



REVIEW ARTICLE

Unveiling the global nexus of organic farming in horticulture: A bibliometric insight into research trends, thematic evolution and global collaboration

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Abstract

Organic farming in horticulture has emerged as a vital component of sustainable agricultural transformation, integrating ecological principles with production efficiency and food quality. This study provides a comprehensive bibliometric analysis of global research trends, thematic evolution and collaborative networks in organic horticulture from 2001 to 2024 based on data extracted from the Scopus database. Employing R–Bibliometrix and VOSviewer, a total of 3190 publications were analysed to identify prolific authors, institutions, countries and evolving research themes. Results revealed a consistent annual growth rate of approximately 11.67 %, with major contributions from the United States, Italy, the Netherlands, Brazil and Spain. Thematic analysis identified “organic production,” “fruit quality,” and “compost” as motor themes, while “sustainability,” “agroecology,” and “soil fertility” represented foundational domains. Keyword evolution indicated a shift from input optimisation and yield studies toward holistic sustainability, biodiversity and climate-resilient systems. Collaboration networks showed strong regional clustering in Europe and North America, though global participation remains uneven. Highly cited works focused on soil ecology, nutrient cycling and quality differentiation, highlighting enduring scientific priorities. The findings underscore organic horticultures’ interdisciplinary nature and its growing role in achieving ecological balance, food safety and climate adaptation. Strengthened international collaboration, particularly across the Global South and the integration of emerging technologies are crucial for equitable and resilient organic production systems worldwide.

Keywords: bibliometric insight; horticulture; organic farming; research trends; sustainable agriculture; Sustainable Development Goals (SDGs)

Introduction

The global agricultural landscape is undergoing a major transformation toward sustainability, biodiversity conservation and efficient resource use (1). Within this movement, organic farming has emerged as one of the most promising and environmentally responsible alternatives to conventional agriculture, emphasising natural inputs, ecological processes and closed nutrient cycles (2). It aims to nurture healthy soils, encourage biological diversity and minimise dependency on synthetic agrochemicals, principles that closely align with the broader goals of sustainable development and climate resilience (3). The continuous expansion of organic agriculture globally

reflects growing consumer awareness, policy support and environmental ethics, particularly in high-value agricultural sectors such as horticulture (4). Horticulture, which includes fruits, vegetables, ornamentals, plantation crops and spices, plays a crucial role in ensuring global food and nutritional security. Beyond its contribution to diet diversity, it significantly supports agricultural gross domestic product (GDP), employment and export earnings, particularly in developing countries (5). The sectors’ inherent diversity, short production cycles and market-driven nature make it a lively platform for adopting organic principles. Organic horticulture integrates ecological processes with precision production, emphasising the use of compost, green manures, biological pest control and microbial inoculants to

maintain soil fertility and crop quality (6, 7). This synergy ensures higher value addition, better nutritional profiles and improved ecosystem services, offering both environmental and socioeconomic advantages (8).

The convergence of horticulture and organic farming also responds to consumer-driven transformation in food systems. Globally, consumers increasingly prefer organically produced fruits, vegetables and ornamentals due to concerns over pesticide residues, environmental degradation and food safety (9, 10). Consequently, the organic horticultural market has expanded rapidly, particularly in Europe, North America and Asia, reflecting changing dietary patterns and sustainability consciousness (2). Moreover, horticultural crops, due to their high perishability and value, demand efficient management of soil fertility, pest regulation and postharvest handling areas where organic research has made substantial scientific progress (7, 11). Despite its rapid growth and economic importance, research on organic horticulture remains dispersed across disciplines such as soil science, plant physiology, pest management and market economics. This interdisciplinary nature necessitates a systematic assessment of its intellectual landscape, thematic evolution and collaboration patterns. While several studies have analysed global trends in organic agriculture (12, 13), comprehensive bibliometric evaluations focusing specifically on horticultural systems are limited. Understanding how research in this field has evolved across topics like nutrient management, biological pest control, sustainability valuation and postharvest quality is essential for shaping future research and policy directions (14).

Bibliometric analysis offers a robust methodological framework to achieve this goal. It enables quantitative mapping of research outputs, intellectual structures and collaborative networks, thereby revealing thematic hotspots, emerging trends and influential actors within a research domain (15, 16). Therefore, applying this approach to organic horticulture helps identify how knowledge production has shifted over time, which countries and institutions lead global research and how collaboration networks foster innovation and sustainability-oriented practices. In this context, the present study aims to provide a comprehensive bibliometric assessment of global research on organic farming in horticulture. Using data from the Scopus database and analytical tools such as VOSviewer and Biblioshiny (an interface of the Bibliometrix R package), it investigates (1) the temporal evolution of research output; (2) the most influential authors, institutions and countries; (3) thematic clusters and keyword co-occurrences that define research frontiers; and (4) the extent and nature of international collaboration shaping this field. The insights derived from this study will contribute to a deeper understanding of the intellectual, thematic and collaborative dynamics of organic horticultural research and will support the strategic development of sustainable, climate-resilient and health-oriented agricultural systems worldwide.

Materials and Methods

Data source and retrieval

In this study, a bibliometric analysis was conducted to examine the research output in the field of organic farming of horticulture. Data was extracted from the Scopus database on 22 August 2025, which is widely recognised for its extensive coverage of peer-reviewed

literature and suitability for bibliometric and scientometric analyses (17). Scopus, managed by Elsevier, is the world's largest abstract and citation database of peer-reviewed academic literature, encompassing disciplines such as science, technology, medicine, social sciences and the arts and humanities. It currently indexes more than 22000 titles from over 5000 international publishers and provides access to over 100 million records, including 30200 active serial titles, 404000 books and 2.6 million preprints. Owing to its breadth and reliability and is widely recognised as a trusted source for bibliometric assessments (18, 19), along with its compatibility with bibliometric software such as VOSviewer and R (Bibliometrix package) (15, 20).

The search query was designed to capture all relevant publications focusing on organic farming within the horticultural sector, encompassing fruits, vegetables, ornamental plants, spices and plantation crops. The final search string used in Scopus was as follows: TITLE-ABS-KEY (("organic farming" OR "organic agriculture" OR "organic cultivation" OR "organic production" OR "organic practices") AND ("horticulture" OR "fruit" OR "vegetable" OR "floriculture" OR "ornamental plants" OR "spices" OR "plantation crops")) AND PUBYEAR > 2000 AND PUBYEAR < 2025 AND (LIMIT-TO (SUBJAREA, "ENVI") OR LIMIT-TO (SUBJAREA, "BIOC") OR LIMIT-TO (SUBJAREA, "SOCI") OR LIMIT-TO (SUBJAREA, "AGRI")) AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "cp")) TITLE-ABS-KEY refers to the search within the document title, abstract and keywords, ensuring that the selected publications are directly related to the research field of organic farming. This query targeted documents published between 2000 and 2024, including articles (ar) and conference papers (cp). Only documents published in English were considered. The search was conducted in August 2025 and the retrieved records were exported in CSV format, including bibliographic information such as authors, affiliations, titles, abstracts, keywords, citation counts and source details.

Data cleaning and refinement

After retrieving the data, a thorough review was conducted to exclude irrelevant publications, ensuring that only pertinent articles were included. Publications or articles not directly related to organic farming in horticulture, such as those focusing solely on conventional agriculture, livestock systems, or non-plant-based studies, were excluded. Additionally, incomplete records and documents with missing author or affiliation information were filtered out. This rigorous data cleaning ensured that the final dataset accurately represented research specific to organic horticultural systems. A total of 3250 articles were extracted from the Scopus database; after refinement and the removal of irrelevant or duplicate records, 3190 documents were finalised for analysis.

