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Bibliometric Analysis on Agronomy Topics

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ABSTRACT

This study employs bibliometric analysis and network visualization techniques to explore the evolution and current trends in agronomy research over the past decade. Through a series of VOSviewer visualizations, we analyze thematic clusters, research trends over time, author collaborations, and potential research opportunities within the field. Our findings indicate a dynamic shift from foundational topics such as soil and nutrient management towards more complex issues like crop-specific adaptations and environmental stress responses. Additionally, the analysis of co-authorship networks reveals robust collaborative patterns among scholars, emphasizing both dense clusters and isolated research activities. The study also identifies emerging research areas, including sustainable pest management and the agronomic impact on food quality, highlighting gaps and opportunities for future research. This comprehensive overview not only charts the scientific landscape of agronomy but also serves as a guide for future scholarly endeavors aimed at enhancing sustainable agricultural practices.

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1. INTRODUCTION

Agronomy, the science of soil management and crop production, has evolved significantly over recent decades. This evolution is driven by the urgent need to enhance crop yields and improve agricultural sustainability in response to global challenges such as population growth, climate change, and food security concerns. Advances in technology and methodology have diversified the research topics within agronomy, ranging from genetic modification and pest management to sustainable farming practices and soil health. Consequently, a vast amount of scholarly literature has accumulated, necessitating a comprehensive synthesis to better understand the field's developmental trajectory and current focuses [1]–[5].

The practice of bibliometric analysis serves as a powerful tool to map the scientific landscape of agronomy by quantifying and analyzing the patterns in academic publications. By employing various metrics such as citation analysis, co-authorship, and keyword frequency, bibliometrics can reveal the most influential research, prevailing themes, and emerging trends. This methodological approach not only provides a structured overview of the

research activity but also highlights the relationships and networks among researchers and institutions globally [6]–[10].

However, despite the richness of research topics in agronomy, there is a noticeable gap in comprehensive bibliometric studies that encapsulate the breadth of the field. Many existing bibliometric analyses tend to focus on specific areas such as organic farming or crop biotechnology, often overlooking the interconnectedness of various agronomy sub-disciplines. This fragmented approach limits our understanding of the field's holistic scientific structure and its dynamic changes over time, underscoring the need for a broader and more inclusive bibliometric study [1], [7], [11]–[13].

The primary challenge addressed in this research is the fragmented nature of bibliometric analyses within agronomy, which often focuses narrowly on specific sub-disciplines. This specialization restricts a unified understanding of the field, hindering the identification of multidisciplinary research opportunities and the allocation of resources. There is a clear need for a comprehensive bibliometric analysis that encompasses a wide array of topics within agronomy, to better understand how these diverse research areas interact and evolve.

The objective of this research is to conduct a bibliometric analysis on a broad spectrum of agronomy topics to identify key research trends, major contributors, and pivotal publications that have shaped the field. This study aims to map the landscape of agronomy research, providing a holistic view of its development, inter-disciplinary links, and future directions. The significance of this research lies in its potential to influence future research and policy decisions within the agronomic community. By providing a comprehensive overview of the agronomy field, this study will help stakeholders identify under-researched areas and potential collaborations, thereby driving more strategic and well-informed approaches to tackling agricultural challenges. Moreover, the insights gained from this bibliometric analysis will guide educational and funding priorities to support key areas of agronomy that promise the greatest impact on food production and sustainability.

2. LITERATURE REVIEW

2.1 Evolution of Agronomy Research

Agronomy research has historically focused on optimizing crop production and soil management to meet the demands of growing populations and changing environmental conditions. Early studies often emphasized practical techniques for enhancing yield and managing pests, as seen in the foundational works of [14] and [15] during the early 20th century. As technology advanced, the scope of agronomy expanded to include genetic engineering, precision agriculture, and sustainable practices, reflecting a shift towards more holistic and scientifically sophisticated approaches. For instance, the work of [16] introduced the concept of integrated pest management, marking a significant milestone in how agronomists address crop health and productivity.

2.2 Bibliometric Studies in Agronomy

Bibliometric analyses have become increasingly prevalent as tools to assess the scientific output and evolution of various disciplines, including agronomy. A seminal paper by [17] provided one of the first comprehensive bibliometric reviews of agronomic research, highlighting key trends in publication rates and thematic evolution from the 1980s to the early 2000s. More recent studies, such as those by [1], have employed advanced metrics like co-citation and network analysis to reveal the dynamic collaborations and core topics within the field. These studies demonstrate the growing complexity and interdisciplinary nature of agronomic research, emphasizing themes such as climate resilience and biofortification [11].

