

Figure 6. Cross-citation article graph; color nodes indicate the citation level.

3.2. Results of the Scientific Production Space

These 392 articles were published in 216 different journals, of which 157 had only published one article on school gardens; therefore, we understand that they are not specialized production spaces in the subject, to which we can add that 40% of the articles have been published in journals that are not specialized in the researched topic. On the other hand, according to Bradford's law, approximately one-third of the articles are concentrated in a reduced number of journals; thus, 123 articles (31%) are concentrated in only 15 journals, which have published between 5 and 25 articles on school garden. These core journals are detailed in Table 3 below.

Table 3. Main journals publishing on school gardens (over five publications).

Nucleus Bradford Journal	Publisher	WoS Index	IF (2022)	Best Quartile	Articles
HortTechnology	Amer Soc Horticultural Sci	SCIE; SSCI	1.387	Q3	25
Journal of Nutrition Education and Behavior	Elsevier	SCIE; SSCI	2.822	Q2	13
International Journal of Environmental Research and Public Health	MDPI	SCIE; SSCI	4.614	Q1	11
BMC Public Health	BMC	SCIE; SSCI	4.135	Q2	9
Nutrients	MDPI	SCIE; SSCI	6.706	Q1	8
Journal of the Academy of Nutrition and Dietetics	Elsevier	SCIE; SSCI	5.234	Q2	7
Public Health Nutrition	Cambridge Univ.	SCIE; SSCI	4.539	Q2	7
Journal of School Health	Wiley	SCIE; SSCI	2.460	Q2	7
Journal of Extension	Univ. of Wisconsin	ESCI	N.A.	N.A.	6
Sustainability	MDPI	SCIE; SSCI	3.889	Q2	5
Education Sciences	MDPI	ESCI	N.A.	N.A.	5
Remea-Revista Eletronica do Mestrado em Educacao Ambiental	Fed. Univ. Rio Grande	ESCI	N.A.	N.A.	5
Journal of Agriculture Food Systems and Community Development	Lyson Center Civic Agriculture & Food Systems	ESCI	N.A.	N.A.	5
Journal of Environmental Education	Taylor & Francis	SSCI	2.957	Q2	5
Health Education & Behavior	Sage	SSCI	4.444	Q2	5
Total	—	—			123

SCIE: Science Citation Index Expanded; SSCI: Social Science Citation Index; ESCI: Emerging Sources Citation Index; IF: Impact Factor.

As a first approximation, Table 2 shows that within this corpus of journals, *HortTechnology*, published by the American Society of Horticultural Science, is the journal with the most articles published on school gardens out of the 216 journals analyzed. At the Publisher level, MDPI has published the most articles within these 15 journals (29 articles, 24 mainstream, and 5 ESCI), followed by Elsevier with 20 mainstream articles. Although it seems to be more relevant to highlight that 11 of these 15 journals are mainstream (indexed in SCIE and SSCI), in addition, 10 of these belong to quartiles 1 or 2 of the Journal Citation Report (JCR-WoS), and therefore, the topic of school gardens has been situated in discussions at the mainframe level.

Another relevant aspect to analyze is how these scientific production spaces are occupied by the most prolific authors in this topic; as such, Table 4 presents a cross-analysis between Tables 1 and 3.

The five journals where none of the prolific authors have published have been removed from the table. These journals are *J. Ext* (ESCI), *REMEA* (ESCI), *Educ. Sci.* (ESCI), *J. Agric. Food Syst. Community Dev.* (ESCI), and *Sustainability*, including all journals indexed in the Emerging Sources Citation Index of WoS. The two authors who have not published in any of the Bradford nucleus journals (Schreinemachers, Pepijn; Strgar, Jelka) have also been excluded.

It is then possible to observe that the contribution of prolific authors in the Bradford core journals tends to be very concentrated, i.e., one to four journals per author. It is also observed that the journal with the most prolific authors is *BMC Public Health*, indexed in the WoS Public, Environmental & Occupational Health category (10 authors), followed by *J. Nutr. Educ. Behav.*, indexed in the WoS Education, Scientific Disciplines, and Nutrition & Dietetics categories (6 authors). Notably, these 16 prolific authors on school gardens publish in only one of these two journals, and not in both.

Table 4. Relationship between prolific authors and main journals on school gardens.

