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Hydroponics Research Trends: A Review and Bibliometric Analysis (2008- 2018)

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Abstract

Hydroponic as a concept is characterized by complexity. It has long been used to grow plants, largely vegetables. On the one hand, the concept is challenging in terms of content, but it is also a multidimensional and cross-disciplinary research domain.Based on a bibliometric analysis, the purpose of this descriptive paper is to provide a macroscopic overview of the main characteristics of hydroponics publicationsbetween 2008 and 2018.The data for this study was obtained from Scopus' bibliometric database.According to the study findings, there have been 2013 scholarly publications over an 11-year period, with an average of about 183 publications per year.China, Japan, United State and Iran stand as the dominant position in Hydroponics research. Furthermore, Acta Horticulturae is the leading Journal publishing on Hydroponic research. Key authors were Pardossi, Alberto and Rodrigues, Fabrício Ávila. Chinese Academy Sciences is the productive institution/Affiliation with a total of 78 publication in this domain. It can be concluded that there is need for much more research on Hydroponic and related areas.

Keywords: Hydroponics,Growing medium, Soilless cultivation, Trend

Introduction

The word hydroponics means 'water working' which originated from Greek words; hydro meaning 'water' and Ponic meaning 'working'.This is a technique of growing Crops under controlled conditions in nutrient rich water without the presence of soil for a short duration of time (Bekuma, 2019; Malhi*et al.,* 2020).Hydroponicshas long been used to grow plants, largely vegetables.The news media popularized hydroponics in the 1920s, when a scientist named Dr. William F. Gericke of the University of California began to popularize the idea that plants could be grown in a solution of nutrients and water instead of soil, and it is now being used across many countries to relieve land pressure, water shortage, erratic rainfall, and frequent draughts.Hydroponics is a type of intensive growing unit that uses only water and nutrients to produce nutrient-rich plants(Mulik, 2013; Emam, 2016).It is a highly efficient method of crop farming and it reduces waste of water and the necessary natural and man-made resources required to cultivate crops while controlling the effects of climate and growing conditions(Bekuma, 2019).The wick system, water culture, ebb and flow (drain and flow), drip system recovery/non-recovery, Nutrient film Technique (N.F.T), and Aeroponic system are all types of hydroponic systems(Mulik, 2013).

The cost of production under hydroponics system varies with the production capacity of the hydroponic system employed by the farmer and also the various fixed and variable expenditures incurred during production.Hydroponics has a plethora of advantages; it requires very little area for cultivation, there is a reduction in loss of crops during harvesting. It is a viable alternative technology for farmers who do not have grazing lands, do not have irrigation facilities, and face water scarcity(Greenourplanet, 2020; Malhi*et al.,* 2020). Other advantages include: Easy and quick growing, Almost zero environmental pollution, It produces more than conventional cultivation, Crops grown are more nutritious, providing important sources of carbohydrate, vegetable protein, vitamin, and minerals, they are more palatable and digestible in nature, Easily grown in urban areas where land is limiting factors, Can be used all year round, Requires less labour, It has no adverse effect of climatic conditions, It is environmentally friendly, Less attack of insect pest is recorded, Free from pesticides and any other harmful chemicals, In the same amount of space, production increases by 3 to 10 times, In a well-managed hydroponic system, several crops can be grown twice as quickly.

Many problems have emerged in recent years as a result of the world's rapid population growth.(Pradhan *et al.,* 2019).Other agricultural and environmental issues arise as per capita land available for soil-based agriculture decreases.The advancement of advanced technologies and techniques to withstand the current situation has become crucial in these critical circumstances.

Based on a bibliometric analysis, the purpose of this descriptive paper is to provide a macroscopic overview of the key characteristics of hydroponics publications.The knowledge provided in this paper gives a clear picture of the scientific progress made in the field of hydroponics research, and it can help researchers and practitioners recognize fundamental influences from writers, scientists, and others.

Materials and Methods

The data for the hydroponic research came from Scopus' bibliometric database.The search was carried to show the trends in hydroponic research for the past eleven years (2008-2018) on January 16, 2019. Scopus is a peer-reviewed literature abstract and citation database that is one of the largest in the world.

The keyword used in retrieving the data from Scopus database comprised of hydroponic* and Culture* or soilless* and culture* or aquaponic* and culture*. To attain the combination of terminology and to the possibly reduce error in the search result in bibliometric data from Scopus search engine, the asterisk (*) was used. Based on the search 2013 document was sorted out and analyzed during the period of 2008-2018.

