International Journal for Applied Information Management
Vol. 3, No. 3, September 2023, pp. 125-133

Examination of the Global Plant Factory's National Competitiveness via Artificial Intelligence-Driven Research Analysis

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(Received: June 25, 2023; Revised: July 15, 2023; Accepted: August 31, 2023; Available online: September 10, 2023)

Abstract

The plant factory is an advanced stage of the development of modern facility agriculture. It integrates biotechnology, engineering technology and system management to free agricultural production from the constraints of natural ecology and other objective conditions. A factory agricultural system that produces production according to human plans. Plant factories are one of the most dynamic and potential fields in the process of absorbing and applying high-tech achievements in the process of agricultural industrialization, and have attracted more and more attention from countries. This paper uses the SCI-EXPANDED database of Web of Science as the data source, adopts bibliometric methods, and focuses on the analysis of the competitiveness of various countries in the field of plant factory research in the world, providing information support and data reference for related.

Keywords: Plant Industrialization, Situation Analysis, National Competitiveness

1. Introduction

Amidst the constantly evolving landscape of agriculture, the concept and realization of plant factories have emerged as a groundbreaking and transformative solution to the challenges of modern food production. These plant factories, characterized by their integration of cutting-edge technologies and precision-controlled environments, represent a significant stride towards achieving sustainable and efficient agricultural systems. Leveraging advanced computer systems, these facilities meticulously manage crucial environmental parameters, including temperature, humidity, light exposure, CO2 concentration, and nutrient composition. This orchestration of conditions aims to attain an unparalleled level of precision, fostering an agricultural paradigm wherein crops are produced continuously and in harmony with human-defined parameters [1-3]. The plant factory concept can be perceived as an advanced evolution within the continuum of facility-based farming practices [4-6].

At the heart of the plant factory's innovation lies its amalgamation of biotechnology, engineering acumen, and systematic management strategies. This unique convergence offers a remarkable departure from conventional agricultural practices, liberating crop cultivation from the constraints imposed by natural ecosystems and external factors [7,8]. By harnessing the capabilities of biotechnology, plant factories push the boundaries of traditional crop breeding and cultivation. Through meticulous environmental control, they create a realm where crops can be nurtured and harvested irrespective of seasonal variations or geographical limitations. This paradigm shift in agricultural production underscores the plant factory's dynamic potential to assimilate and apply state-of-the-art technological achievements. As such, it emerges as a beacon in the trajectory of agricultural industrialization, embodying the future of agricultural development and high-tech integration [9-11].

In the current landscape of plant factory research, a compelling research gap beckons further exploration. While the potential and promise of plant factories are evident, critical questions remain regarding their optimal implementation, scalability, and adaptability across diverse agro-ecological contexts. Understanding how these innovative systems interface with local environments, economies, and social structures is essential for their successful integration into

global agricultural practices. Moreover, the harmonization of advanced technologies with traditional agricultural wisdom is a challenge that necessitates careful consideration.

The state of the art in plant factory research showcases a dynamic interplay between academic investigations and practical applications. Researchers have made significant strides in elucidating the molecular and physiological mechanisms that govern plant responses to controlled environments. This knowledge serves as the bedrock for optimizing growth parameters and enhancing crop yield and quality. The integration of data-driven approaches, such as artificial intelligence and machine learning, has further bolstered the efficiency and predictive capabilities of plant factories.

However, as the plant factory concept evolves, a comprehensive understanding of the diverse factors influencing its implementation is still emerging. The intricate dance between technology, ecology, and economics necessitates an interdisciplinary approach that draws from agronomy, engineering, environmental science, economics, and sociology. Moreover, the dynamic nature of plant factories requires adaptable regulatory frameworks to ensure safety, sustainability, and equitable access.

Plant factories represent a nexus of scientific ingenuity, technological advancement, and agricultural innovation. As research advances, bridging the identified research gaps and refining the state of the art will be paramount. This journey requires a collaborative effort that transcends disciplinary boundaries, connecting researchers, policymakers, and practitioners in a concerted push towards a sustainable and technologically empowered future of agriculture.

