









A GLOBAL OVERVIEW OF HYDROPONICS: NUTRIENT FILM TECHNIQUE

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ABSTRACT

Hydroponics is a cultivation technique without soil. There are several modalities for the system and among them is the Nutrient Film Technique (NFT), which consists of using channels to circulate nutrient solution intermittently. Due to the risks of soil and water contamination in metropolitan areas, this technique is a potential alternative to agricultural production in cities. The objective was to assess the panorama of the knowledge of the NFT system in the literature and the performance of various countries on it. For this purpose, a bibliographic survey was carried out from 2010 to 2019 on the international research bases Science Direct, Portal of Journals of the Coordination for the Improvement of Higher Education Personnel (CAPES) and Scielo, using the search terms “Hydroponics” and “Nutrient Film Technique Hydroponics”. There was an increase in the number of studies in the last four years of the analyzed period, from 2016 to 2019, thus representing an increase in interest in hydroponics, especially of the NFT type. This increase may be related to the efficiency and ease of handling of this system, productivity gains and the potential that the NFT has to reduce the carbon footprint. Thus, NFT is of great value in urban agriculture, especially in Brazil – its biggest representative –, with the potential to grow a lot in the future.

Palavras-chave:

Agricultura Urbana
Alternativas de produção
Análise de estudos
Revisão sistemática 2010-2019

UMA VISÃO GLOBAL DA HIDROPONIA: TÉCNICA DO FILME DE NUTRIENTES

RESUMO

A hidroponia é uma técnica de cultivo sem solo. Entre as diversas modalidades há a Técnica do Filme de Nutrientes (NFT), que consiste em utilizar canais para fazer circular solução nutritiva de forma intermitente. Devido aos riscos de contaminação do solo e da água nas áreas metropolitanas, esta técnica é uma alternativa potencial à produção agrícola nas cidades. O objetivo foi aferir o panorama do conhecimento do sistema NFT na literatura e a atuação dos países sobre o mesmo. Para isso, foi realizado um levantamento bibliográfico de 2010 a 2019 nas bases de pesquisa internacionais Science Direct, Portal de Periódicos da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) e Scielo, utilizando os termos de busca “Hydroponics” e “Nutrient Film Technique Hydroponics”. Observou-se um aumento no número de estudos nos últimos quatro anos do período analisado, ou seja, de 2016 a 2019, representando, assim, um aumento do interesse pela hidroponia, especialmente do tipo NFT. Esse aumento pode estar relacionado à eficiência e facilidade de manuseio desse sistema, ganhos de produtividade e ao potencial que o NFT tem para reduzir a pegada de carbono. Assim, o NFT é de grande valia na agricultura urbana, principalmente no Brasil – seu maior representante –, com potencial para crescer muito no futuro.

INTRODUCTION

Hydroponics is an agricultural technique that aims to produce plants using a nutrient solution instead of soil (CHEN *et al.*, 2020; GERICKE, 1938). This technique emerged as a way of optimizing the use of water, space, time, nutrients and labor (CHEN *et al.*, 2020; VILLELA JUNIOR *et al.*, 2003; NORSTRÖM *et al.*, 2003; RABABAH and ASHBOLT, 2000). Hydroponics can be used for many crops, including leafy vegetables, fruits and tubers (ANDRIOLO *et al.*, 2004; LEE and LEE, 2015). For many leafy vegetables there are already specific formulations used on a commercial scale for hydroponics (FURLANI *et al.*, 1998). The most common have a high concentration of salt, reaching electrical conductivity levels greater than 2.0 dS.m⁻¹ (COMETTI *et al.*, 2008).

Hydroponics in metropolitan areas shows itself as a potential alternative to conventional production, since there is no use of soil and there is the possibility of using water from the local supply center, in addition to which these areas may present risks of soil and water contamination due to, for example, improper disposal of domestic waste and effluents (PEDRON *et al.*, 2004; HUNDLEY and NAVARRO, 2013).