In this study, Hydroponic research were analyzed based on the year of publication, source title, document, language institution/affiliation. Also, several components were identified like the most prolific authors and their affiliation, number of publication and citations in hydroponics research during the period of study (2008-2018).

The data were further analyzed to show the trend in document type which includes publication, number of citation and document h-index. Furthermore, countries with the most productive publication and their

document h-index. Keywords and subject areas were also part of the components analyzed

The 2013 documents sorted form Scopus using CSV Excel, were exported to an excel spreadsheet where they are put in figures and in tabular form. However, undefined authors, affiliation and countries were excluded from the analysis in the excel spreadsheet.

Result and Discussion

Publication Productivity

Table 1. According to the results of this report, there were 2013 scholarly documents on various aspects ofhydroponics for the period of 2008 to 2018.The Relative Growth Rate (RGR) was calculated as RGR = (lnN2 - lnN1) / (t2 - t1), where N2 and N1 are the total number of publications in the years t2 and t1.RGR increased from 0.63 (2008) to 2.31 (2018), according to the study results in Table 1, with some variations in the years in between.Similarly, the average RGR for five-year block spans rose from 1.26 to 2.12 from 2009 to 2013 and 2014 to 2018 respectively.The doubling time, or the amount of time it takes for a given quantity of publications to double, is directly related to RGR because if the number of articles doubles in a given period, the difference between the logarithms of the numbers at the beginning and end of that period is 693.As a result, Dt = 0.693/RGR is used to measure the doubling time (Mahapatra, 1994).The results indicate a downward trend from 1.10 (2008) to 0.30 (2018), with some variations in between.The average Dt for five-year block periods fell from 0.62 within the years 2009-2013 to 0.33 between 2014 - 2018.The mean RGR and Dt for the entire study period were 1.70 and 0.47, respectively, indicating that as the rate of growth of publications increased, the doubling time decreased.This indicates that over a ten-year period, the number of publications in the field of hydroponics has increased.However, the findings indicate that, while hydroponics has become a hot topic in recent years, it has received little attention from academics.Because of the recent nature of the research subject and insufficient financial resources to carry out research activities, research productivity is poor.

Table 1: Year-by-Year Publishing Production

Year	No. of publications	Percent Of Total	Cumulative publications	*ln*N1	*ln*N2	RGR	Mean RGR	Dt	Mean Dt
2008	157	7.8	157	-	5.06	-			
2009	178	8.8	335	5.18	5.81	0.63		1.10	
2010	159	7.9	494	5.07	6.20	1.13		0.61	
2011	181	9.0	675	5.20	6.51	1.31		0.53	
2012	203	10.0	878	5.31	6.78	1.47		0.47	
2013	177	8.8	1055	5.18	6.96	1.78	1.26	0.39	0.62
2014	190	9.4	1245	5.25	7.13	1.88		0.37	

2015	175	8.7	1420	5.16	7.26	2.10		0.33	
2016	197	9.8	1617	5.28	7.39	2.11		0.33	
2017	196	9.7	1813	5.28	7.50	2.22		0.31	
2018	200	9.9	2013	5.30	7.61	2.31	2.12	0.30	0.33
						1.70		**0.47**	

Source: Authors' Review, 2021

Document Type

The findings in Table 2 shows that the vast majority of literature has been published as journal articles(88.52%)at a distance, followed byconference proceedings (7.80%). Other publications were book chapters (1.54%) and review (0.94%), Erratum (0.10%),as well as books (0.04 percent).Since most scholarly articles are published in journals, this was anticipated.

Table 2: Distribution by Document type

Document Type	Publication Count	Percent	No of Citation	Document h-Index
Article	1782	88.52	22122	61
Conference Paper	157	7.80	383	9
Book Chapter	31	1.54	85	4
Review	19	0.94	610	10
Article in Press	14	0.69	5	1
Note	3	0.15	6	2
Conference Review	2	0.10		0
Erratum	2	0.10		0
Book	1	0.04	119	1
Letter	1	0.04	5	1
Short Survey	1	0.04	14	1