2. Research Methodology

2.1. Data Acquisition

This research takes plant factories as the research object. Through extensive study of relevant documents such as papers and monographs in the field of plant factories, the relevant keywords in the field of plant factory research are sorted out, and the SCI-EXPANDED database of Web of Science is used as the research data source [12,13]. The limited time range of the search is from 1961 to 2021, and the search date is February 15, 2021. A total of 9,429 documents were obtained. After manual screening, 1,332 documents were determined as the final research data set.

2.2. Overview of Global Publications

Global research in the field of plant factories began in 1961, and related research has gradually increased since 2021. It can be roughly divided into three stages of development so far, and it has reached a stage of rapid growth, as shown in Figure 1.

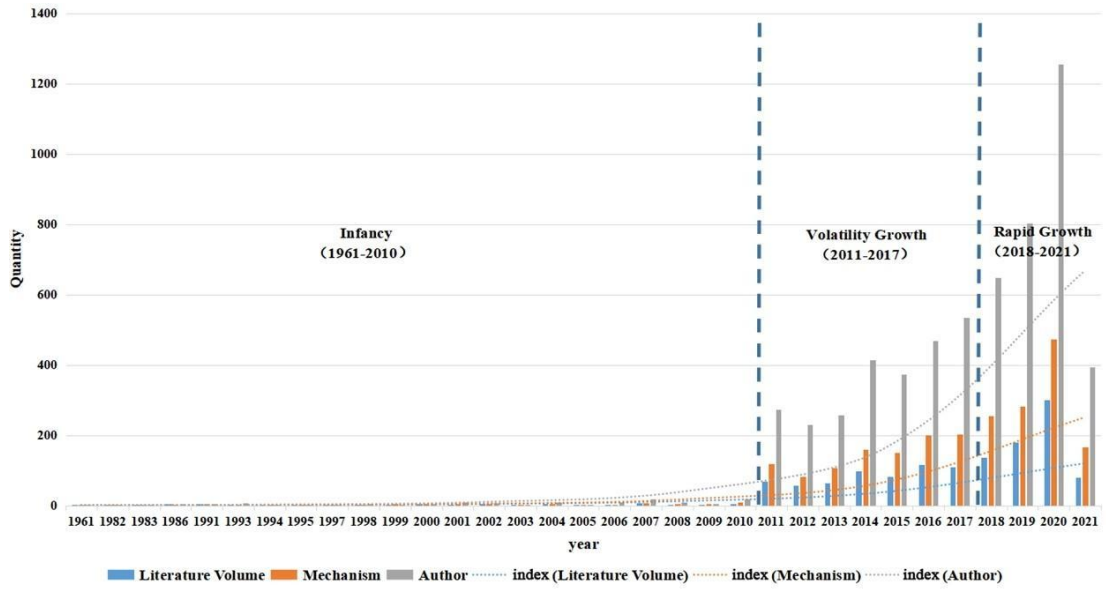

Figure 1. Annual distribution of global publication volume, number of authors, and number of institutions

1) The first stage: the budding period (1961 to 2010).

   From 1961 to 2010, the total number of documents in the field of global plant factories was 45, an average of 2 per year. During this period, there were few research results and a relatively stable state. Research in the field of plant factories began to sprout and began to develop slowly.

2) The second stage: period of volatile growth (2011 to 2017).

   From 2011 to 2017, the total number of documents in the field of global plant factories was 592, an average of 84 articles per year. During this period, the research in the field of plant factories gradually attracted attention, and the research results showed an obvious growth state, which laid a good foundation for the subsequent rapid development.

3) The third stage: a period of rapid growth (2018 to 2021).

   From 2018 to 2021, the total number of documents in the field of global plant factories was 695, an average of 174 per year. During this period, the research in the field of plant factories has received attention, and the research results are in a state of rapid growth, but there is still room for growth before the research mature stage.

3. Research Discussion

3.1. Analysis of The Amount of Papers Issued By Various Countries

From the distribution map of the number of articles issued by countries in the field of plant factories, the distribution of the amount of articles issued in the field of plant factories can be intuitively reflected [14-16]. As shown in Figure 2, research papers in the field of global plant factories are distributed in 75 countries, mainly in Asia, Europe, and Europe. North America, Africa and other regions. Among them, China, the United States, South Korea and Japan are important producers in the field of plant factories. China ranked first with 211 posts, ahead of other countries; the United States ranked second with 174 posts; South Korea ranked third with 156 posts; Japan with 128 posts. It is closely followed by fourth. The top four countries posted 39.91% of the total global postings, and the top ten countries posted 60.79% of the total global postings. It can be seen that the field of plant factories is very concentrated in global research.