There are several types of hydroponics (WANG *et al.*, 2019), which include wick, deep water, drip, ebb and flow, aeroponics, window farming and nutrient film techniques (NFT) (LEE and LEE, 2015; GUO *et al.*, 2002). In the NFT, the roots of the plants are suspended in a nutrient solution that flows through a channel intermittently for aeration of the roots (JONES, 1983). Although NFT has a high implementation cost and requires permanent monitoring, this system is characterized by the practicality of implementing and cleaning the vegetables, in addition to increasing productivity, and is established as the prevalent type of hydroponics in Brazil (ANDRIOLO *et al.*, 2004; GEISENHOFF *et al.*, 2009).

The evolution of the use of hydroponics, especially the NFT system, has been great, but surveys of this evolution have not been done very often. This can be done by checking the current study of knowledge, that is, the state-of-the-art. Thus, due to the importance of the NFT system in the country of the present work – Brazil –, the authors sought to verify the state-of-the-art of studies published on hydroponics of the NFT

type in the international literature, analyzing the performance of the countries involved. There are several works on Brazil including by Soares *et al.* (2015) and Lira *et al.* (2015).

For this, a bibliographic survey was carried out on the international research bases: Science Direct, Portal de Periódicos da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) and Scielo, individually, that is, without analyzing overlapping data. For that, the search terms “Hydroponics” and later “Nutrient Film Technique Hydroponics” were used, and for both terms, only scientific research articles were included in the evaluation, within the period from 2010 to 2019. On the international research base CAPES, there was a difference between the number of articles when using the time filter from 2010 to 2019 and the number of articles when using the time filter of each year separately in that same time interval. The difference was 33 articles.

For the first and second terms, the articles were checked in general. However, for the second term, some relevance criteria were also adopted, such as the application of the NFT technique in the study. For this, the screening was performed by reading the “Abstract” and “Materials and Methods” in order to select the articles that used hydroponics of the NFT type. The selected articles were recorded in an Excel spreadsheet for later data analysis. To understand the progress of study of this hydroponics technique by country, the countries where each previously selected NFT survey was carried out were registered.

Published studies of hydroponics

Worldwide, hydroponics research has been growing over the past ten years (Figure 1). In 2019, 987 research articles were published. This was observed when the results of the three databases were added, without considering the data overlap. Therefore, 2019 was the year with the highest number of articles published in CAPES and Science Direct – the two research bases with the highest number of results among the three used. Between 2010 and 2019, there was a growth of 381.0% in the number of published studies referring to this type of agricultural production. The average annual growth rate was 7.41% with a variance of 0.85% and, through the analysis of the trend line, it is possible to observe that this growth rate may be even higher.