Analytical tools and software

The cleaned dataset was analysed using R Studio (version 4.3.1) with the Bibliometrix and Biblioshiny packages and VOSviewer (version 1.6.20) (21). R (Bibliometrix/Biblioshiny) was used for descriptive, bibliometric indicators such as publication growth trends, most productive authors, institutions, countries and sources. VOSviewer was employed to construct and visualise co-authorship, co-occurrence, citation and keyword networks, which helped identify the intellectual structure, thematic clusters and collaboration patterns within the field.

Data interpretation and visualisation

All visualisations were generated using VOSviewer and the

Biblioshiny web interface in R. The results were interpreted to understand the evolution of research themes, collaborative linkages among countries and institutions and emerging directions in organic horticultural research. Network maps were examined for node size (frequency of occurrence), link strength (collaborative intensity) and cluster density (thematic grouping). The integration of both R-based bibliometric analysis and network visualisation tools ensured robustness and reliability in interpreting the scientific landscape and thematic evolution of organic farming research in horticulture.

Results

Overview of the data

The data presented in Table 1, covering publications retrieved from Scopus, provides an overview of research activity related to organic farming in horticulture from 2001 to 2024. Over this period, a total of 3190 documents were published across 692 different sources, including journals, books and other outlets. The field has experienced a steady expansion, with an annual growth rate of 11.67 %, indicating increasing scholarly interest. The average age of the documents is about 9.75 years, suggesting that while the field has matured, much of the literature is still relatively recent. Each document, on average, has received 23.22 citations, reflecting a moderate to strong impact within the academic community. The research base is extensive, with 22239 references cited overall. In terms of terminology, the data show 8427 Keywords Plus and 13852 author-supplied keywords, highlighting the thematic diversity within this area. The research community is large, comprising 16250 authors, yet only two documents were single-authored, emphasising a high level of collaboration, with an average of 13.3 co-authors per paper. Additionally, 17.15 % of the publications involve international co-authorship, indicating notable but not dominant global collaboration. Most outputs are journal articles (2547), followed by conference papers (421), suggesting that formal scholarly dissemination is the primary mode of knowledge sharing in this research domain.

Annual scientific production

The data on annual scientific production illustrate the steady and

Table 1. Main information about the data on organic farming research in horticulture

Description	Results
Timespan	2001:2024
Sources (Journals, Books, Etc)	692
Documents	3190
Annual growth rate %	11.67
Document average age	9.75
Average citations per doc	23.22
References	22239
Keywords plus (Id)	8427
Authors' keywords (De)	13852
Authors	16250
Authors of single-authored docs	2
Single-authored docs	2
Co-authors per doc	13.3
International co-authorships %	17.15
Article	2547
Conference paper	421

significant growth of research output on organic farming in horticulture from 2001 to 2024 (Fig. 1). In the early years (2001-2005), publication numbers were relatively low, ranging between 18 and 53 articles per year, reflecting the initial stages of academic interest in this field. However, from 2006 onward, there was a marked upward trend, with publications rising from 56 in 2006 to over 100 by 2008, indicating that the topic was gaining momentum among researchers. The period between 2009 and 2016 shows a phase of consistent expansion, with article numbers increasing from 113 in 2009 to 178 in 2016, suggesting growing recognition of the importance of organic horticultural practices for sustainability and environmental health. Although a slight decline occurred in 2018 (139 articles), the following years saw renewed growth, reaching a peak in 2021 with 244 publications, the highest in the recorded timespan. This surge may correspond to heightened global awareness of sustainable agriculture, food security and climate-related challenges. After 2021, production stabilised at a high level, with 219-222 publications per year from 2022 to 2024, indicating that the field has matured and maintained strong research activity. Overall, the data demonstrate a more than tenfold increase in scientific output over two decades, highlighting the expanding global commitment to understanding and improving organic farming practices within horticulture. This upward trend

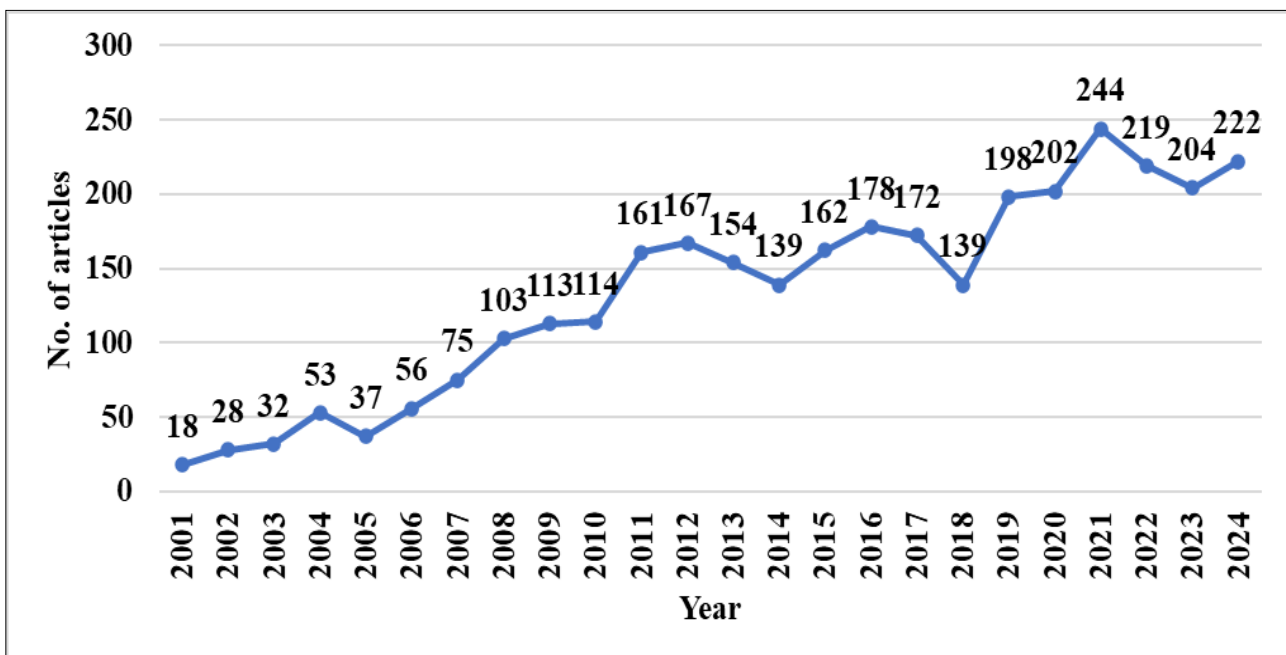


Fig. 1. Annual scientific production on organic farming research in horticulture.

underscores both the scientific and societal relevance of sustainable agricultural research.

Most relevant sources

The data on publication sources (Fig. 2) reveal the most influential journals contributing to research on organic farming in horticulture. *Acta Horticulturae* leads the field with 406 publications, underscoring its central role as a primary outlet for disseminating horticultural research. It is followed by *Scientia Horticulturae* (68 articles) and *Agronomy* (63 articles), both of which consistently publish studies connecting organic practices with crop performance and environmental sustainability. Journals such as *Renewable Agriculture and Food Systems* (62 articles) and *Sustainability (Switzerland)* (54 articles) reflect the growing interdisciplinary focus that integrates agricultural and socio-environmental dimensions. *HortScience* (53 articles) and *Biological Agriculture and Horticulture* (48 articles) contribute substantially to applied aspects of organic production, while *Food Chemistry* (50 articles) and the *Journal of Agricultural and Food Chemistry* (45 articles) highlight interest in the nutritional and biochemical quality of organically grown produce. The inclusion of *Crop Protection* (42 articles) further emphasises the importance of pest and disease management research in organic systems. Overall, the distribution pattern demonstrates that organic farming research in horticulture is interdisciplinary, drawing from horticultural science, agronomy, sustainability and food quality domains.

