

# Sustainable Horticulture: A bibliometric Study

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**Abstract**— *This paper examines the scientific researches regarding "sustainable horticulture" to identify research flows with potential for future investigation. Through a bibliometric and content analysis for the 2011-2015 periods and the 2016 first semester, 12 articles, according and relevant to the theme, were selected. The results obtained from the analysis demonstrated the importance of the subject for both academic research and for the practice, since it elucidated scientific production and trends, impact factor, relevant scientific periodicals, contribution by countries and its institutions, methods and research tools, keywords. It stands out that the theme "sustainable horticulture" is used in most cases to address only the environmental dimension and, in a few cases, in the economic and social dimensions. Based in the analysis of the keywords, the terms production, systems and sustainability formed the main research clusters, attracting great attention during the study period.*

**Keywords**— *Sustainability, sustainable horticulture, sustainable agricultural production, bibliometric analysis.*

## I. INTRODUCTION

Around three decades ago, the Bruntland Report has defined "sustainable development as a development that meets the needs of today's generations without compromising the ability of future generations to meet their own needs" (WCED, 1987). Since its conception in the late 1980s, sustainability and sustainable development have become popular words, used in various contexts; to become a motto for international aid organizations; a slogan for environmental and development activists; the jargon of State heads; and the theme of academic

conferences and research (Karrazi et al., 2013; Sartori et al., 2014).

People have different ideas about sustainability in different contexts and thus "solutions tend to be sustainable within sectors rather than across society" (Kajikawa, 2008). According Bell and Morse (2008), to understand sustainability it is necessary to recognize and work with units or areas of interest, which we, as observers, are also part. So, this research is directed to horticulture.

Horticulture is an agriculture branch and, therefore, the basic concepts of sustainable agriculture also apply to it (Lal, 2008). However, to achieve sustainable agriculture, observance and balance between the economic, social and environmental dimensions are essential (Elkington, 1994).

Agriculture by itself can be a major villain responsible for environmental degradation, but it is also a key element in mitigating this degradation. It is responsible for the production of the food necessary for human consumption, but traditional methods of production, besides unbalancing ecosystems, still alter the social structures of rural life (Capellesso, Cazella, 2013; Moreira, Carmo, 2004; Neto et al., 2008).

Since the second half of the 20th century, agriculture has been based almost exclusively on economic aspects, with negative effects on natural resources, soil pollution, water and air pollution, and the reduction of biodiversity (Scialabba, Müller-Lindenlauf, 2010). This reflected, years later, in an intense search for a sustainable agricultural production, less harmful to human health that recognizes the social importance of the activity (Stolze, Lampkin, 2009).

Within agriculture, horticulture stands out as an activity of great social importance (Pudup, 2008). This is

corroborated by the strong presence of horticulture in the context of family farming, where several families depend on this type of activity for their survival. It is a crop that needs a small land extension to be economically viable, when compared to other agricultural crops (Castelo Branco, Alcântara, 2011; Faulin, Azevedo, 2003).

In the last decades, there has been an exponential increase in the quest to reduce chemical inputs in horticultural systems, also to prevent the contamination of the waters in subterranean rivers. Governments and horticulturists are constantly seeking alternative means to reduce this type of contamination, given the large number of accidents caused by contamination to ecosystems (Phogat et al., 2014).

In this context, this paper aims to promote a mapping of publications on the theme "sustainable horticulture". The objective is to form a set of articles (Bibliographic Portfolio - Appendix) aligned with the researchers' view on the subject; and establish the most prominent journals, contribution by countries and their institutions, methods/research tools and keywords on this topic. Lastly, directions for future research are presented.

## II. MATERIALS AND METHODS

The method chosen for this research was bibliometry. This method, according to Pritchard (1969), is the characteristics study of scientific publications. Quantitative aspects of the production, dissemination and use of the registered information are considered in it. This research modality is applicable in all areas of knowledge. In the agrarian sciences field, this method has been widely used in recent years as in the researches of Castelo Branco and Alcântara (2011); Cousins and McDowell (2012); Dias et al. (2015); Krauskopf (2012); Pautasso (2016); Randolph (2013); Vargas and Vanz (2014).