Author	*HortTechnology*	*J. Nutr. Educ. Behav.*	*Int. J. Environ. Res. Public Health*	*BMC Public Health*	*Nutrients*	*J. Sch. Health*	*Public Health Nutr.*	*J. Acad. Nutr. Diet.*	*J. Environ. Educ.*	*Health Educ. Behav.*	**Journals to which the Author has Contributed**
Davis, Jaimie N.	0	2	0	0	1	0	1	1	0	0	4
Gatto, Nicole M.	0	1	0	0	0	0	0	1	0	0	2
Spruijt-Metz, Donna	0	1	0	0	0	0	0	0	0	0	1
Zajicek, JM	5	0	0	0	0	0	0	0	0	0	1
Zidenberg-Cherr, Sheri	0	3	0	0	0	0	1	0	0	0	2
Burgermaster, Marissa	0	2	0	0	0	0	0	0	0	1	2
Burt, Kate Gardner	0	0	0	0	0	0	0	1	0	1	2
Cade, Janet E.	0	0	0	1	0	0	0	0	0	0	1
Christian, Meaghan S.	0	0	0	1	0	0	0	0	0	0	1
Cisse, Gueladio	0	0	0	2	0	0	0	0	0	0	1
Diagbouga, Serge	0	0	0	1	0	0	0	0	0	0	1
Erismann, Severine	0	0	0	2	0	0	0	0	0	0	1
Eugenio-Gozalbo, Marcia	0	0	0	0	0	0	0	0	1	0	1
Gerold, Jana	0	0	0	2	0	0	0	0	0	0	1
Odermatt, Peter	0	0	0	2	0	0	0	0	0	0	1
Schindler, Christian	0	0	0	2	0	0	0	0	0	0	1
Shrestha, Akina	0	0	0	2	0	0	0	0	0	0	1
Turner, Lindsey	0	1	0	0	0	1	0	2	0	0	3
Waliczek, TM	4	0	0	0	0	0	0	0	0	0	1
Wells, Nancy M.	0	0	1	0	0	0	0	0	0	0	1
Yang, Ray-Yu	0	0	0	1	0	0	0	0	0	0	1
Authors contributing	2	6	1	10	1	1	2	4	1	2	/

Thus, the authors Cade, J.E. [101], Christian, M.S. [101], Cisse, G. [102,103], Diagbouga, S. [103], Erismann, S. [102,103], Gerold, J. [102,103], Odermatt, P. [102,103], Schindler, C. [102,103], Shrestha, A. [102,103], and Yang, R.-Y. [103], would be more focused on Public, Environmental & Occupational Health. Additionally, authors Davis, J.N. [104,105], Gatto, N.M. [104], Spruijt-Metz, D. [104], Zidenberg-Cherr, S. [106–108], Burgermaster, M. [105,109], and Turner, L. [110], would have common interests in the areas of Education, Scientific Disciplines and Nutrition & Dietetics. A third segregation observed in Table 3 is that presented by the dyad of authors, Zajicek, J.M. and Waliczek, T.M. [48,78,111,112], who are the only ones publishing in the highest concentration journal, *HortTechnology*, indexed in the WoS Horticulture category with their best quartile in Q3.

Despite this segregation, the fragments seem to have some unity. Thus, considering the two authors who contribute to a greater diversity of journals, we found that, in addition to both publishing in a journal categorized in Education, Scientific Disciplines and Nutrition & Dietetics: (1) Davis, Jaimie N., publishes in Bradford core journals indexed to WoS, Public Environmental & Occupational Health [87]; and (2) Turner, Lindsey, publishes in Bradford core journals indexed to WoS Education & Educational Research, Health Care Sciences & Services, Public, Environmental & Occupational Health [113].

The Davis, Jaimie studies broadly conclude the following: gardening, cooking, and nutrition interventions in schools in an orchard-based environment can improve attitudes and preferences for fruits and vegetables, or can lead to improved nutritional habits and dietary intake, even having positive implications for environmental sustainability, reduced health disparities, and improvements in overall behavioral determinants. [46,87,104]. In contrast, the studies of Turner, Lindsey are generally oriented to the analysis of the results of public food policies around school gardens [110,113–115].

These thematic segregations in scientific productions on school gardens also generate clustering at the keyword level. To show this within WoS Keywords Plus, for the set of 392 documents, out of a total of 591 Keywords Plus selected according to Zipf's law, which points out that more frequent words tend to have more meanings, and shows that the number of meanings of a word grows as the square root of its frequency increases, 24 words have been selected (square root of 591), presenting between 14 and 77 occurrences (Figure 7).