Source: Authors' Review, 2021

Productive Authors and their Affiliation

In this section, presented in Table 3,The most productive authors and their affiliation were analyzed, in respect to their article publication ranking. It was observed that the most productive author in hydroponic research during the period of the study was Pardossi, Alberto from Università di Pisa, Department of Agriculture, Pisa, Italy with a total number of 13 article published and 143 citations. Secondly, Rodrigues, Fabrício Ávila from Universidade Federal de Vicosa, Departamento de Fitopatologia, Vicosa, Brazil with 12 articles published and 253 citation which is higher than the productive author. Thirdly, Savvas, Dimitrios from Geoponiko Panepistimion Athinon, Department of Crop Sciences, Athens, Greece with a total of 12 publication and 73 citation, follow by Tzortzakis, Nikos G from Cyprus University of Technology, Limassol, Cyprus, with 11 article publication and 83 citation. Also, Asao, Toshiki from Shimane University, Faculty of Life and Environmental Science, Matsue, Japan, Sun, Li'na from Shenyang University, College of Environment, Shenyang, China and Zhang, G. from Zhejiang University, Department of Agronomy, Hangzhou, China had 8 article each respectively and 97, 22 and 279 citation respectively. However, it was also observed that Zhang, G. who came last in the Tables below with 8 article publication but has the highest number of citation of 279. This observation might probably be as a result of the quality of his work.

Table 3: Top 10 Productive Authors and their Affiliation

#	Author Name	No of Publication	Affiliation	Country	No of citation
1	Pardossi, Alberto	13	Università di Pisa, Department of Agriculture	Pisa, Italy	143
2	Rodrigues, Fabrício Ávila	12	Universidade Federal de Vicosa, Departamento de Fitopatologia	Vicosa, Brazil	253
3	Savvas, Dimitrios	12	GeoponikoPanepistimionAthinon, Department of Crop Sciences	Athens, Greece	73
4	Tzortzakis, Nikos G	11	Cyprus University of Technology	Limassol, Cyprus	86
5	Bao, Tong	10	henyang University, Key Laboratory of Regional Environment and Eco-Remediation,	Shenyang, China	32
6	Maggini, Rita	10	Università di Pisa, Department of Agriculture	Pisa, Italy	134
7	Uno, Yuichi	9	Kobe University, Department of Plant Resource Science,	Kobe, Japan	25

8	Asao, Toshiki	8	Shimane University, Faculty of Life and Environmental Science,	Matsue, Japan	97
9	Sun, Li'na	8	Shenyang University, College of Environment,	Shenyang, China	22
10	Zhang, G.	8	Zhejiang University, Department of Agronomy,	Hangzhou, China	279

Source: Authors' Review, 2021

Subject and Source Distribution

Table 4provides details on the top-15 most active hydroponics research journals. Key journal in the field of Hydroponics research are Acta Horticulture and Journal of Plant Nutrition with 120 and 66 publication on the topic, respectively. This was followed by Plant and Soil with 47 publication. Among the top 15 journal 'Hortscience andInternational Journal of Phytoremediation has the lowest with 19 publication respectively.

The leading subject Area in the field of Hydroponic are Agricultural and Biological Sciences, Biochemistry, Genetics and Molecular Biology and Environmental Science with 1443, 564 and 472 publications respectively as shown in Table 4.

Table 4: Top 10 Subject Area on Hydroponics Research

Subject Area	No of Publication
Agricultural and Biological Sciences	1443
Biochemistry, Genetics and Molecular Biology	564
Environmental Science	472
Chemistry	113
Medicine	99
Engineering	96
Immunology and Microbiology	88
Pharmacology, Toxicology and Pharmaceutics	53
Chemical Engineering	46
Earth and Planetary Sciences	46

Source: Authors' Review, 2021

Journal Title and Hydroponics Research

The results on Table 5 presents scopus indexed journals where hydroponics researches are published. Acta hortticulturae ranked first with the highest frequency of 120 publications in hydroponics research, following from a distance by Journal of plant Nutrition(66) and Plant and Soil (47). While Hortscience and Internation Journal of Phytoremediation ranked last with publication count of 19 each.

Table 5: Top 10 Journal Title on Hydroponic Research

Journal Title	No of Publication
Acta Horticulturae	120
Journal Of Plant Nutrition	66
Plant And Soil	47
Scientia Horticulturae	38
Environmental Science And Pollution Research	32
Plos One	32
Environmental And Experimental Botany	27
Plant Physiology And Biochemistry	27
Frontiers In Plant Science	25
Ecotoxicology And Environmental Safety	22
Chemosphere	21
Acta PhysiologiaePlantarum	20
Hortscience	19
International Journal Of Phytoremediation	19

Source: Authors' Review, 2021

Productive Countries and Language Distribution

The total number of countries and territories included in the 2491 publications with country or territory details was 92, as shown in Table 6. (one author can be affiliated to more than one country or territory, or a publication can be written by several authors from different countries or territories).Twenty publications were eliminated because they were unrelated to any region.