The used instrument to obtain the data was based on the Knowledge Development Process - Constructivist (Proknow-C), proposed by Ensslin et al. (2010), and used in researches such as Afonso et al. (2011); Rosa et al. (2012) and Loss et al. (2016). This paper emphasizes that the directions were inspired by the two initial stages of Proknow-C. Through these, two roadmaps were developed to conduct the research. It is the "selection of the Bibliographic Portfolio" that will provide the literature review and the "bibliometric analysis of the Bibliographic Portfolio" that will provide the analysis of the results.

### 2.1 Bibliographic Portfolio Selection

To develop a paper and produce knowledge, the researcher's first step is to review the literature on the subject. The selection of bibliographic references through ProKnow-C is conducted recursively through the following steps: a) definition of scientific articles in databases; B) establishment of a Gross Articles Database,

filtering and selection of the relevant Bibliographic Portfolio and aligned with the researcher's theme (Afonso et al., 2011).

### 2.2 Gross Articles Selection

Aiming to define the gross articles database, one begins with the axis determination of the research, according to the researcher's perception. In this paper, there are two research areas: Sustainability and Horticulture. The selection of the Gross Articles Database is composed of: a) Definition of the key words: "sustainability" and "horticulture"; "sustainable" and "horticulture"; B) Definition of databases: ISI Web of Knowledge and Science Direct. Regarding the content of these 2 databases, it has to be registered that the keyword combinations were searched, using the title, abstract, topic and keywords. The period of analysis is 5 years (2011 to 2015), also being considered articles of the first half of 2016; C) Survey of the articles in the databases with the keywords: after completing the search of the keywords in the 2 databases, publications were selected to compose the Bibliographic Portfolio called the Gross Articles Bank. Only journal articles were used as the subject of analysis. The searches were conducted in July/2016.

### 2.3 Gross articles database filtering

In the filtering process of the Gross Articles Database, 105 publications were analyzed regarding the following aspects: a) repeated articles; B) titles of articles aligned to the research theme; C) articles with scientific recognition; D) abstracts aligned to the research theme; and e) full text of articles aligned with the research theme.

The spreadsheet was used to tabulate selected publications in the searched databases. In the redundancy analysis, duplicate articles were removed, leaving 98 articles in the Gross Articles Database.

Analyzing the alignment of the title in relation to the research theme, a large number of articles were detected outside the relationship between sustainability in horticulture and also not available for reading. Consequently, there were 18 non duplicate articles with a title aligned to the research theme, which were submitted to scientific recognition in Google Scholar. Considering the aims of this analysis, scientific recognition of an article is understood to be the number of citations found for the article after checking them at Google Scholar.

Thereafter, the 18 selected articles were analyzed in relation to the alignment of the abstract and later to the full text with the research theme. From the 18 articles, 2 did not have the full text available for reading, and were deleted. The remaining 16 articles had their texts analyzed in their entirety, and then 4 articles were excluded because they were not aligned. The remaining 12 articles were considered relevant and aligned to the

theme and made up the Bibliographic Portfolio of the research (Appendix).

For these Bibliographic Portfolio articles, it is presented the descriptive analysis and characteristics in terms of the selection of the most outstanding articles, periodicals, quoted authors, research methods / tools and the most used keywords in the subject.

In order to map specific research areas, themes or topics, the similarity mapping technique (VOS) by VOSviewer computer program (<http://www.vosviewer.com/>), of Leiden University, Netherlands (Van Eck, Waltman 2007). In order to generate this scientific map, representing by cluster, the articles abstracts and titles of the Bibliographic Portfolio were used.

**III. RESULTS AND DISCUSSION**

This topic presents the characteristics analysis of the articles that formed the Bibliographic Portfolio aligned to the theme: "Sustainable Horticulture" in terms of the selection of the most prominent journals, quoted authors, research methods/tools, the most used keywords and subjects covered in the surveys.

Bibliometric analysis. The Bibliographic Portfolio bibliometric analysis consists of the statistics survey of the defined set of articles for the management of information and scientific knowledge of the research theme (Ensslin et al., 2012). The bibliometric analysis main objective is to arrive at a set of consistent indicators (Van Raan, 2005). The analysis of the Bibliographic Portfolio was developed in five stages: i) to evaluate the relevance degree of the periodicals; ii) evaluate the scientific recognition of articles; iii) the research institutions origin from the Bibliographic Portfolio; iv) research methods and used tools; and v) evaluate the most commonly used keywords and terms.