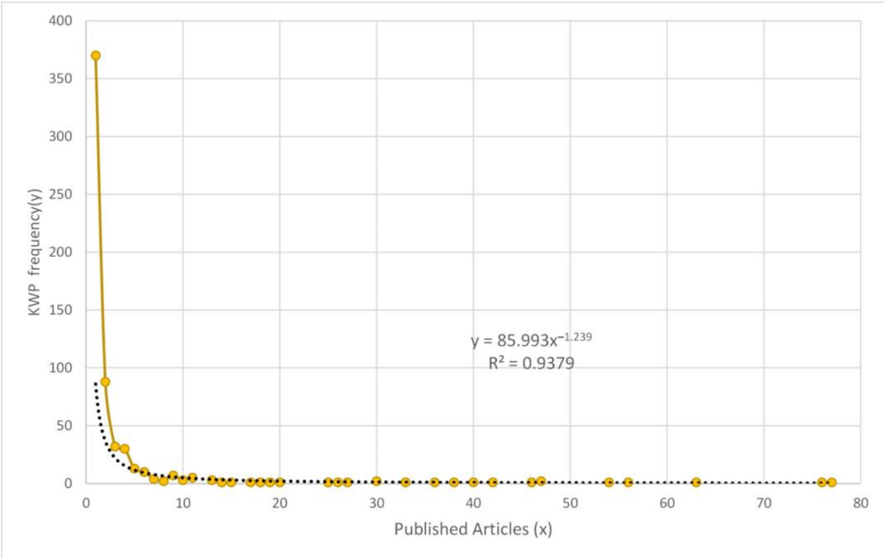

Figure 7. Relationship between scientific production level and KWP frequency.

Thus, the Keywords Plus group is organized into three clusters: red, focused on behavior; blue, related to education; and green, associated with health and well-being. It is important to note that apart from this analytically functional segregation, the level of connection between the three clusters is dense. You can see in Figure 8.

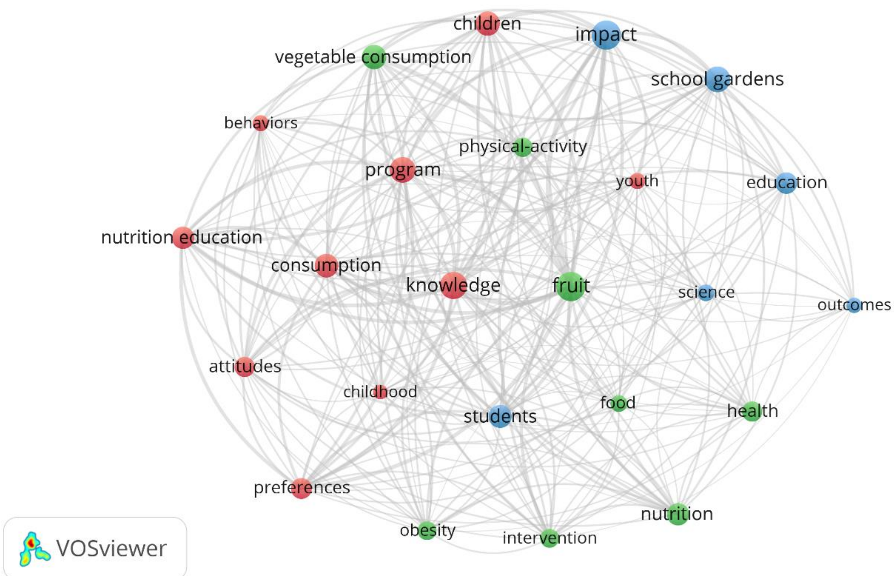

Figure 8. Keywords Plus co-occurrence graph.

4. Discussion

This article provides the scientific community with an analysis of school garden studies from the research evolution and trends perspective, being the first bibliometric study on this specific topic. There has been one previous bibliometric study by Bozdogan et al. [116], published in 2022 under the title "Bibliometric Assessment Based on Web of Science Database: Educational Research Articles on Botanic Gardens, National Parks, and Natural Monuments", where they relate educational practices with evaluative aspects oriented to contact with nature. Although methodologically they share certain criteria and bibliometric laws, they are certainly different in aspects of search vectors where they are only close to the topics of this research. Nevertheless, when comparing both studies, some overlaps can be found in these different areas. The first is that both studies reiterate that the United States is the most influential country in terms of scientific production, and there is a relationship between the scientific production on school gardens and educational practices in larger places such as botanical gardens, natural museums, and national parks. In addition, two countries that stand out in both studies for their scientific production are Brazil (South America) and Spain (Europe). Although these relationships may be interesting to study in greater depth in future research, it is important to note that when comparing the study by Bozdogan et al. [116] with the development of meta research, we observed differences in methodological aspects, such as: exponential science growth, or Price's law [56,57]; publication concentrations in authors, or Lotka's law [58]; publication concentrations in journals, or Bradford's law [61,62]; and keyword concentrations, or Zipf's law [63]. Thus, one contribution of this article is the methodological strengthening for studies of school gardens.