ISSN 2776-8007

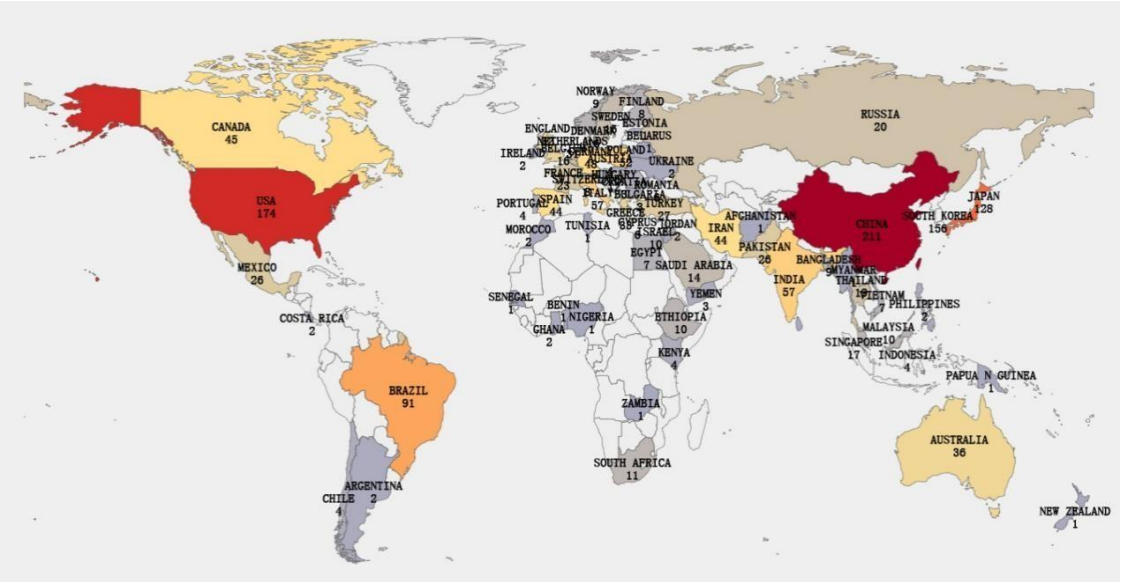

Figure 2. Distribution of the number of posts issued by various countries

3.2. Analysis of The Influence of Countries

In the field of global plant factories, relevant research documents from 67 countries have been cited, mainly in Asia, Europe, Oceania, North America, South America and other regions, as shown in Figure 3. Among them, China, the United States, South Korea and other countries have high influence in the field of plant factories and much higher than other countries. China ranked first with 1,887 total citations and 1,301 first/corresponding author total citations; the United States ranked first with 1,550 total citations and 1,222 first/corresponding author total citations. Second; South Korea ranks third with 1,245 citations and 1,022 first/corresponding author citations. The total citation frequency of the top three countries and the total citation frequency of the first/corresponding author are much higher than those of other countries. It can be seen that the research results of China, the United States and South Korea in the field of plant factories have a high degree of influence.