Sources metrics

The bibliometric indicators highlight the most influential publication sources in organic farming research within horticulture (Fig. 3). *Food Chemistry* emerges as the most impactful journal, with an h-index of 37, g-index of 50 and 2941 citations across 50 papers, reflecting its strong influence in studies linking organic cultivation to food quality and composition. The *Journal of Agricultural and Food Chemistry* follows with the highest total citations (4580), underlining its bridging role

between agricultural practices and food science. *Scientia Horticulturae* maintains a robust research profile (h-index 32; 68 publications), affirming its consistent contribution to horticultural science. Environmental and management-focused journals, including *Agriculture, Ecosystems and Environment* (h-index 24) and *Crop Protection* (h-index 22), indicate a strong representation of sustainability and pest management studies. *Renewable Agriculture and Food Systems* and *HortScience* contribute significantly to applied research on sustainable horticultural practices. The journal *Sustainability (Switzerland)*, despite its recent entry in 2014, shows a promising m-index of 1.67, suggesting rapid citation growth and emerging importance in interdisciplinary research. In contrast, *Acta Horticulturae*, though the most prolific source with 406 publications, records comparatively lower citation-based indicators (h-index 18), indicating a higher publication frequency but moderate citation impact. Collectively, these patterns depict a diverse and interdisciplinary publication landscape integrating horticultural science, environmental sustainability and food quality research.

Most relevant authors

The data on author productivity identifies the most prolific researchers contributing to organic farming research in horticulture (Fig. 4). M. Dorais leads with 24 published articles, highlighting her as a central figure in this field, likely focusing on sustainable cultivation techniques, greenhouse management and organic crop production. Following her, S Canali, with 19 articles and E. Hallmann with 18 articles, also emerge as key contributors, with research often emphasising soil fertility, organic inputs and the nutritional quality of organically grown produce. Authors such as B C Strik (17 articles) and C Ciaccia (16 articles) demonstrate significant and consistent engagement, possibly focusing on specific horticultural crops and organic management systems. Overall, the data reveal a collaborative and international research community, with several leading authors driving innovation and advancing scientific understanding of organic horticulture. The presence of multiple high

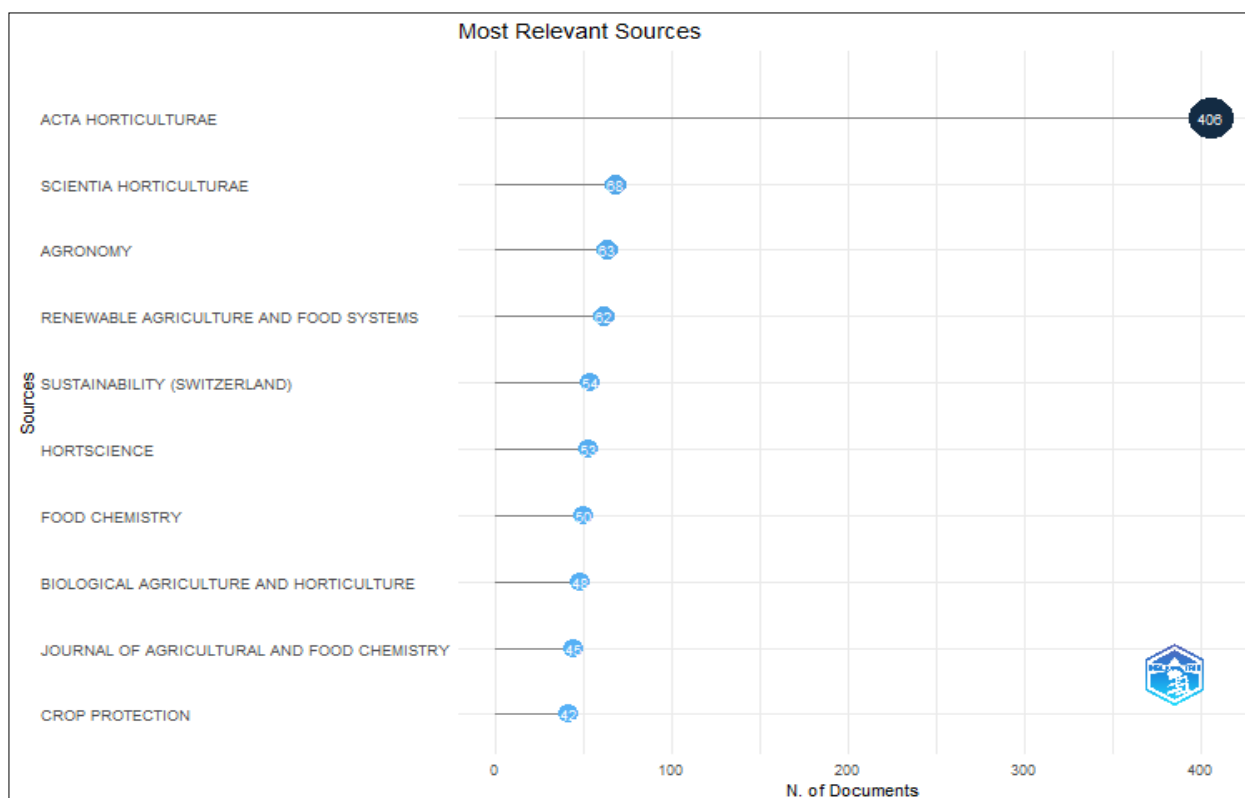


Fig. 2. Most relevant sources on organic farming research in horticulture.

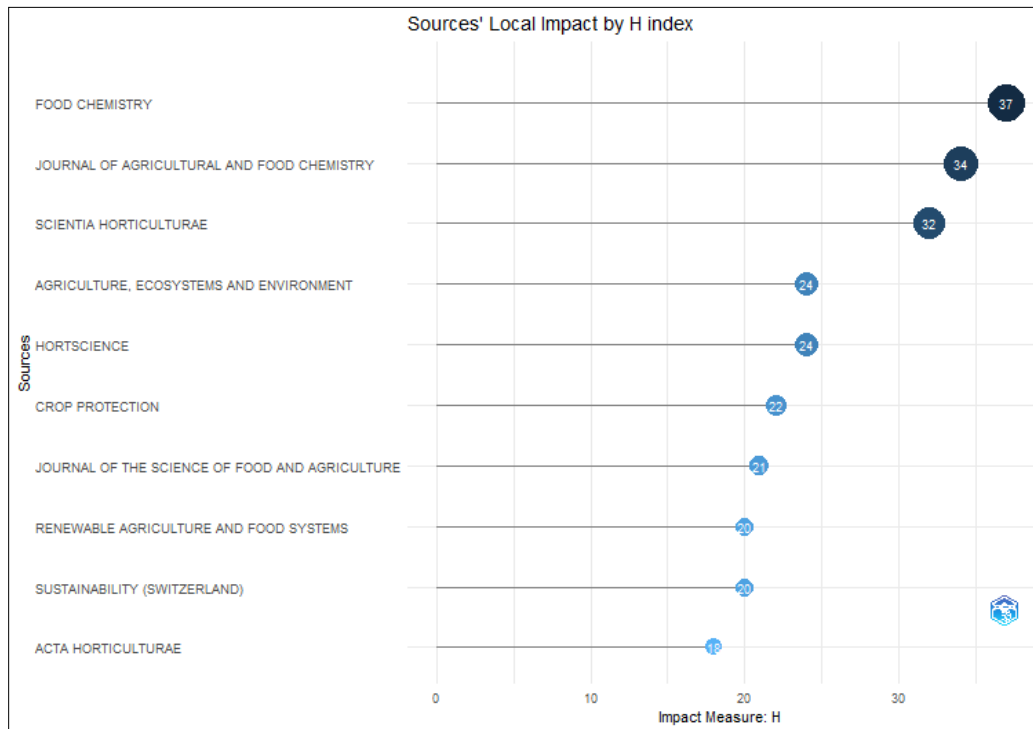


Fig. 3. Source metrics on organic farming research in horticulture.