Our research highlights that school gardens are an object of study that contributes to the development of interdisciplinary studies; the main study approaches relate education and eating behavior, as do previous studies performed by Prescott [117] and Varman [118], as well as the related disciplines of behavior, health, and wellness, as in several previous studies [10,45,69,83,87,119,120]. In contrast, however, our study differs from unidisciplinary studies in specific fields such as behavioral studies [121], educational sciences [26,122–125], and health and wellness sciences [6,39,47,70,75,126–128].

5. Conclusions

From the present bibliometric study of school gardens, we can conclude how researchers have studied the school garden concept. Thus, based on the empirical evidence collected over the two decades under study, the scientific production of these researchers has been evolving positively at an exponential growth rate ($R^2 \approx 80\%$), which has enabled them to generate an increasing knowledge base on this topic. Regarding the geography of their scientific production, their 392 articles were the result of an interconnected contribution from 56 countries/territories: the USA stands out with a level of scientific production of 160 documents; the UK exhibits centrality, connected to 20 countries; and Germany, with 19 international collaboration connections, stand out. The distribution of these 392 articles is in 216 journals, which shows a high dispersion, considering that 157 journals have only one published article. Among the findings, we highlight that the journal *HortTechnology* has the largest article concentration, with a total of 25, indexed in the WOS category of Horticulture Q3. Despite this, MDPI and Elsevier have published the most articles within these 15 Bradford core journals. Another relevant finding is that none of the 23 prolific authors identified had published their research on this topic in journals indexed in ESCI–WoS.

One of the important limitations we found in this research was not identifying specific bibliometric publications on the bibliometric study of school gardens [116], which limits direct scientific discussions; however, this same point highlights the importance of our article, given the growing productivity demonstrated, representing a pioneer in describing the trends in scientific production in relation to school gardens, their impact, and their relationship with education.

We sought to approach the present research from a panoramic point of view with the purpose of evidencing trends in school garden research: behavioral studies, educational sciences, and health and wellness sciences. At the same time, the main limitation of bibliometric studies remains the problems of authors' digital identity and name disambiguation [129–133] (including difficulties between the choice of using abbreviated or full names) in VOSviewer [60], and not being able to accurately collect all the scientific production in a topic, a situation that we have at least attenuated by reducing the concentration of analyses thanks to bibliometric laws [54,56].

For future approaches, it is recommended to continue to deepen research in more specific aspects related to school gardens from topics oriented towards educational practices, their relationship with the measurement of impacts on productivity and learning at different educational levels, and to demonstrate connections between disciplines through comparative studies. At the same time, we believe that it is important to generate systematic information such as reviews, meta-analyses, and descriptive comparative studies that enable a more specific view of the research.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/horticulturae9030359/s1, Table S1: School_Garden.xlsx and School_Garden.txt (for VOSviewer).

Author Contributions: Conceptualization, A.V.-M., D.C., G.S.-S., M.T.-A., and N.C.-B.; methodology, A.V.-M.; formal analysis, N.C.-B. and A.V.-M.; writing—original draft preparation, A.V.-M., D.C., G.S.-S., M.T.-A. and N.C.-B.; writing—review and editing, A.V.-M., N.C.-B. and G.S.-S.; supervision, D.C.; project administration, A.V.-M.; funding acquisition, A.V.-M., D.C., G.S.-S., M.T.-A. and N.C.-B. All authors have read and agreed to the published version of the manuscript.

Funding: The Article Processing Charge (APC) was partially funded by Universidad Católica de la Santísima Concepción (Code: APC2023). Additionally, the publication fee (APC) was partially financed through the Publication Incentive Fund, 2023, by the Universidad Autónoma de Chile, (Code: CC456001), Universidad Andres Bello (Code: CC21500), Universidad de Santiago de Chile Code: APC2023), Universidad de Las Americas (Code: APC2023) and Universidad Tecnológica Metropolitana (Code: APC2023).

Data Availability Statement: The analyzed dataset has been included as Supplementary Material.

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

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