Evaluating the relevance degree of periodicals refers to identifying in which journal the largest number of articles among those that compose the Bibliographic Portfolio was published. 10 different journals were found, among them the Journal of Cleaner Production stands out, with 4 published articles (Figure 1).

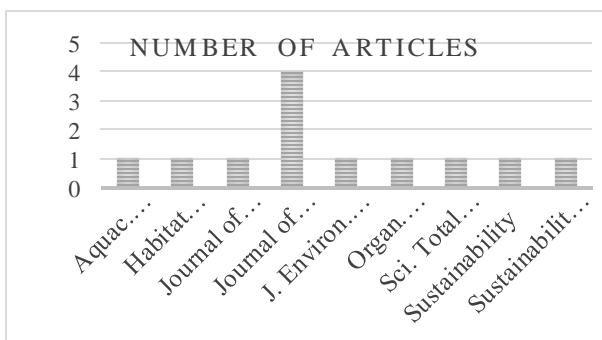


Fig. 1: Number of articles per journal

As a complement to the journals relevance degree, it has been searched the Journal Citations Reports (JCR) index of the journals that formed the Bibliographic Portfolio - BP. The JCR provides a perspective for periodical evaluation and comparison through the accumulation and tabulation of citation counts. It is a globally accepted and respected index. Figure 2 presents the indexes for the year 2015 of the Bibliographic Portfolio – BP journals.

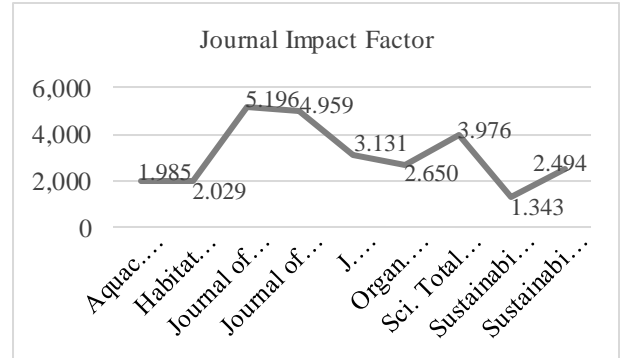


Fig. 2: Journal impact factor – 2015

From the articles in the Bibliographic Portfolio (Appendix), the "Journal of Applied Ecology" is noteworthy, with a 5.198 index, followed by the "Journal of Cleaner Production" with 4.959 and the "Science of the Total Environment" with 3.976, as the three Journals with the highest Bibliographic Portfolio indexes.

As for the scientific recognition degree of the articles that make up the Bibliographic Portfolio (see Appendix), a query was made regarding the citations number of the articles in the Google Scholar databases, according to the surveys of Afonso et al. (2011); Loss et al. (2016) and Sartori et al. (2014). Evaluating the scientific recognition of the articles in the Bibliographic Portfolio (Figure 3), the following articles stand out: Girija Page, Brad Ridoutt and Bill Bellotti "Carbon and water footprint tradeoffs in fresh tomato production" with 81 citations; and "Environmental life cycle assessment of Ethiopian rose cultivation" by Abiy Sahle and Joseph Potting with 28 citations.

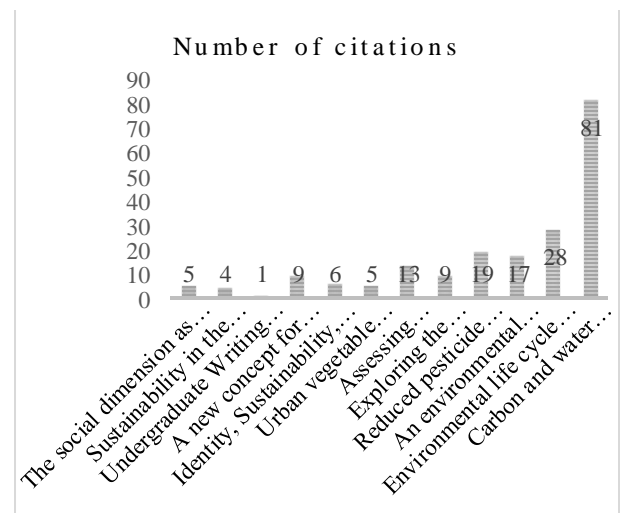


Fig. 3: Number of citations (BP articles)

The following analysis (Figure 4) bring forward the present and cited journals relevance in the bibliographical references of the articles that make up the Bibliographic Portfolio, emphasizing, again, the “Journal of Cleaner Production”, followed by the “International Journal of Life Cycle Assessment”, “Agriculture, Ecosystems and Environment” and “Journal of Environmental Management”.