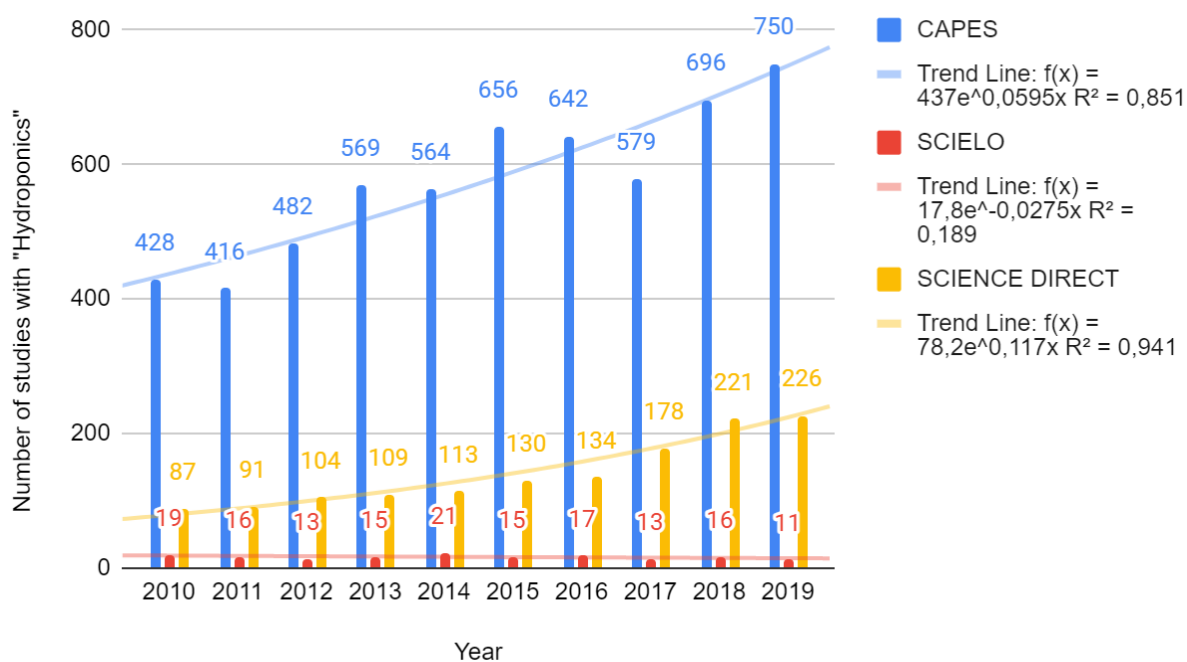


Figure 1. Number of studies (N.S.) related to the search terms “Hydroponics”

Published studies of Nutrient Film Technique Hydroponics

For the search term Nutrient Film Technique Hydroponics, there was a variation in the number of studies published over the analyzed period (Figure 2). However, through data analysis, it was observed that the average annual growth rate of the number of studies was 22.0% over the adopted period. This growth is greater than that of hydroponics studies generally, although it occurs less uniformly, with a variance of 29.5%. The year with the largest total number of published research articles was also 2019, but when each of the international research bases was analyzed, it was observed that 2016 was the year with the most results for CAPES, which may have occurred due to the water crisis experienced, for example, in São Paulo in the summers of 2013–2014 and 2014–2015, as suggested by the authors Marengo *et al.* (2015). Furthermore, in 2015, the World Resources Institute (WRI) released a water stress ranking for 167 countries for the years 2020, 2030 and 2040 in which 33 countries were predicted to experience high water stress in 2040 (MADDOCKS *et al.*, 2015). Regarding the Scielo research base, there was only one result for this search term and it

occurred in 2010.

When analyzing scientific articles with relevance criteria, there were many fewer published studies that used NFT hydroponics experimentally – 179 instead of 345 – than those that appeared as a result of the search term “Nutrient Film Technique Hydroponics” (Figure 3). This was due to the fact that many articles only mention the type of hydroponics. As a result, there is a change in the response of the growth rate, although the last four-year period continues to represent its peak, with 62.6% of the total of publications in the evaluated period.

This increase in the number of works published on the Nutrient Film Technique corroborates what is presented by Lu and Grundy (2017), according to whom, in recent years, interest in urban agriculture has increased. This may be because hydroponics is an alternative for reducing a city’s carbon footprint, being more sustainable and simultaneously increasing productivity. Other advantages are water use efficiency and, since the plants receive controlled and adequate nutrition and there is no contact with soil, the use of pesticides is much less (CHEN *et al.*, 2020; MENEGAES *et al.*, 2015).

As the main limiting factors of agricultural

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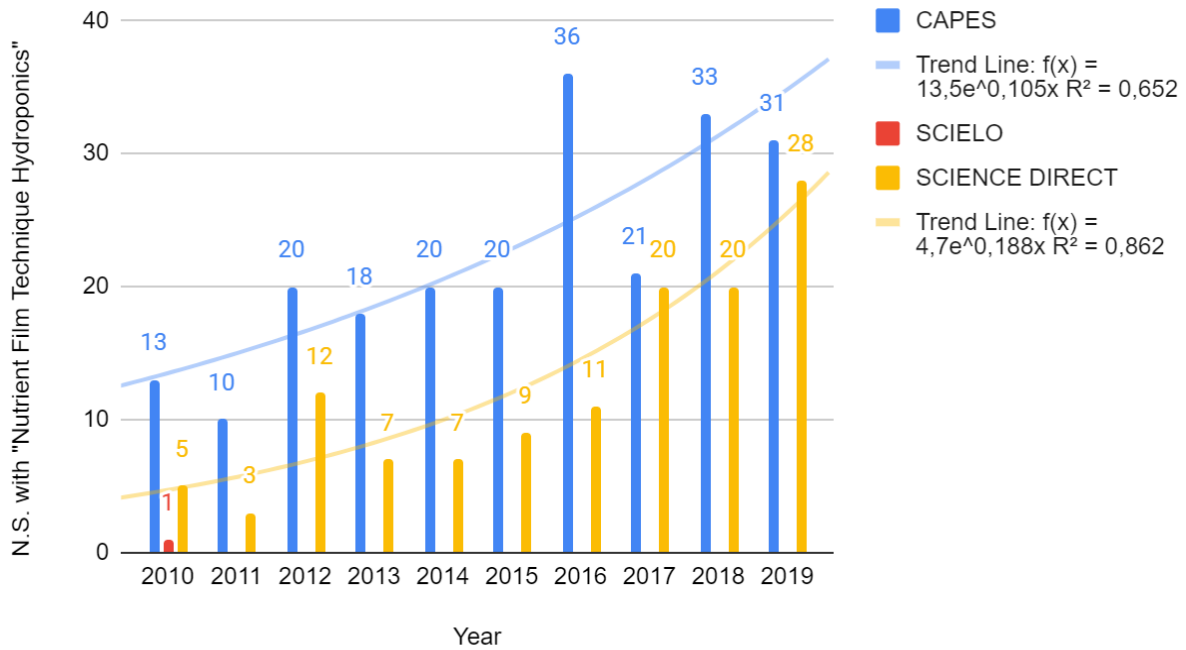