2.3 Gap in Existing Bibliometric Analyses

While bibliometric analyses in agronomy are insightful, they frequently concentrate on isolated topics such as sustainable agriculture or soil science, as evidenced by the works of [1], [11], [18]. This

specialization tends to obscure the broader, integrative trends across the discipline, leaving significant gaps in our understanding of how different research areas within agronomy intersect and influence one another. For example, the connection between soil health research and crop genetics has been underexplored in existing bibliometric studies, despite their evident relevance to the overarching goals of enhancing yield and sustainability in agriculture.

2.4 The Need for Comprehensive Bibliometric Research

The existing literature underscores the need for a more comprehensive approach to bibliometric analysis in agronomy. By integrating diverse sub-disciplines, a more detailed and interconnected view of the field can be achieved, which is crucial for addressing complex global challenges. For instance, the recent review by [19] calls for broader bibliometric studies that not only track publication trends but also analyze thematic shifts and knowledge integration across the entire spectrum of agronomic research. Such holistic studies are essential for identifying emerging trends, guiding research and development efforts, and fostering collaborations that span multiple areas of expertise.

3. METHODS

3.1 Study Design

This research employs a bibliometric analysis to systematically review and quantify the scientific literature on agronomy. The analysis will cover publications spanning the last three decades, capturing the evolution and trends within the field. By utilizing comprehensive databases and employing both qualitative and quantitative bibliometric techniques, this study aims to identify key research themes, influential authors, and the dynamic networks among them.

3.2 Data Collection

Data for the bibliometric analysis will be sourced from multiple scientific databases to ensure coverage of a wide range of journals and conference proceedings. Key database which is Google Scholar. Publications will be selected based on keywords such as "agronomy", "crop production", "soil management", and other relevant terms identified during a preliminary keyword frequency analysis. The search will be refined to include papers published between 1928 and 2020 to provide a comprehensive overview of the developments in agronomy over the specified period.

3.3 Data Analysis

The collected data will be analyzed using the VOSviewer software for creating and visualizing bibliometric networks. Key analysis metrics will include:

1. Citation Analysis, to determine the most influential studies, authors, and journals within the agronomy field.
2. Co-authorship Network: To identify and visualize the collaborations between researchers, highlighting the most prolific and influential networks.
3. Keyword Co-occurrence: To assess the prevalence and evolution of research themes, facilitating the identification of emerging trends and shifts in research focus.

4. RESULTS AND DISCUSSION

4.1 Research Data Metrics

Table 1. Metrics Data of Literature

Publication years:	1928-2024
Citation years:	96 (1928-2024)
Papers:	1000
Citations:	94922
Cites/year:	988.77
Cites/paper:	94.92
Cites/author	33226.24
Papers/author	328.52
Authors/paper:	3.99
h-index:	141
g-index:	224
hI,norm:	78
hi,annual:	0.81
hA-index:	47
Papers with ACC >= 1,2,5,10,20:	
987,952,887,732,262	

Source: Publish or Perish Output, 2024

Table 1 presents a comprehensive set of bibliometric indicators derived from the

Publish or Perish database for a corpus of 1,000 papers published between 1928 and 2024. Over this 96-year span, the literature amassed a substantial 94,922 citations, averaging 988.77 citations per year and 94.92 citations per paper. This indicates a high impact of the published works in the field, as also reflected by a robust h-index of 141, suggesting that 141 papers have each received at least 141 citations. The g-index is even higher at 224, indicating that the top 224 papers have together received a minimum of 49,984 citations. The average number of citations per author is remarkably high at 33,226.24, with each author contributing to approximately 328.52 papers on average, which may indicate extensive collaborative work as there are about 3.99 authors per paper. The normalized individual h-index (hI,norm) stands at 78 and the annual h-index (hi,annual) at 0.81, which are indicators of the influence of the authors in relation to their career length. The hA-index, an adjustment of the h-index accounting for multi-authorship, is 47, highlighting significant contributions by individual authors. Moreover, a vast majority of the papers have achieved citation counts surpassing various thresholds, with 987 papers having at least one citation, and 262 papers receiving 20 or more citations, underscoring the relevance and recognition of the research within the academic community. This data provides strong evidence of the extensive influence and robust engagement within the scholarly domain addressed by the analyzed publications.