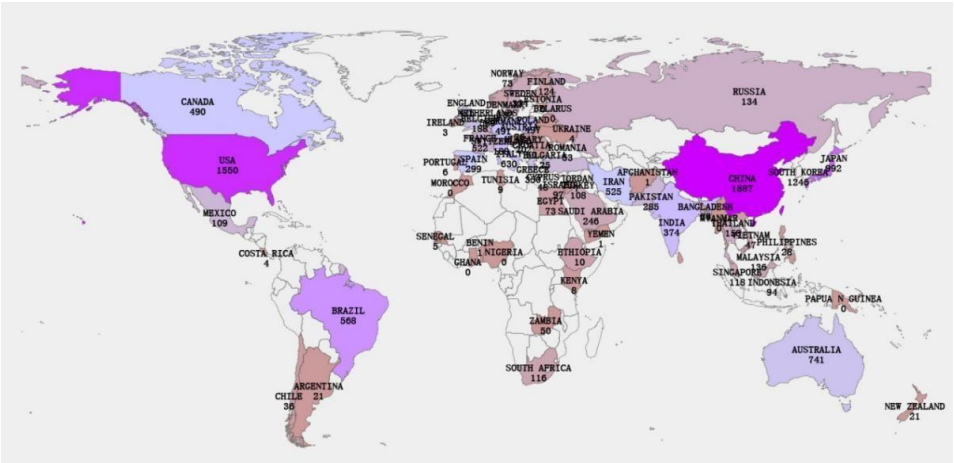

Figure 3. Distribution map of the influence of various countries

3.3. Quality Analysis of Papers in Various Countries

In this study, 18 countries that have published more than 20 papers in the field of plant factories and have a total citation frequency of more than 200 are the research objects of high-competitive countries. Their papers are all cited in frequency and the first/corresponding author is cited. The frequency was statistically analyzed (Figure 4).

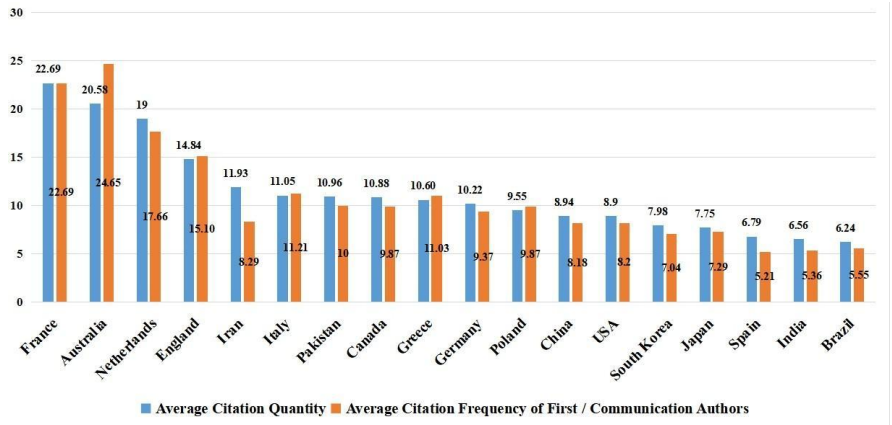

Figure 4. Comparison of the citation frequency of various articles in highly competitive countries

1) The quality of papers in highly competitive countries is quite different. Among the TOP18 highly competitive countries, the citations of the papers and the first/corresponding author are 22.69 and 22.69, respectively, and the lowest are 6.24 and 5.55 respectively. It can be seen that there is a clear gap in the quality of individual achievements in high-competitive countries.

2) The quality of the papers in the field of plant factories in France, Australia, the Netherlands and other countries is very high, and far surpasses other countries. Among them, French articles are ranked first in terms of citation frequency and the first/corresponding author's citation frequency, both are 22.69 times. Both the overall paper quality in the field of plant factories and the first/corresponding author paper quality are both The highest; Australia ranks second with 20.58 citations and 24.65 citations for the first/corresponding author. In addition, the Netherlands and the United Kingdom are both cited and the first/corresponding author. The citation frequency is also higher than 16 times. It can be seen that the quality of papers in France, Australia, the Netherlands, and the United Kingdom is relatively high.

3.4. Analysis of The Posting Trends of Countries

This study takes 16 countries that have published more than 30 articles in the field of plant factories as the research objects, and compares and analyzes their publication situation (Figure 5).