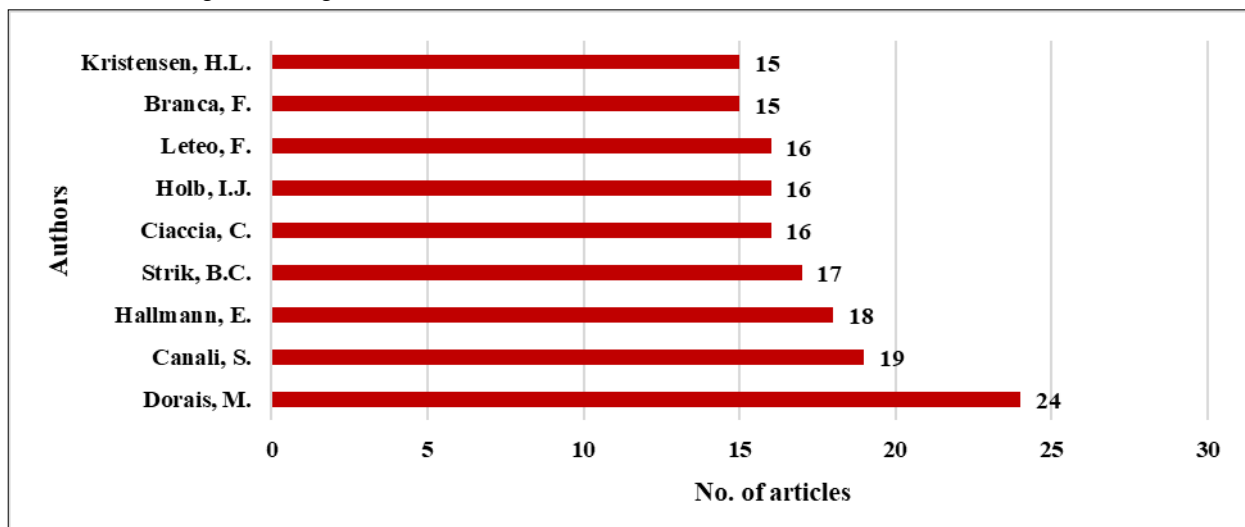


Fig. 4. Most Relevant authors on organic farming research in horticulture.

output contributors indicates that this is a mature and actively expanding research field, supported by a network of experienced specialists.

Most relevant affiliation

The data on institutional affiliations highlights the leading research organisations contributing to organic farming research in horticulture (Fig. 5). The University of California ranks first with 142 publications, confirming its global leadership in agricultural and horticultural research. Its strong focus on sustainable production systems, soil health and crop management under organic conditions positions it as a central hub for innovation and collaboration. Close behind, Italy's Consiglio per la Ricerca in Agricoltura e l'Analisi dell'Economia Agraria (CREA), Italy follows closely with 138 articles, emphasising Europe's commitment to advancing organic agriculture, particularly in Mediterranean cropping systems. Wageningen University and Research in the Netherlands, with 107 publications, is another major contributor, well known for integrating environmental, agronomic and food-system perspectives into organic horticulture. Institutions such as

Sveriges Lantbruksuniversitet (Swedish University of Agricultural Sciences) and Università degli Studi di Catania (both with 98 publications) also play crucial roles, especially in sustainable crop management and agroecological research. Overall, these affiliations demonstrate a strong global network, with North America and Europe leading, while developing regions increasingly shape the future of organic horticultural research.

Most globally cited document

Table 2 highlights the most globally cited documents in the field of organic farming research within horticulture, showcasing key contributions that have shaped the discipline. The most cited paper is by Andrews (2002) in *Agriculture, Ecosystems & Environment*, with 992 citations and a strong citation rate of 41.33 per year, emphasising its influence on soil quality assessment methods in vegetable production systems. Closely following is Di (2002), whose study on nitrate leaching in *Nutrient Cycling in Agroecosystems* has received 920 citations, reflecting the importance of nutrient management in sustainable agriculture. The work of Asami et al. (2003) in the *Journal of Agricultural and Food Chemistry*, comparing

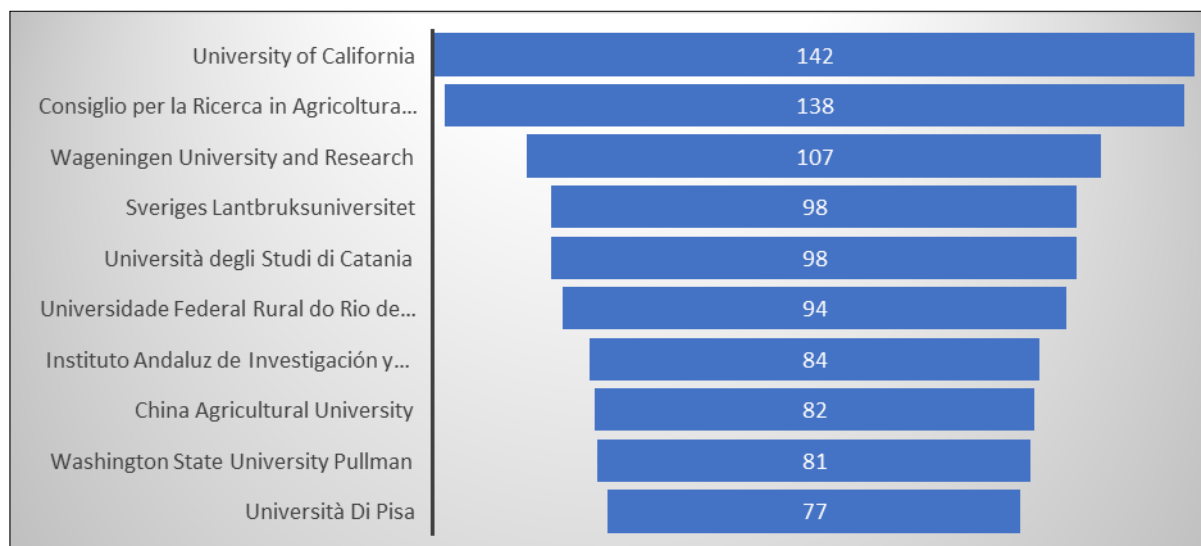


Fig. 5. Most Relevant affiliation on organic farming research in horticulture.

Table 2. Most globally cited documents on organic farming research in horticulture

Author (Year, Journal)	Article Title	DOI	Total Citations	Citations per Year	Normalised Total Citations
Andrews, S. S. (2002), <i>Agriculture, Ecosystems & Environment</i>	A comparison of soil quality indexing methods for vegetable production systems in Northern California	10.1016/S0167-8809(01)00174-8	992	41.33	7.75
Di, H. J. (2002), <i>Nutrient Cycling in Agroecosystems</i>	Nitrate leaching in temperate agroecosystems: Sources, factors and mitigating strategies	10.1023/A:1021471531188	920	38.33	7.18
Asami, D. K. (2003), <i>Journal of Agricultural and Food Chemistry</i>	Comparison of the total phenolic and ascorbic acid content of freeze-dried and air-dried marionberry, strawberry and corn grown using conventional, organic and sustainable agricultural practices	10.1021/jf020635c	848	36.86	12.91
Bowles, T. M. (2014), <i>Soil Biology and Biochemistry</i>	Soil enzyme activities, microbial communities and carbon and nitrogen availability in organic agroecosystems across an intensively managed agricultural landscape	10.1016/j.soilbio.2013.10.004	688	57.33	21.99
Bulluck, L. R. (2002), <i>Applied Soil Ecology</i>	Organic and synthetic fertility amendments influence soil microbial, physical and chemical properties on organic and conventional farms	10.1016/S0929-1393(01)00187-1	510	21.25	3.98
Aguilera, E. (2013), <i>Agriculture, Ecosystems & Environment</i>	Managing soil carbon for climate change mitigation and adaptation in Mediterranean cropping systems: A meta-analysis	10.1016/j.agee.2013.02.003	378	29.07	15.75
Brandt, K. (2001), <i>Journal of the Science of Food and Agriculture</i>	Organic agriculture: Does it enhance or reduce the nutritional value of plant foods?	10.1002/jsfa.903	372	14.88	8.82
Winfrey, R. (2008), <i>Journal of Applied Ecology</i>	Wild bee pollinators provide the majority of crop visitation across land-use gradients in New Jersey and Pennsylvania, USA	10.1111/j.1365-2664.2007.01418.x	347	19.27	11.22
Lammerts van Bueren, E. T. (2011), <i>NJAS - Wageningen Journal of Life Sciences</i>	The need to breed crop varieties suitable for organic farming, using wheat, tomato and broccoli as examples: A review	10.1016/j.njas.2010.04.001	333	22.20	11.05
Van Timmeren, S. (2013), <i>Crop Protection</i>	Control of spotted wing drosophila (<i>Drosophila suzukii</i>) by specific insecticides and by conventional and organic crop protection programs	10.1016/j.cropro.2013.08.003	322	24.76	1