4.2 Citation Analysis

Table 2. Top Cited Literature

Citation	Authors	Title
1482	JR Acosta-Motos, MF Ortuño, A Bernal-Vicente, …	Plant responses to salt stress: adaptive mechanisms
1134	RW Brooker, AE Bennett, WF Cong, TJ Daniell, …	Improving intercropping: a synthesis of research in agronomy, plant physiology and ecology
1036	DJ Parrish, JH Fike	The biology and agronomy of switchgrass for biofuels
973	TJ Clough, LM Condron, C Kammann, C Müller	A review of biochar and soil nitrogen dynamics
772	V Saiz-Rubio, F Rovira-Más	From smart farming towards agriculture 5.0: A review on crop data management
745	M Hasanuzzaman, MHMB Bhuyan, K Nahar, …	Potassium: a vital regulator of plant responses and tolerance to abiotic stresses
722	E Bertoft	Understanding starch structure: Recent progress
668	O Husson	Redox potential (Eh) and pH as drivers of soil/plant/microorganism systems: a transdisciplinary overview pointing to integrative opportunities for agronomy
651	JD Rhoades, J Loveday	Salinity in irrigated agriculture.

634	T Doré, D Makowski, E Malézieux, …	Facing up to the paradigm of ecological intensification in agronomy: revisiting methods, concepts and knowledge

Source: Publish or Perish Output, 2024

Table 2 lists the most cited literature in agronomy as derived from the Publish or Perish database, showcasing seminal works that have significantly influenced the field. The highest cited paper, authored by JR Acosta-Motos et al., discusses adaptive mechanisms of plants to salt stress, reflecting critical research interests in plant resilience with 1,482 citations. Following closely, RW Brooker et al.'s synthesis on intercropping, bridging agronomy, plant physiology, and ecology, highlights interdisciplinary approaches within the field, with 1,134 citations. The paper by DJ Parrish and JH Fike on the biology and agronomy of switchgrass for biofuels, with 1,036 citations, underscores the growing research focus on sustainable bioenergy sources. Further, the review by TJ Clough et al. on biochar and soil nitrogen dynamics, which has garnered 973 citations, indicates significant interest in soil management strategies that enhance crop productivity while mitigating environmental impacts. The list also includes works on smart farming, the role of potassium in plant stress tolerance, and the structural analysis of starch, each reflecting diverse yet pivotal research areas within modern agronomy. This table not only highlights the varied research themes in agronomy but also points to the field's evolution towards addressing both fundamental biological processes and practical agricultural challenges.