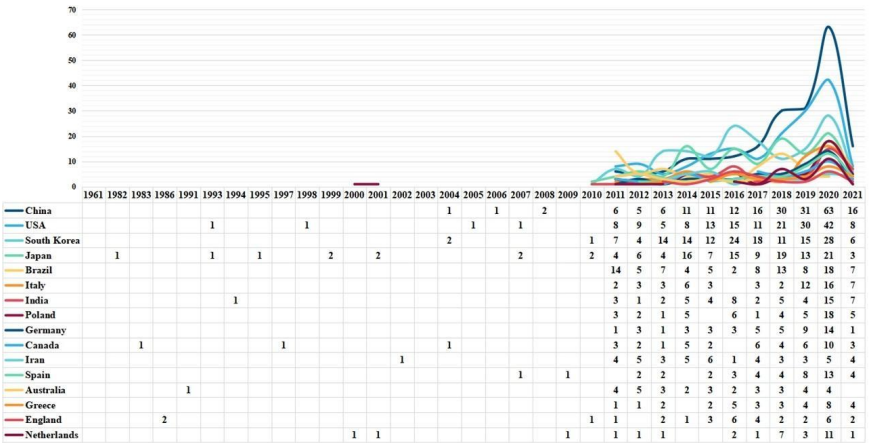

Figure 5. Distribution of papers in high-productivity countries

1) The start time of research in the field of plant factories varies greatly among countries, with Japan, Canada, and the United Kingdom starting earlier.

   Japan began research in the field of plant factories in 1982, the earliest start; Canada began research in the field of plant factories in 1983, the United Kingdom began research in the field of plant factories in 1986, Australia and the United States began in the field of plant factories in 1991 and 1993, respectively The research started relatively early; India started research in the field of plant factories in 1994, the Netherlands and Iran started research in the field of plant factories in 2000 and 2002 respectively, China and South Korea started research in the field of plant factories in 2004, and Spain Research in the field of plant factories started in 2007. Brazil, Italy, Poland, Germany and Greece only started research in the field of plant factories in 2011, and started late.

2) The duration of research in the field of plant factories varies from country to country, and the duration of related research in Japan and Canada is the longest.

   Japan has conducted intermittent research in the field of plant factories for 40 years since 1982. Canada, the United Kingdom, Australia, the United States, and India began to study the field of plant factories in 1983, 1986, 1991, 1993, and 1994, respectively. Continuous research has been conducted for 28-40 years; the duration of research in the field of plant factories in other countries is less than 25 years.

3) The output of papers in the field of plant factories in most countries has shown a fluctuating growth trend. In recent years, China has the highest number of papers published in the world.

   In recent years, the output of research papers in the field of plant factories in China, the United States, Japan, South Korea, Brazil and other countries has shown a fluctuating growth trend, while the output of research papers in the field of plant factories in the United Kingdom, Iran and other countries has shown a fluctuating downward trend. Among them, China's number of documents issued in the field of plant factories has been ranking first in the world since 2018, and the total number of documents issued is also ranked first [17-20]. In addition, the United States, South Korea, and Japan have issued more than 100 articles each year, and they are gaining momentum.

3.5. Analysis of Cooperation Between Countries

In this study, 75 countries in the field of plant factories were used as the research object, and the frequency of national cooperation was used as an indicator to construct a matrix of national cooperation relations [21]. Based on this matrix, the cooperation network between various countries was constructed with VOSviewer software (Figure 6).