Fig. 7. Tree map on organic farming research in horticulture.

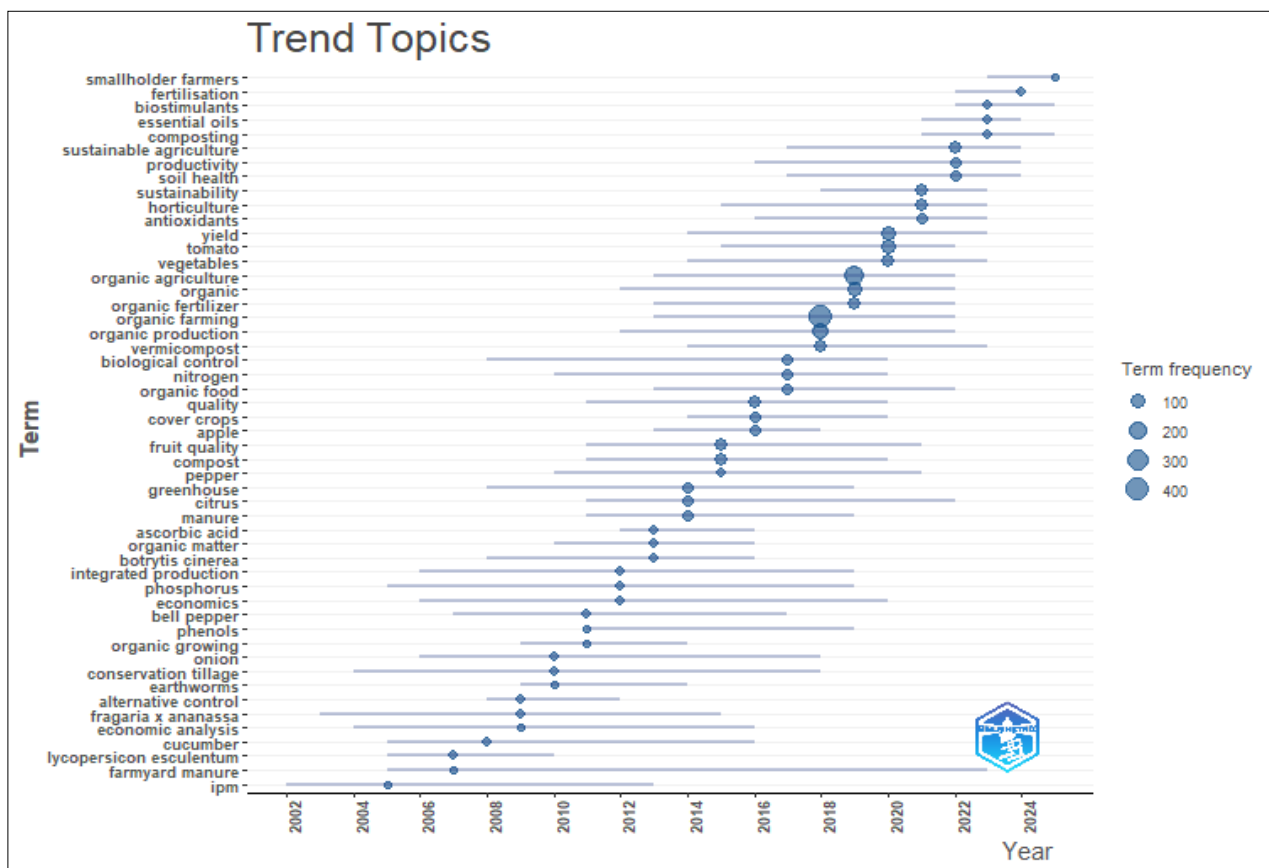


Fig. 8. Trending topics on organic farming research in horticulture.

management, highlighting the integration of productivity with sustainability goals. From 2017 onward, newer research directions have centred on sustainability (2018-2023), soil health, productivity and sustainable agriculture, demonstrating a shift toward holistic, systems-based approaches. Meanwhile, recent emerging topics such as “biostimulants” (2022-2025), “composting”, “essential oils” and “smallholder farmers” suggest a strong focus on innovative, low-impact inputs and social dimensions of organic farming. Overall, the trend data show a clear transition from technical and crop-specific

studies in earlier years to integrated sustainability and innovation-focused research in the most recent period, reflecting the fields’ maturation and global relevance.

Three field plots

The bibliometric visualisation of the three-field plot reveals that research on organic farming in horticulture is geographically diverse, encompassing contributions from multiple regions across the globe (Fig. 9). However, it is distinctly centred around Europe and North