4.3 Visualization of Network

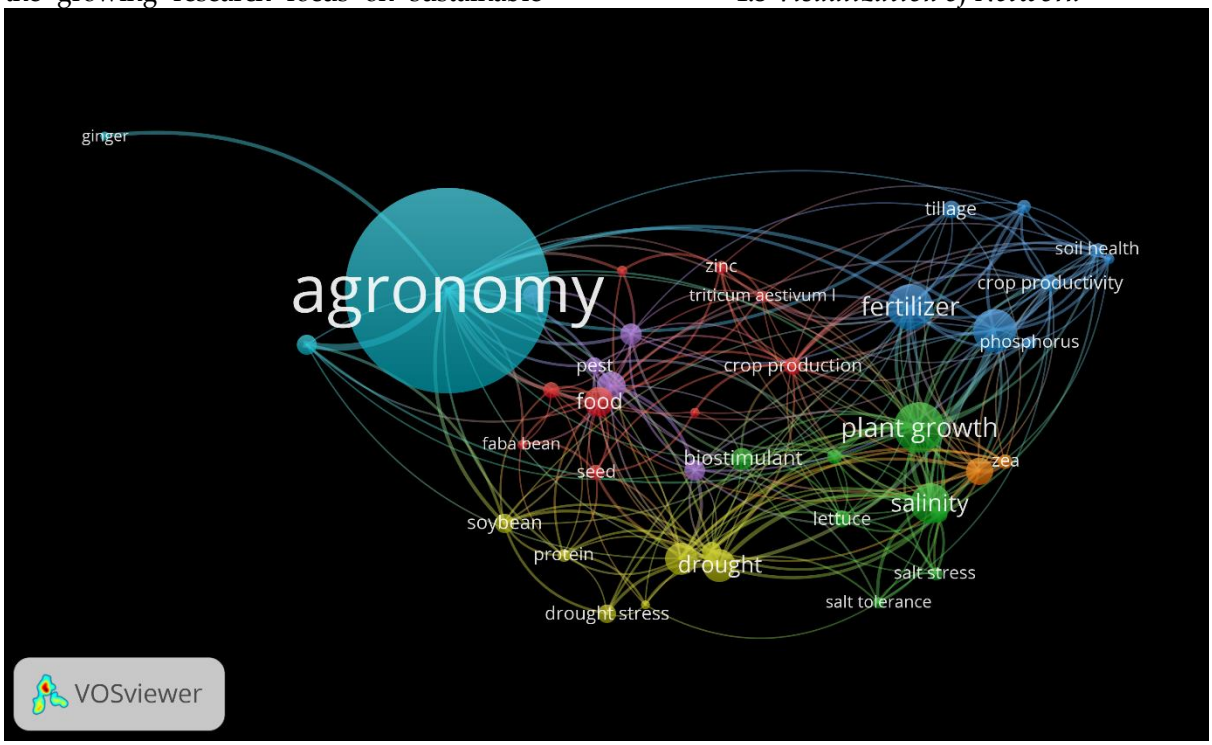

Figure 1. Network Visualization

Source: Data Analysis, 2024

This figure maps out various research themes within the field of agronomy, highlighting the relationships and thematic clusters among key topics. The term "agronomy" is central and significantly larger than others, indicating it as the overarching theme. Connected to a wide array of other nodes, it serves as the hub for the research topics in this field. Based on the figure, several term can be identified:

1. Soil and Plant Nutrition Cluster (Blue)

This cluster includes terms like "fertilizer," "soil health," "phosphorus," and

"crop productivity." It focuses on the aspects of soil management and the role of different nutrients in crop production. This is crucial for understanding how nutrient management affects yield and the sustainability of agricultural practices.

2. Plant Physiology and Stress Response Cluster (Yellow)

Featuring terms such as "drought," "salinity," "drought stress," and "salt stress," this cluster deals with plant responses to environmental stresses. Research in this area is vital for developing crops that are resilient to changing climate conditions and harsh environments.

3. Crop Types and Specific Studies Cluster (Green)

This includes specific crops like "soybean," "lettuce," and "faba bean," and focuses on the agronomic practices tailored to these crops. It also includes "protein," suggesting a focus on the nutritional aspects of these crops.

4. Agronomic Practices and Techniques Cluster (Red)

Terms like "tillage," "crop production," and "plant growth" indicate a cluster focused on agricultural methods and practices. This area explores different cultivation techniques and their impacts on crop growth and productivity.

5. Emerging Technologies and Approaches Cluster (Orange)

With terms like "biostimulant" and "smart farming," this cluster points to newer and innovative approaches in agronomy. These might involve cutting-edge technologies or biologically-based methods to enhance crop resilience and productivity.