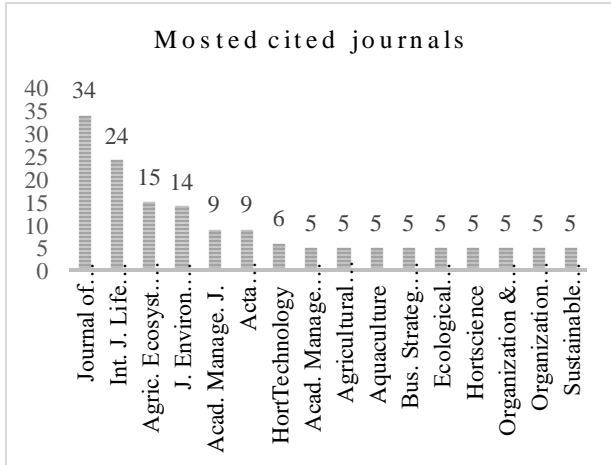


Fig. 4: Number of citations (BP articles)

The most cited authors were mapped in the same way of the journals in the bibliographical references present in the set of articles of the Bibliographic Portfolio - BP. In this sense, 1.254 authors were found, of which 200 authors were cited twice or more. Figure 5 presents the authors with more than six citations, with emphasis on: Assumpció Antón, from the Institute for Research and Technology in Food and Agriculture, Spain; Gabriele L. Beccaro and Giancarlo Bounous, both researchers from the Department of Agriculture, Forestry and Food Science of the University of Turin, Italy; Alessandro K. Cerutti of the Department of Agriculture, Forestry and Food Science, University of Torino, Italy; And Emilio Galdeano-Gomez, Department of Economics and Business, University of Almeria, Spain.



Fig. 5: Most cited authors in the BP references

In terms of the research institutions origin from the Bibliographic Portfolio articles, it can be noted that New Zealand presents with the largest number of institutions, four in total, being Lincoln University, University of Otago, Agricultural Research Group on Sustainability (ARGOS) and Land Care Research, the last aiming to boost innovation in the terrestrial resources and biodiversity management. Australia is also present with two research institutions (University of Western Sydney, Sustainable Agriculture National Research Flagship - CSIRO).

The United States is also present with two institutions (University of Michigan and University of Minnesota). In Europe, five countries are also on the list. Germany with two institutions (Leibniz-Institute of Freshwater Ecology and Inland Fisheries and Humboldt University); Spain also with two (University of Almeria and Institute of Agriculture and Food Research and Technology - Barcelona); Italy with two institutions (University of Turin and Institute for Environment and Sustainability - ISPRA) and, finally, the Netherlands and Sweden respectively with one institution each (Wageningen University; KTH Royal Institute of Technology).

Brazil represented South America with two research institutions on the list: State University of Campinas and the Pontifical Catholic University of Rio de Janeiro. The research institutions origin and percentage on the Bibliographic Portfolio are presented numerically according to table 1.

Table 1: Informations about research centers

Origin of institutions	Number of institutions	Percentage %	Cumulative frequency %
New Zealand	4	22.2	22.2
Australian	2	11.1	31.3
United States	2	11.1	44.4
Germany	2	11.1	55.5
Spain	2	11.1	66.6
Italy	2	11.1	77.7



After analyzing the search methods and tools, the keywords analysis was performed with the VOSviewer program, in which seven clusters were automatically identified. The results are presented and demonstrated graphically through colors in their respective cluster (Figure 6). The most prolific keywords found in these clusters were: Production, System and Sustainability.