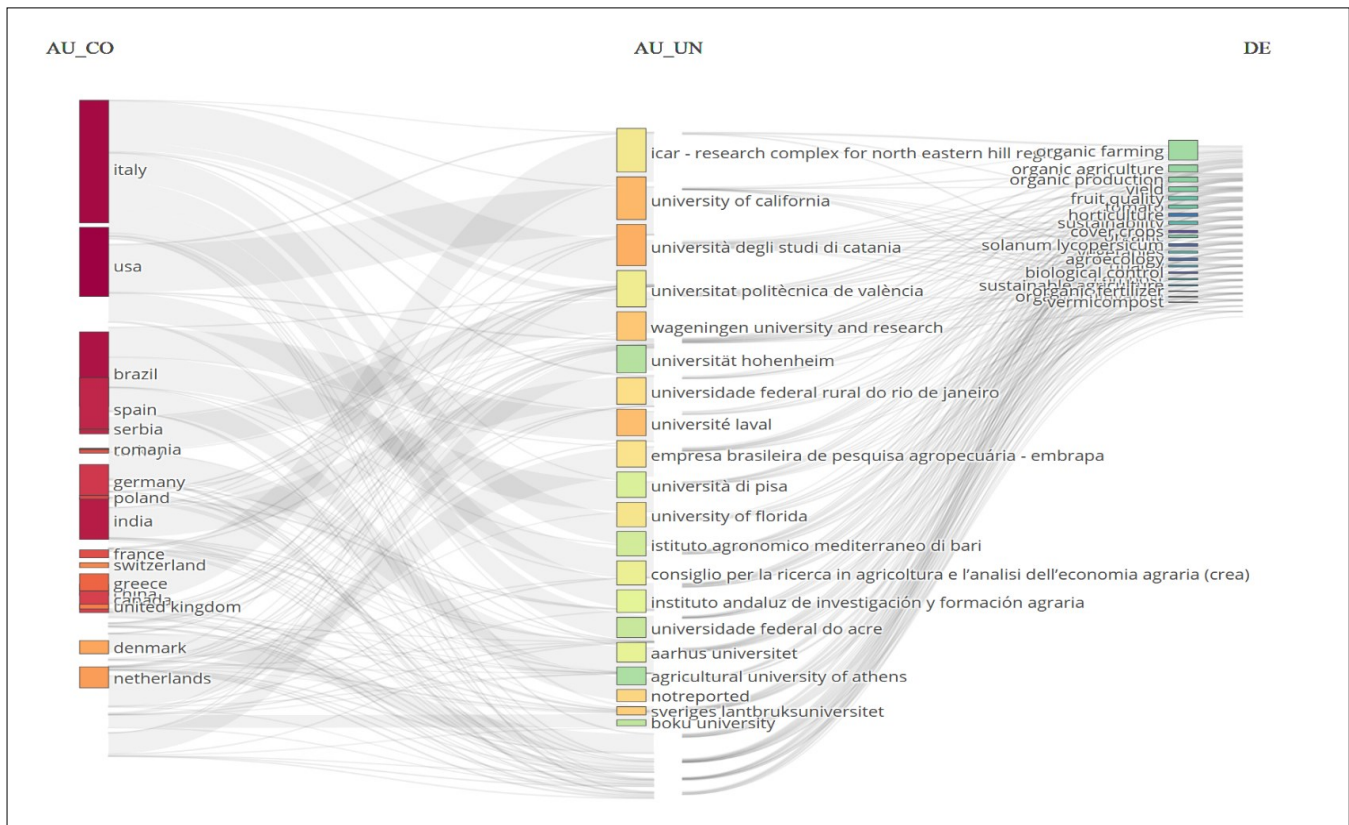


Fig. 9. Three Field Plot of organic farming research in horticulture.

America, with Italy and the United States emerging as the leading contributors, followed by Brazil, Spain, Serbia, Romania and Germany. The prominence of institutions such as the University of California, Università degli Studi di Catania, Wageningen University and Research, Universität Hohenheim, Université Laval, the University of Pisa and Embrapa reflects strong academic and policy-driven engagement in this domain. Mediterranean countries, especially Italy, demonstrate leadership due to their climatic suitability, crop diversity and established organic value chains, while the United States shows a strong emphasis on fruit quality, pest management and economic viability within high-value horticulture. Brazil's participation, led by Embrapa and federal universities, highlights growing interest in tropical and subtropical agroecological systems focused on soil fertility and biological inputs. Western and Central European institutions contribute significantly, driven by sustainability goals and agricultural policy frameworks such as the EU Green Deal and Horizon programs. The keyword dimension indicates a systems-based research approach, with frequent terms such as organic agriculture, fruit quality, horticulture, sustainable crops, biological control and vermicompost, demonstrating the dual emphasis on productivity and environmental stewardship. Dense linkages between author countries, universities and descriptors illustrate active but fragmented collaboration networks, where many institutions engage in multiple small-scale partnerships rather than a few centralised consortia. Regions such as Asia and Africa remain underrepresented, apart from isolated contributions from institutions like ICAR in India, signalling a need for broader inclusion and collaborative capacity building. Overall, the visual network underscores that research intensity aligns closely with national policies, ecological relevance and market demand and that organic horticulture is being investigated through interdisciplinary lenses integrating agronomy, environmental science and sustainable input management.

Thematic map

The thematic map (Fig. 10) of organic farming research in horticulture illustrates the conceptual and structural organisation of the fields' conceptual structure and its developmental dynamics. It categorises research themes based on two key parameters, centrality (relevance) and density (development degree), which together indicate the importance and maturity of each topic within the research network. In the Motor Themes quadrant (upper right), clusters such as organic production, yield, tomato, fruit quality and compost emerge as well-developed and highly relevant areas. These topics represent the driving forces of current research, emphasising productivity enhancement, nutrient management and post-harvest quality improvement in organic horticultural systems. The Basic Themes (lower right) include organic farming, organic agriculture, sustainable agriculture, horticulture and agroecology. These form the conceptual and methodological foundation of the field, serving as integrative frameworks that connect sustainability principles with practical organic cultivation systems. In contrast, the Niche Themes (upper left), represented by organic management, indicate specialised but less widely connected areas. These are mature yet narrowly focused domains that contribute to technical optimisation and management efficiency within organic systems. The Emerging or Declining Themes (lower left), such as biological control and biocontrol, suggest areas either in early development or losing research momentum. However, given the global shift toward ecological pest management, these topics may regain prominence through integration with sustainable and climate-resilient farming strategies. Themes like sustainability, vegetables and integrated pest management positioned near the centre indicate transitional domains bridging foundational and applied research. Overall, the map reflects a maturing discipline increasingly centred on productivity, ecological balance and sustainability. The strong positioning of "organic production" and "fruit quality" as motor

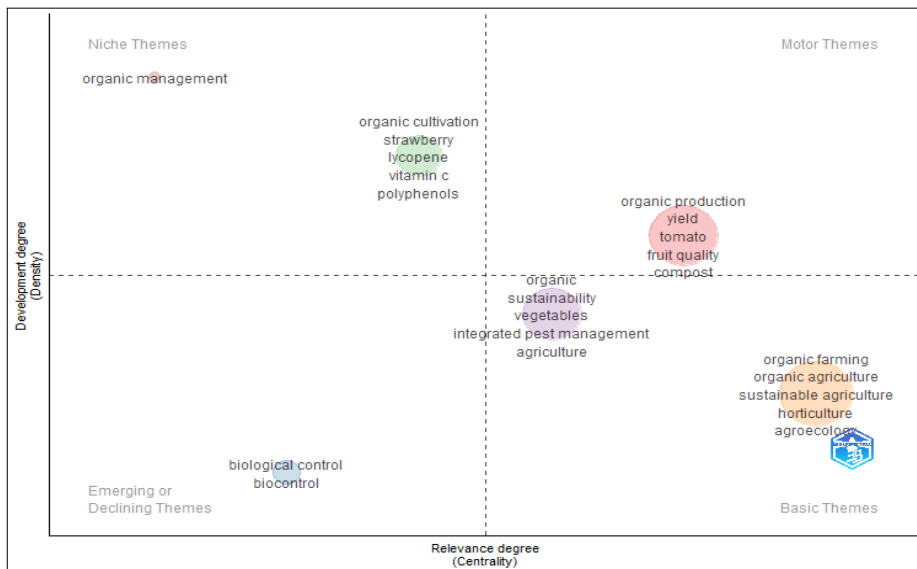


Fig. 10. Thematic map of organic farming research in horticulture.

themes underscores the sectors’ dual focus on yield optimisation and nutritional excellence, marking a sophisticated integration of economic viability with environmental stewardship in organic horticulture.

Collaboration network between authors

Fig. 11 illustrates the author collaboration network in the field of organic farming research in horticulture. Each node represents an individual author, while links indicate co-authorship relationships and clusters (different colours) represent collaborative groups or research communities. The network shows several distinct but interconnected clusters, suggesting both regional and thematic research collaborations. The largest cluster (green) centres around authors like Campanelli G, Canali S and Ciaccia C indicating a strong European collaboration focused on organic production systems and soil management. The yellow cluster led by Hallmann E and Szafrowska A reflects partnerships in organic crop quality and bioactive compound studies. The blue cluster, with Dorais M and Nguyen T T A, highlights collaborations in Canada and related institutions working on greenhouse and organic tomato production. The red and purple clusters, involving Weibel F P, Reganold J P and Granatstein D M, represent North American and European alliances emphasising sustainability and comparative organic-conventional systems. Overall, the map reveals moderate inter-cluster

connectivity, showing that while strong intra-group collaborations exist, cross-regional linkages between European and North American researchers are emerging but still limited. This visualisation underscores the multinational yet fragmented nature of research efforts in organic horticultural farming.