4.4 Overlay Visualization

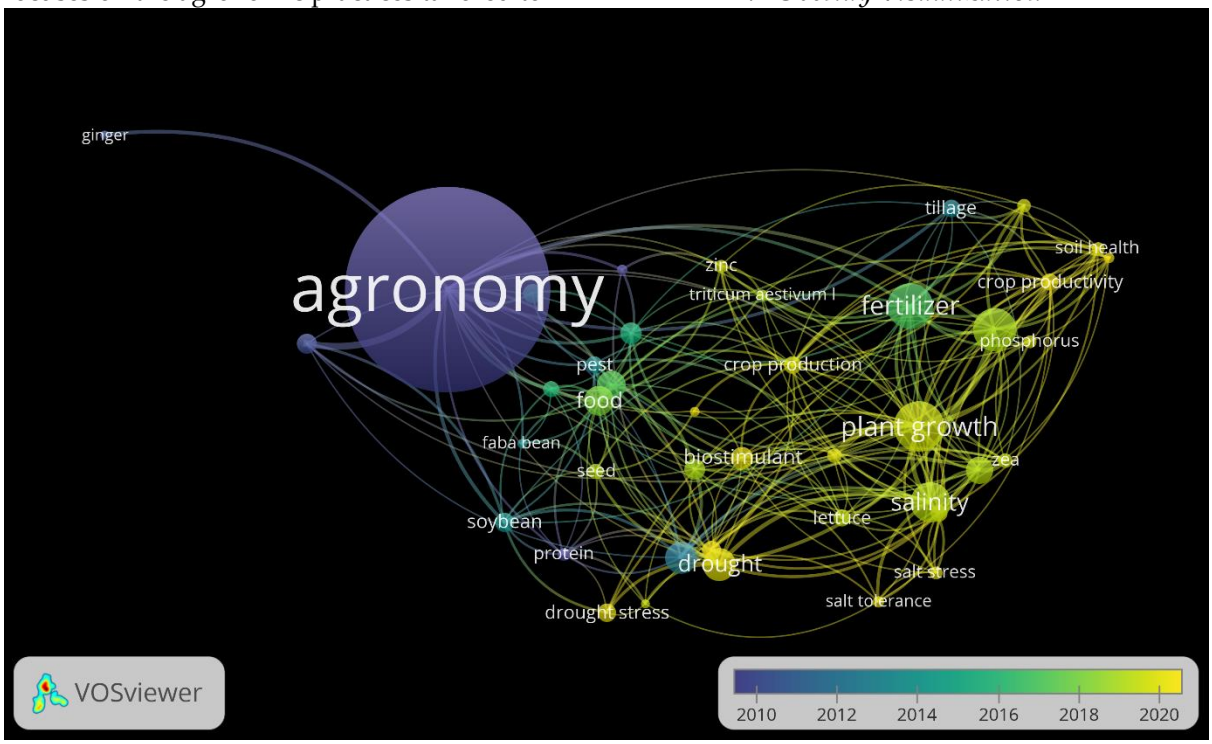

Figure 2. Overlay Visualization
Source: Data Analysis, 2024

This second figure includes a timeline (ranging from 2010 to 2020), provides insights into the temporal trends and shifts in the focus of agronomy research over the decade. The color gradient from blue to yellow on the network nodes represents the progression from earlier to more recent research focus, with blue indicating topics that were prominent around 2010 and yellow representing those more prevalent towards 2020.

1. Early 2010s Focus (Blue Nodes)

The early part of the decade emphasized foundational agronomic practices and basic plant responses. Nodes like "fertilizer" and "soil health" are shown in

darker tones, suggesting that initial research focused heavily on optimizing soil management and nutrient application as a response to the increasing need for sustainable crop production.

2. Mid-decade Transition (Green Nodes)

Around the mid-2010s, there appears to be a shift towards specific crop types and more nuanced agronomic challenges. Terms like "triticum aestivum" (wheat), "soybean," and "faba bean" indicate a growing research interest in particular crops, which may reflect concerns over food security and the adaptation of crops to specific regional climates and soils.

3. Late 2010s and Early 2020s Trends (Yellow Nodes)

In the later years, the emphasis seems to shift towards stress responses and advanced agronomic techniques. This is visible in the prevalence of terms like "drought," "salinity," "biostimulant," and "plant growth." The increasing focus on "drought stress" and "salt tolerance" suggests that research has pivoted towards developing crop varieties and farming practices that can withstand adverse climate conditions, likely driven by global climate change impacts.

Additionally, the emergence of terms such as "biostimulant" indicates a surge in exploring novel products and technologies that enhance plant growth and stress resistance, marking a move towards more technologically advanced and biologically integrated farming solutions.

Throughout the decade, some topics remain continuously relevant, such as "crop production" and "plant growth." This ongoing focus underscores the persistent core objectives of agronomy: enhancing productivity and optimizing plant development.