Cluster four, for example, has the keyword "Sustainability" and it is connected to words "horticulture", "barrier", among others. In this way, the preponderance of the following keywords was identified:

- Cluster 1 - system (red) is connected to family farm, grower, case study, country, interest;
- Cluster 2 - use (green) is connected to contribution, farm, emission, fertilizer, abiotic depletion, input;
- Cluster 3 - project (blue) is connected to allotment, aim, range and Rio de Janeiro;
- Cluster 4 - sustainability (yellow) is connected to horticulture, number, practice, benefit, barrier, interview, understanding;
- Cluster 5 - productivity (violet) is connected to aquaponic system, tomato unit, water, water use;
- Cluster 6 – production (light blue) is strongly connected to tool; calculator and environmental impact
- Cluster 7 - density (turquoise) is connected to orchard and directed to application.

These keywords found in articles are important because they represent the concepts that authors want to communicate and draw the readers and the scientific community attention. According to Ercan and Cicekli (2007), the keywords are concise representations of a certain text, which allows the reader to identify the relevance of the theme in advance.

In this sense, the following analysis presents the articles distribution of the Bibliographic Portfolio regarding the coverage of the subjects in relation to sustainability. Although the term sustainability is highlighted in the keywords analysis and be the research topic, it was verified in the bibliographic portfolio that 4 articles (33.33%) tried to research the three dimensions of sustainability - environmental, economic and social.

The remaining eight articles (66.66%) assessed sustainability by the lens of the environmental dimension. When dealing with the environmental sustainability dimension, it returns to a condition of equilibrium, resilience and interconnection, which allows society to meet its needs without exceeding the capacity of ecosystems (Morelli, 2011), according to the Bibliographic Portfolio studies described below.

The article by Kloas et al. (2015) assesses greenhouse gas emissions in the agricultural sector, specifically in the

tomatoes and fish production; Torrellas et al. (2013) developed an environmental support tool to determine the environmental impacts of protected crops; the work of Beccaro et al. (2014) assesses the environmental impact of a nursery and also an orchard; Page et al. (2012) evaluated the carbon footprint of tomato production in Australia; Sahle and Potting (2013) conducted a life cycle assessment (LCA) for growing roses in Ethiopia.

Nakajima and Ortega (2015) present the environmental behavior of different horticultural production systems. MacLeod et al. (2012), describe that a complete conversion to an organic system may not be necessary to improve biodiversity in agroecosystems. These authors advocate that the transfer of specific land management practices to benefit biodiversity in organic systems has the potential to increase biodiversity in other more intensively managed systems. Silva and Forbes (2016) assess sustainability in the New Zealand horticulture industry. This research focuses on the producer's views of sustainability, the types of sustainability practices adopted, the benefits of implementing those practices, and the obstacles to implementing additional practices.

Regarding the three dimensions of sustainability, Johnson's research (2012) investigates environmental, economic and social initiatives in United States botanic gardens. Galdeano-Gómez et al. (2016), address in their research the social dimension as an important driver in sustainable development. Social factors in agriculture in southeastern Spain are analyzed, identifying how family farms and their networks can integrate socioeconomic and eco-social issues, promoting the generation of synergies between the dimensions of sustainability.

Anderson and Kelly's (2011) research assess the incorporation of sustainable production into the course syllabus of an existing horticulture course at the University of Minnesota through intensive writing tasks. The objective was to promote understanding of the complex sustainability issue, as to provide students with the knowledge about the specific cultivars development of each country within a sustainable production framework.

Rego (2014) evaluates an urban model of vegetable production based on organic farming techniques. His research involves: (i) production methods from a local supply perspective considering the political feasibility of the project; (ii) the capacity of continuous production in small and medium urban areas using specific techniques of organic cultivation; (iii) the economic and social sustainability of the productive system.

Thus, it is clear that all these researches seek to highlight sustainability in horticulture, aiming at maintaining or improving the natural resources situation within the scope of production restrictions. However, the challenges faced by current and future generations of horticultural

producers remain the same: to seek sustainability by minimizing the effects of past production practices, by identifying more environmentally friendly production methods that foster social and economic empowerment of horticulture dependent communities.