Collaboration network between institutions

Fig. 12 depicts the institutional collaboration network in organic farming research within horticulture. Each node represents an institution and the connecting lines indicate co-authorship or joint research projects. The clustering of institutions in different colours signifies distinct yet interconnected research communities working across regions and themes. These clusters were generated using the VOSviewers’ clustering algorithm. The largest and most central cluster (light blue) revolves around Wageningen University and Research (Netherlands), which acts as a global hub linking European, American and Asian institutions, highlighting its leadership in sustainable horticultural and organic systems research. The green cluster, including Washington State University, USDA Agricultural Research Service and Michigan State University, reflects strong North American collaboration focused on sustainable soil management and organic fruit and vegetable systems. The red cluster, with Embrapa Agrobiologia and Empresa Brasileira de Pesquisa Agropecuária (Brazil), represents Latin American efforts

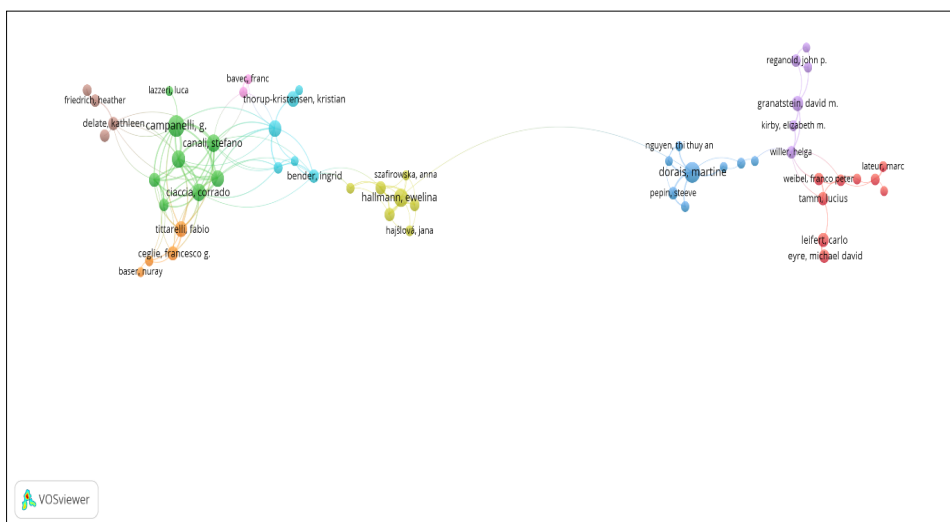


Fig. 11. Collaboration network between authors on organic farming research in horticulture.

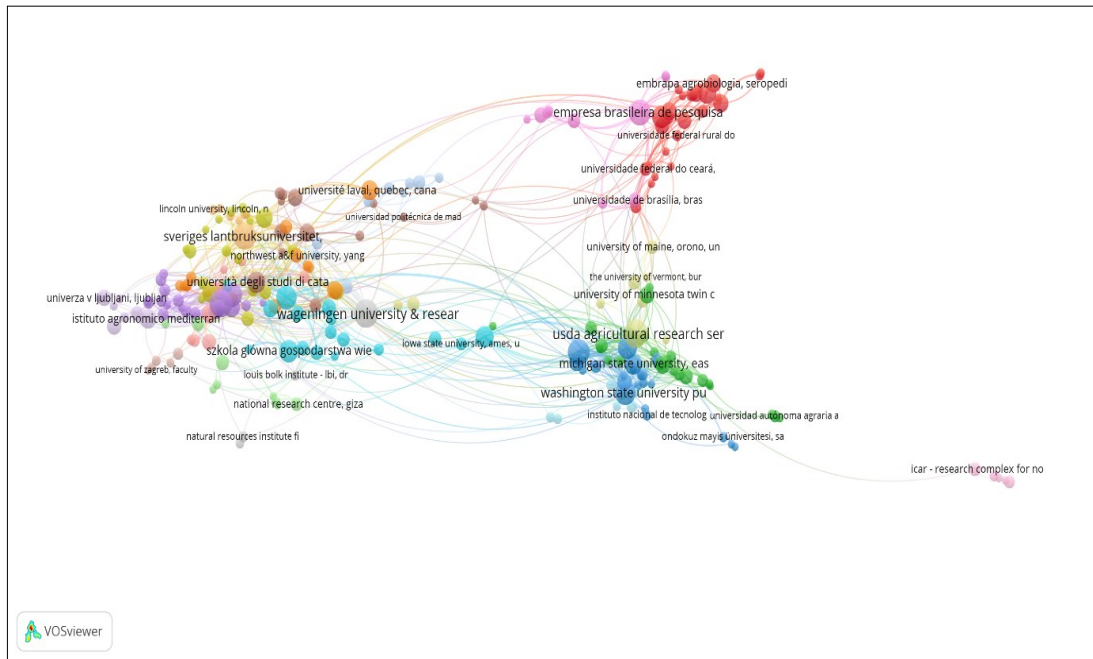


Fig. 12. Collaboration network between institutions on organic farming research in horticulture.

emphasising organic soil fertility and tropical horticultural systems. European universities such as Università degli Studi di Catania, Sveriges Lantbruksuniversitet (Sweden) form dense collaborative groups (yellow and orange clusters), indicating strong intra-continental partnerships in organic agronomy and horticultural quality studies. The purple cluster includes Mediterranean and Eastern European institutes, showing emerging participation from diverse agro-climatic zones. Overall, the visualisation reveals a globally connected but regionally intensive network, where Europe and North America lead collaboration in organic horticultural research, with growing involvement from Latin America and Asia.

Country collaboration network

Fig. 13 demonstrates the country collaboration network, a robust and well-distributed pattern of international cooperation in organic farming research related to horticulture. The United States occupies

the most central and leading position, forming strong collaborative ties with Canada, China, Spain, Germany and Italy, signifying its global leadership and influence. European countries, particularly Italy, Spain, Germany, the Netherlands and the United Kingdom, form a dense and interconnected cluster, largely driven by European Union-funded programs and long-term sustainability partnerships. India, China and Japan act as major Asian nodes, showing growing integration with North American and European research networks. The Mediterranean and Eastern European nations, such as Greece, Turkey, Slovenia and Poland, contribute actively within regional clusters, promoting research diffusion at the continental level. Connections extending to Kenya, South Africa, Bangladesh and Sri Lanka highlight the gradual inclusion of developing and emerging economies, enhancing the global diversity of research participation. The intricate web of linkages across continents reflects a change from localised studies to globally coordinated research efforts,