4.5 Density Visualization

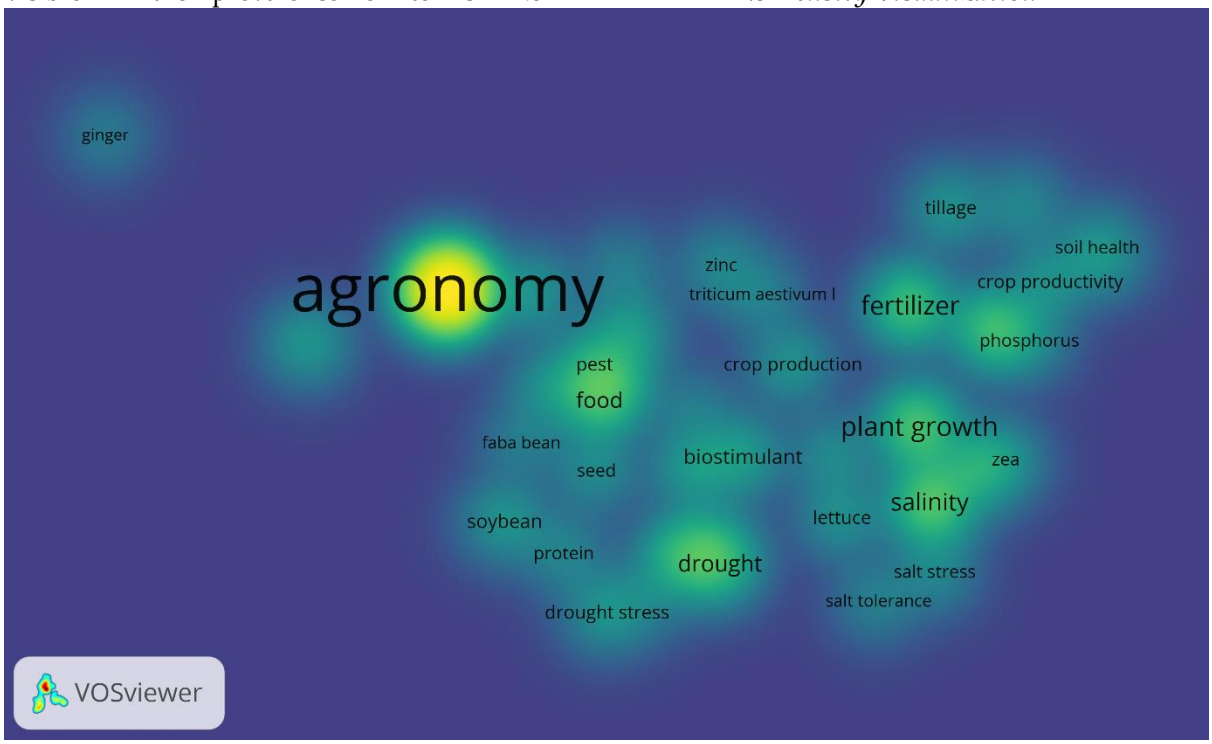

Figure 3. Density Visualization
Source: Data Analysis, 2024

This third visualization also presents a bibliometric network analysis, focusing on the connectivity and intensity of research topics within agronomy. The color gradient from blue to green to yellow illustrates the degree of focus or intensity on specific topics, with the brightest areas (yellow) indicating the most frequently discussed or currently active areas, and the darker areas (blue) potentially highlighting less discussed or emerging topics.

The bright areas like "plant growth," "fertilizer," "salinity," and "drought" indicate these topics are currently hotspots of research in agronomy. They likely represent well-established fields with substantial ongoing research activities focusing on improving crop resistance to environmental stresses and enhancing soil and plant health.

The darker blue areas, such as around "ginger," "pest," and "food," suggest these are less intensely discussed in the current corpus of agronomy research analyzed. These topics might represent emerging or niche areas that could benefit from increased research attention:

1. Ginger: This indicates a potential for increased research into specific crops that may not have been as heavily studied as others. Research could focus on optimizing ginger cultivation, understanding its unique pest management needs, or exploring its medicinal and nutritional properties.
2. Pest: While pest management is a critical aspect of agronomy, the darker shading around this term suggests there might be room for novel research approaches, possibly integrating more sustainable, biocontrol methods, or exploring the impacts of climate change on pest dynamics.
3. Food: This could indicate a broader, less-explored area concerning the impact of agronomic practices on food quality and safety. Future research could delve into how agricultural techniques influence nutritional outcomes or explore new food security strategies in the face of global supply challenges.