Table 6 lists the top ten participating countries and territories around the world.On the subject of hydroponics science, 13 countries or territories (14.13 percent) produced 50 or more publications, 25 countries or territories (27.17 percent) produced 11 to 50 publications, and 54 countries or territories (58.92 percent) produced 10 or fewer publications.The country with the most publications (n = 548) was China, then Japan(n = 220) and United State (n = 184). Table 6 Reveals that English language with (n-1831) have the highest number of publications, followed by

Chinese with (n=131), Spanish with (n=29), Korean (n=5).

Table 6: The top 14 most prolific countries or territories in terms of hydroponics research publications.

Country	No of Publication	Document h-index
China	548	5731
Japan	220	1701
United States	184	3635
Iran	106	672
Brazil	97	827
Spain	97	1674
India	96	995
Germany	83	1076
Italy	73	1076
Australia	57	1034
France	55	1007
South Korea	54	607
Mexico	53	236
Poland	47	487
Canada	46	-

Source: Authors' Review, 2021

Language Frequency Publishing on Hydroponics Research

The results on Table 7 presents the frequency distribution of the languages in which hydroponics researches are published. 1831 publication representing 91% of the publications are published in English Language, while majority of the remaining publications were published in Chinese, Portuguese, and Spanish (131, 30, 29). This implies that majority of hydroponics researches are published in English Language which makes it available to a wide variety of readers.

Table 7: Language Frequency publishing on Hydroponics research

Language	No of publication
English	1831
Chinese	131
Portuguese	30
Spanish	29
Korean	5
Japanese	3
Turkish	3
German	2
Russian	2
Bulgarian	1
Polish	1

Source: Authors' Review, 2021

Institution Frequency

The results in Figure 1 show the top ten most active institutions in the field of hydroponic science.

The 2013 publications with institution details included 160 separate research institutions.The organization that has written the most papers on the subject isChinese Academy of Sciences with 78 publication, followed by Ministry of Education China, Zhejiang University, Nanjing Agricultural University with 62, 59 and 57 publications.It would be useful to categorize all 2013 hydroponic research institutions

into the following categories: academic (colleges and universities), private enterprise (e.g. business, hospital), or government organization (policy makers).Based on this division, it can be determined if hydroponic research belongs in academia, and it can also shed light on stakeholder participation and policy emphasis (Gall et al., 2015).This division, however, takes a long time because this knowledge isn't in Web of Science and must be manually searched one by one.