ISSN 2776-8007

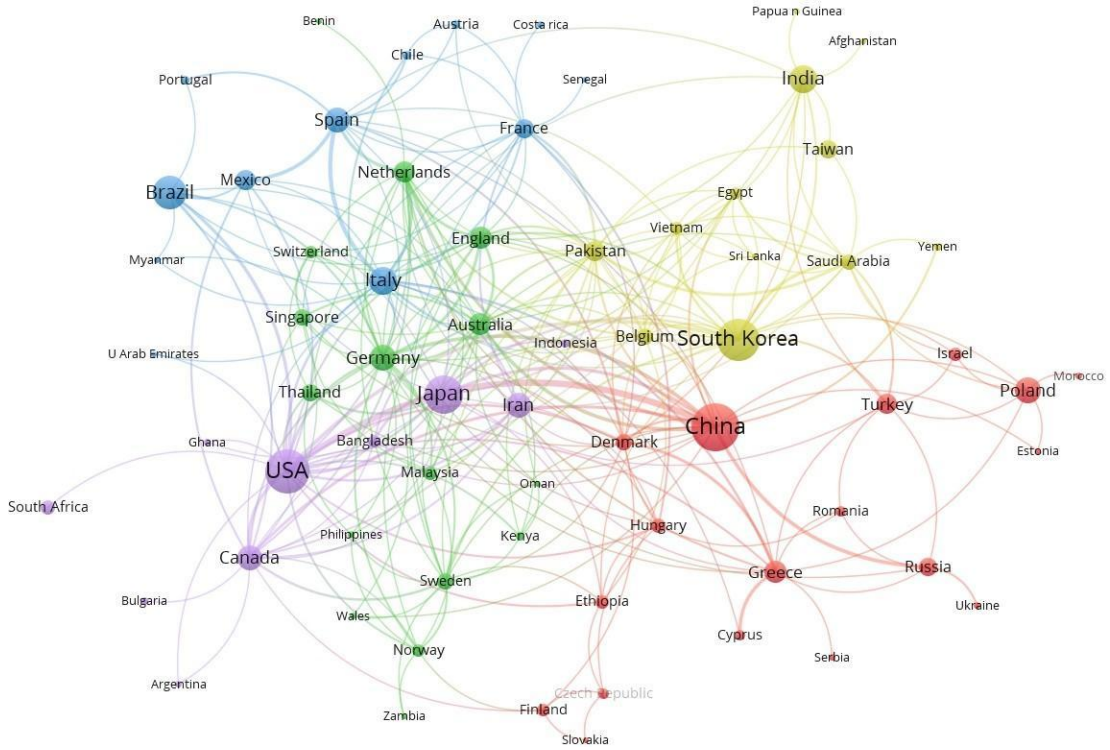

Figure 6. Cooperation relationship diagram of various countries

The cooperation network between countries has formed five types of academic communities, namely (1) Academic communities with China, Poland and Turkey as the core, including Denmark, Greece, Russia, Israel, Hungary, Finland and other countries. These countries are mainly concentrated in Asia, Europe and other regions. (2) The academic community centered on the United States and Japan, including countries such as Iran, Bangladesh, South Africa, Bulgaria, etc. These countries are mainly concentrated in North America, Asia, Africa, Europe and other regions. (3) The academic community with South Korea and India as the core, including Afghanistan, Vietnam, Saudi Arabia, Belgium, Egypt and other countries, these countries are mainly concentrated in Asia, Europe, Africa and other regions. (4) The academic community with Germany, Australia and the United Kingdom as the core, including Thailand, Singapore, the Netherlands, Switzerland, Malaysia, Sweden and other countries. These countries are mainly concentrated in Europe, Oceania, Asia and other regions. (5) The academic community with Brazil, Italy and Spain as the core, including Portugal, Myanmar, France, Chile, Mexico and other countries, these countries are mainly concentrated in South America, Europe, Southeast Asia, North America and other regions.

4. Conclusion

The global research on plant factories started in 1961 and presents three stages of development, namely the budding period (1961 to 2010), the fluctuating growth period (2011 to 2017), and the rapid growth period (2018 to 2021).), which shows that the plant factory has become the latest research hotspot in the field of agriculture in the world. In terms of the amount of publications, 75 countries have carried out research on plant factories, mainly in Asia, Europe, North America, Africa and other regions. Among them, China, the United States, South Korea and Japan are important producers in the field of plant factories, and China ranks first with a total of 211 articles issued. From the analysis of the influence of various countries, relevant research documents of 67 countries have been cited, mainly in Asia, Europe, Oceania, North America, South America and other regions. Among them, China, the United States, South Korea and other countries have a high influence in the field of plant factories and are much higher than other countries. China ranks first with a total citation frequency of 1,887 times and a first/corresponding author total citation frequency of 1,301 times.. From the analysis of the quality of papers in various countries, the quality of

papers in the field of plant factories in France, Australia, the Netherlands and other countries is very high, and far exceeds other countries. Among them, French articles are ranked first in both citation frequency and first/corresponding author articles. Based on the analysis of the post situation of various countries, the start time of research in the field of plant factories varies greatly among various countries, with Japan, Canada and the United Kingdom starting earlier. The duration of research in the field of plant factories varies from country to country, and the duration of related research in Japan and Canada is the longest. From the analysis of cooperation between countries, a total of 5 types of academic communities have been formed, with China, Poland and Turkey as the core, the United States and Japan as the core, South Korea and India as the core, and Germany, Australia and the United Kingdom as the core. Brazil, Italy and Spain are the core.

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