#### IV. CONCLUSIONS

Sustainable horticulture considers the environmental, social and economic production implications, seeking to use the best and least harmful practices that contribute to the producers and consumers quality of life. In this sense, this study characterized an examination on "sustainable horticulture" research in the 2011-2015 periods and during the first semester of 2016. The number of citations and Impact Factor show that the quality of the examined articles contributes to the scientific academy and to the community at large.

However, most of the articles focus only on the environmental dimension, that is, despite the increased awareness about the conceptual definition and practices of sustainability, there is a lack of applications to monitor and evaluate impacts on horticulture in all dimensions (economic, social and environmental).

Regarding the scientific gaps that can promote and guide future studies, these gaps include the need to expand existing theory, as well as the proposal of sustainability models in horticulture. In this sense, future studies may:

- Address aquaponic systems to achieve sustainability, increase productivity in different production systems and reduce environmental impacts, as highlighted in the study by Kloas et al. (2015);
- Develop a model for the life-cycle assessment (LCA) that includes the economic evaluation of crops, that is, to address the economic and environmental issues together, as presented in the study by Beccaro et al. (2014), Sahle and Potting (2013) and Torrellas et al. (2013). Address the need for inclusion of several types of pollutants, such as pesticides, which are few considered in the footprint or LCA - a gap highlighted in the work of Page et al. (2012);
- Address the different productive sectors and organizations can behave responsibly in relation to the natural environment, which means, there is a need for studies on environmental behavior as highlighted by Johnson (2012);
- Address the lack of knowledge about the benefits of farmers' practice of sustainability is a prominent gap in the research by De Silva and Forbes (2016);
- Consider studies that address the transformations required to fulfill sustainability in relation to

family agriculture compared to industrial agriculture is an important gap identified in the Galdeano-Gómez et al. (2016);

- Suggest solutions for urban vegetable production, involving recovery areas, disused areas, recycling of organic matter, community participation, and in turn, development of tools to control activities to ensure continuous production, social and economic viability (Rego, 2014).

In addition, it is necessary to develop broad research projects in line with governments, companies, universities and other stakeholders. Research on horticulture sustainability is increasing due to the diverse stakeholders, which include the growing demand for pesticide-free food and the reduction of economic, social and environmental impacts. Finally, as limitations of this research, some studies may not have been found in the search process, due to variations in the keywords.

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## APPENDIX

## BIBLIOGRAPHIC PORTFOLIO – BP

Article's code	Autors/year	Title	Journal
A1	Galdeano-Gómez, E. et al (2016)	The social dimension as a driver of sustainable development: the case of family farms in southeast Spain	Sustainability Science
B2	De Silva, T. A.; Forbes, S. L. (2016)	Sustainability in the New Zealand horticulture industry	Journal of Cleaner Production
C3	Anderson, N. O.; Kelly, J. A. (2011)	Undergraduate Writing Promotes Student's Understanding of International Sustainable Development in Horticulture	Sustainability
D4	Kloas, W. et al. (2015)	A new concept for aquaponic systems to improve sustainability, increase productivity, and reduce environmental impacts	Aquac. Environ. Interact.
E5	Johnson, V. (2012)	Identity, Sustainability, and Local Setting at U.S. Botanical Gardens	Organ. Environ.
F6	Rego, L. F. G. (2014)	Urban vegetable production for sustainability: The Riortas Project in the city of Rio de Janeiro, Brazil	Habitat International
G7	Beccaro, G. L. et al. (2014)	Assessing environmental impacts of nursery production: methodological issues and results from a case study in Italy	Journal of Cleaner Production
H8	Nakajima, E. S; Ortega, H. (2015)	Exploring the sustainable horticulture productions systems using the emergy assessment to restore the regional sustainability	Journal of Cleaner Production
I9	MacLeod, C. J. et al. (2012)	Reduced pesticide toxicity and increased woody vegetation cover account for enhanced native Bird densities in organic orchards	Journal of Applied Ecology
J10	Torrellas, M. et al. (2013)	An environmental impact calculator for greenhouse production systems	J. Environ. Manage.
K11	Sahle, A.; Potting, J. (2013)	Environmental life cycle assessment of Ethiopian rose cultivation	Sci. Total Environ.
L12	Page, G. et al (2012)	Carbon and water footprint tradeoffs in fresh tomato production	Journal of Cleaner Production