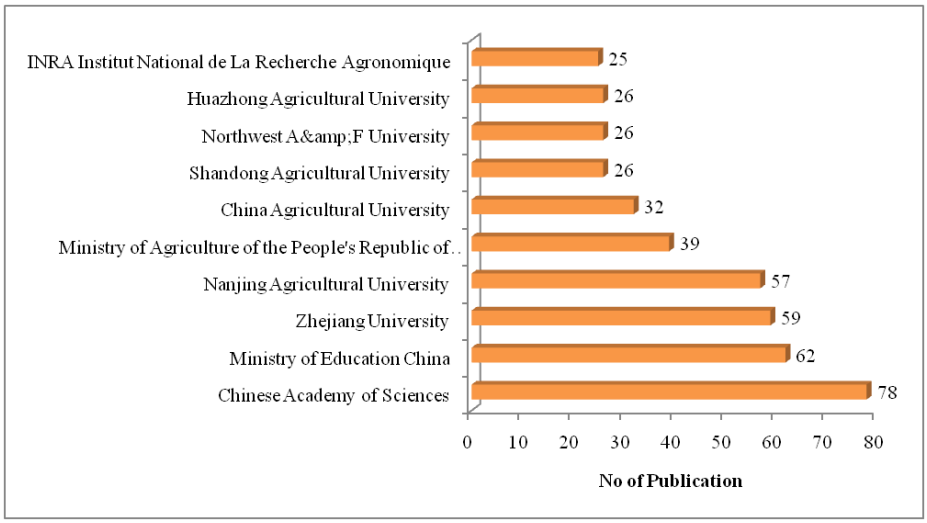

Fig 1: Top-10 of most productive institutions publishing on Hydroponics Research

Source: Authors' Review, 2021

Keyword Trend

The results presented in Fig 2. Shows the most common keyword used on hydroponics research during the period of this study. A total of 160 keyword have used by hydroponic researcher based on data from the Scopus database from 2008 to 2018 terms with broad definitions, such as post, were omitted. *Karolien et al. 2018.* Hydroponics with n= 387 making it the most common keyword used by researcher on hydroponic research during the period of this review. This was followed by metabolism, plant root with n=313 and n=299 respectively.

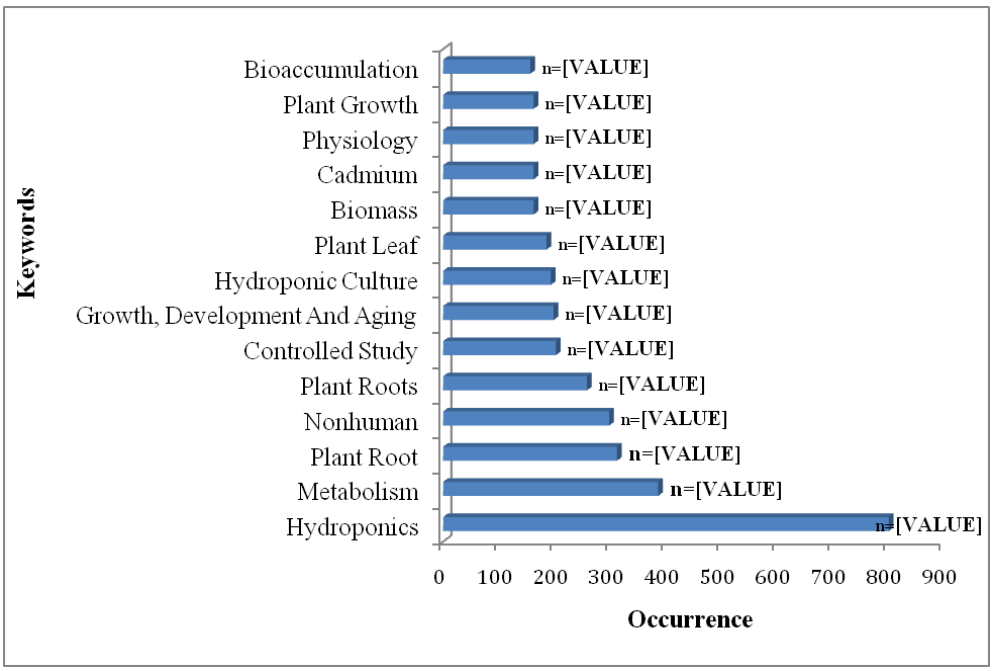

Fig 2 Keyword Trend Analysis of Hydroponics Research Publications

Source: Authors' Review, 2021

Conclusions

An analysis of global research patterns in hydroponics research publications from 2008 to 2018 is presented in this paper.Hydroponics, also known as Soilless agriculture, has been the subject of intensive study over the last ten years, with an exponential increase in publication output.Several component were analysed such as most productive Author, affiliation/institution, subject area, keyword, source title, Country wise, language e.tc.

Based on the result from this study there is steady increase of publication since 2008-2018. Article had the highest number of publication. Pardossi, Alberto from the Università di Pisa, Department of Agriculture is the leading Author on hydroponics research. Neverthless, Zhang, G had the highest number of citation with 279. The leading Journal is Acta Horticulturae. China is the most productive country on hydroponics research and related topics during the period of this study. This review show that Chinese Academy of Sciences is the top institute on hydroponics publication.

This study reveals some findings that can help guide researchers in the field of hydroponics and related domain.There are a few flaws in this bibliometric analysis that should be fixed. The scope of the search was restricted to publications included in the Scopus database. Despite being one of the world's largest databases, Scopus does not contain all publications in the field of hydroponics science. Based on the limitations of bibliometric analysis, a more in-depth content analysis is suggested for future studies Karolien et al. 2018, Dunk and Arbon, 2009. Furthermore, there is need for Additional longitudinal analysis of the field will help determine if our forecast of the trend of hydroponics activities in the future.

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Declaration

There are no conflicts of interest declared by the writers.

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