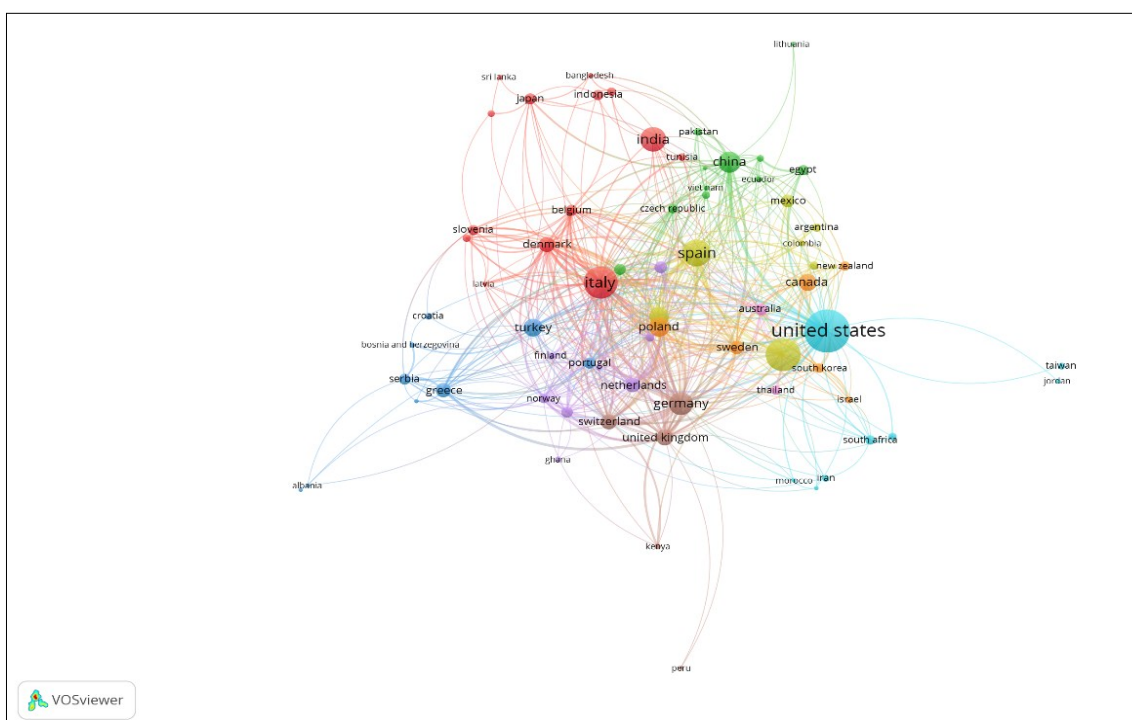


Fig. 13. Country collaboration network on organic farming research in horticulture.

emphasising the collective pursuit of ecological sustainability, resource-efficient horticulture and climate-resilient production systems. This collaborative network underscores the globalised and multidisciplinary nature of organic farming research in the horticultural domain.

Discussion

The results of this bibliometric analysis specify that research on organic farming in horticulture has evolved from a niche scientific interest into a mature, globally networked knowledge domain. The upward publication trajectory since the early 2000s reflects increasing scientific and policy attention to sustainability, food safety and ecological resilience, consistent with global agricultural transitions described by Reganold and Wachter (2). The sustained growth rate and high citation averages underscore the fields' transition from exploratory research to an established scholarly agenda. This aligns with broader patterns reported in bibliometric assessments of organic agriculture, but with a more pronounced focus on high-value horticultural crops (12, 13). The dominance of journals such as *Acta Horticulturae*, *Scientia Horticulturae* and *Agronomy* demonstrates the applied and interdisciplinary orientation of research output, while the influence of *Food Chemistry and Agriculture*, *Ecosystems and Environment* reflects the integration of soil science, postharvest physiology and environmental impact assessment. The strong performance of journals with higher *m*-index and citation density indicates that scholarship is not only increasing quantitatively but is also diffusing into adjacent domains such as nutrition, climate adaptation and environmental biotechnology. Previous research has similarly noted the interdisciplinary pull of organic systems, particularly in soil microbial ecology and sustainable intensification (8).

The authorship profile characterised by high collaboration rates, minimal single-authorship and increasing international co-publication signals a shift toward collective knowledge production. This pattern mirrors global scientific collaboration trends in agroecology and sustainable farming systems (16). The prominence of authors such as Dorais, Canali and Hallmann highlights the existence of thematic leadership clusters that influence both experimental and policy-oriented discourse. However, the dispersion of productive authors across countries indicates a polycentric research network rather than dominance by a few geographies. Institutional output patterns reflect the regional diversity of organic horticultural systems, with leadership from the United States, Italy, the Netherlands, Canada, Brazil, Spain and Germany. The concentration of active institutions such as the University of California, CREA, Wageningen University and Research and Embrapa aligns with their agricultural innovation mandates and national funding priorities. Similar trends have been noted in organic certification and sustainability transition studies in Europe and North America (7). Yet, limited participation from Africa and parts of Asia suggests persistent disparities in research investments, technology access and scientific visibility. The thematic and keyword evolution indicates a balanced progression from foundational topics such as nutrient management, compost and yield to more integrative areas like sustainability assessment, biodiversity, cover crops and circular bioeconomy approaches. The prominence of crops like tomato, strawberry, lettuce and cucurbits demonstrates a product oriented research culture driven by market relevance. The inclusion of terms

such as “climate change,” “biostimulants,” and “vermicompost” reflects emerging ecological and economic priorities consistent with global sustainability agendas (3).

Motor themes identified in the thematic map, particularly those centred on production efficiency and fruit quality, affirm that organic horticulture research is attempting to reconcile productivity constraints with quality optimisation and environmental stewardship. The persistence of agroecology, sustainable agriculture and soil health as basic themes reinforces their role as foundational concepts in research and practice (10). Meanwhile, the transitional positioning of integrated pest management, vegetables and sustainability points to ongoing conceptual and applied convergence. Sustainable agriculture also plays a key role in preserving biodiversity by creating habitats for pollinators and beneficial insects while ensuring the welfare of farm animals (22, 23). These environmental benefits are intricately linked to social well-being, highlighting the importance of healthy natural ecosystems for producing safe and nutritious food (24). Organic farming is gaining recognition not only for its environmental benefits but also for its alignment with several (SDGs), particularly SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-being), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action) and SDG 15 (Life on Land) (25). As part of the broader sustainability movement, organic farming continues to evolve and expand, offering a promising pathway toward a more resilient and ecologically responsible agricultural system. Collaboration networks across authors, institutions and countries reveal considerable regional clustering but also increasing intercontinental engagement, particularly between Europe, North America and Latin America. These linkages reflect both policy-driven research consortia and shared agronomic challenges. However, the fragmented connectivity across clusters highlights a need for stronger South-South and North-South collaboration to address localised production constraints, climate vulnerabilities and knowledge asymmetries.

The analysis of highly cited documents demonstrates that soil ecology, nutrient cycling, environmental risk mitigation and quality differentiation have served as intellectual anchors for the field. Seminal works were done to influence contemporary thinking on soil quality, nitrogen management and microbial function, showing the durability of environmental science frameworks in organic horticulture (26-28). Despite the fields' expansion, several gaps persist. Research on smallholder systems, tropical and sub-tropical horticulture, climate stress adaptation, postharvest sustainability and organic input innovation in low-income regions remains underrepresented. Additionally, emerging areas such as digital traceability, life cycle assessment, eco-certification economics and consumer perception require deeper integration with agronomic research. Addressing these gaps is essential to achieving global equity in research impact and production outcomes.

Conclusion

This bibliometric analysis highlights the growing global significance of organic farming in horticulture, marked by expanding interdisciplinary collaboration and rising research productivity. Europe and North America lead scientific output, with emerging contributions from Asia and Latin America, though regional disparities persist. Thematic evolution shows a shift from soil fertility and yield optimisation to sustainability, biodiversity and climate

resilience. Dominant journals such as *Acta Horticulturae* and *Scientia Horticulturae* reflect this multidisciplinary focus. Future research should emphasise digital innovation, bioeconomy integration and inclusive collaboration to strengthen global participation and advance organic horticultures' role in achieving the Sustainable Development Goals on food security, health and environmental sustainability.

Authors' contributions

RRT conceptualized and designed the study, provided overall guidance and contributed significantly to the bibliometric analysis, data interpretation and manuscript preparation and revision. P carried out the literature review, bibliometric analysis and drafted the manuscript. RS contributed to the research trend analysis and thematic evolution and helped with manuscript revisions. AWM assisted in the analysis of global collaboration trends and supported manuscript writing. PKJ supported data collection related to global collaboration and contributed to the manuscript drafting. AK helped with the data analysis and provided revisions to the manuscript. RA assisted with the thematic evolution analysis and contributed to statistical analysis. PM provided critical insights into the study design and manuscript revisions. PHG assisted in data interpretation and manuscript finalization. All authors read and approved the final manuscript.

Compliance with ethical standards

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