4.6 Author Collaboration Network

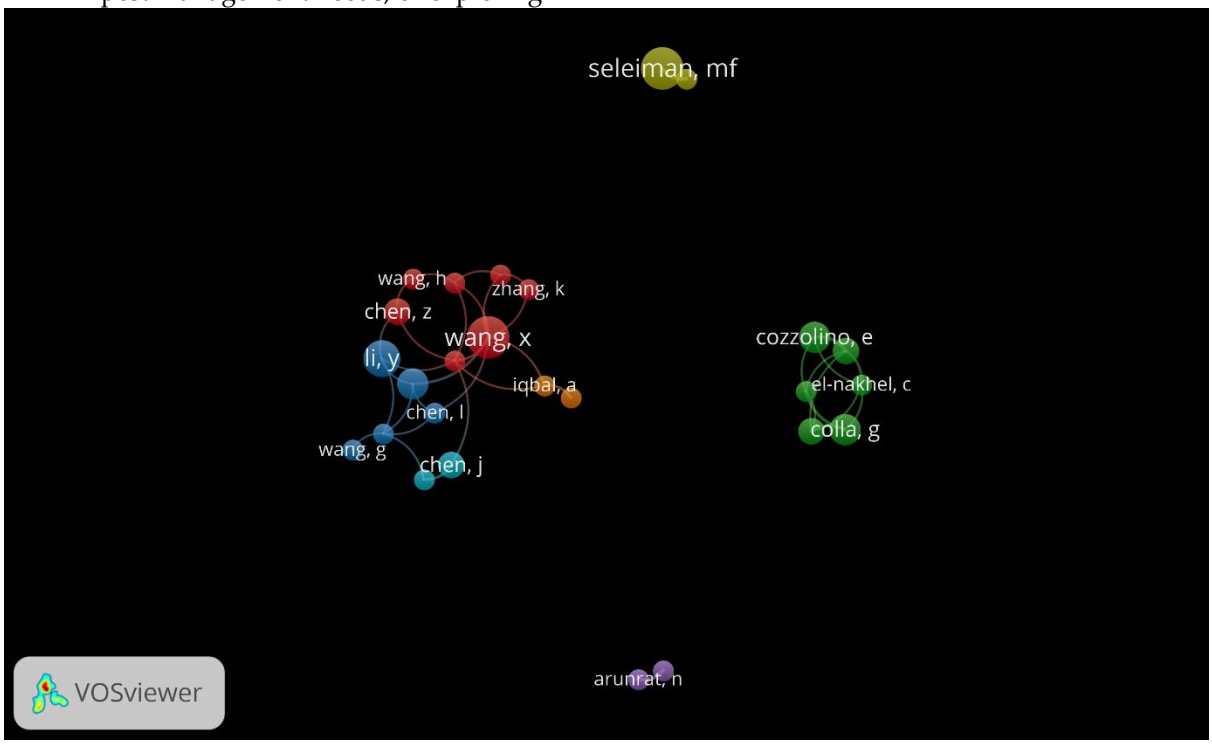

Figure 4. Author Collaboration Network
Source: Data Analysis, 2024

This VOSviewer visualization showcases a co-authorship network within a field likely related to agronomy, illustrating various clusters of researchers according to their collaborative and thematic associations. The blue cluster, featuring authors such as "chen, j", "li, y", "wang, g", and "chen, l", suggests a focus possibly on basic plant sciences or specific crops, indicated by their close connections. The red cluster, centrally located and including "wang, x", "zhang, k", and "iqbal, a", likely represents a more

specialized area within agronomy, perhaps focusing on applied techniques or agricultural innovations. To the right, the distinct green cluster with "cozzolino, e", "colla, g", and "el-nakhel, c" might be concentrating on unique research areas such as sustainable practices or soil health, as shown by their separation from other groups. Additionally, isolated nodes like "seleiman, mf" and "arunrat, n" suggest these authors might work in highly specialized or emerging areas, or have fewer collaborations within the studied dataset. This network visualization thus provides a clear depiction of the collaborative landscape and possible research domains within agronomy, highlighting both group dynamics and individual contributions.

4. CONCLUSION

The series of VOSviewer visualizations provide a multifaceted overview of the current state and evolution of research in agronomy. Initially, the thematic cluster analysis revealed diverse research areas encompassing soil and plant nutrition, stress responses, specific crop studies, and advanced agronomic practices, indicating a wide range of focal points within the field. Subsequent analysis of research trends over the years showed a notable shift from basic soil and nutrient management to addressing more complex challenges such as crop-specific adaptations and responses to environmental stresses, highlighting the field's progression towards sustainability and resilience in farming practices. The co-authorship network further elucidated the collaborative dynamics among researchers, revealing distinct clusters that suggest both intense collaborations within certain domains and unique, specialized research efforts by individual scholars. Lastly, the analysis of less brightly highlighted areas in thematic maps pointed out potential research opportunities in emerging or less-explored topics such as specific crop studies like ginger, sustainable pest management, and the broader impacts of agronomic practices on food quality. Together, these insights underscore a vibrant, evolving field with ongoing collaborative efforts driving innovation and addressing both foundational and emergent challenges in agronomy. This comprehensive view not only reflects the current scientific landscape but also suggests pathways for future research and development in agronomy, fostering a deeper understanding and enhanced practices for sustainable agriculture.

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