Figure 2. Number of studies (N.S.) related to the search term “Nutrient Film Technique Hydroponics” in the evaluated period

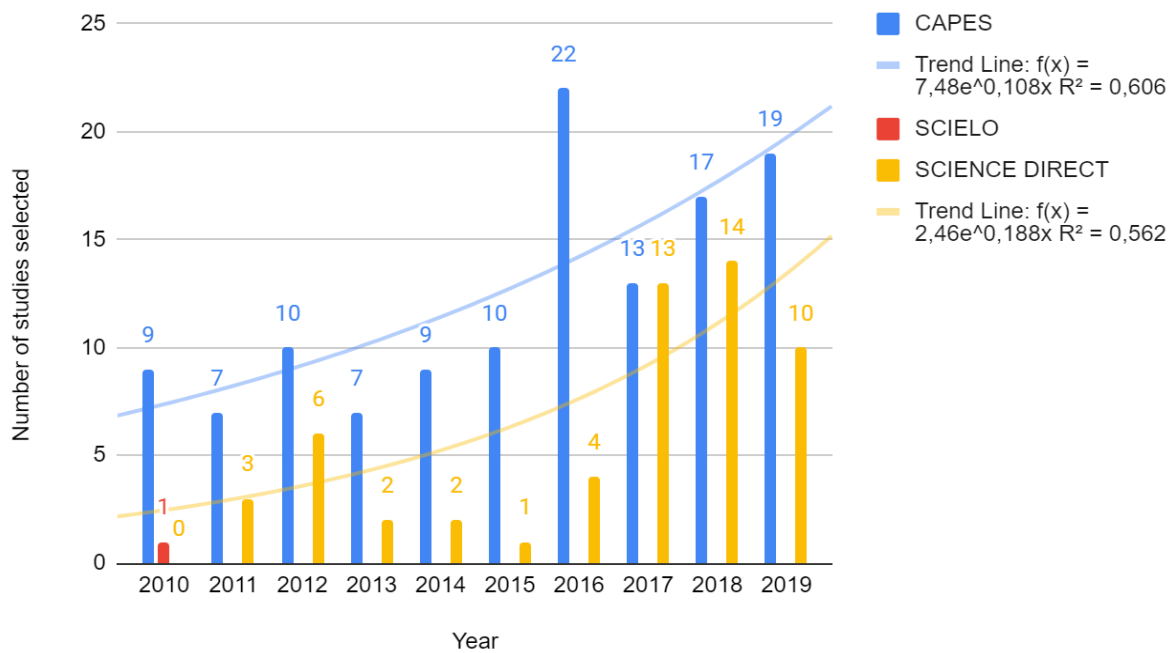


Figure 3. Number of studies selected and measured in the screening with the term “Nutrient Film Technique Hydroponics” in the evaluated period

production are land and water (FIAZ *et al.*, 2016), hydroponics acquires even more importance, since through the NFT technique it can contribute to achieving food security, ensuring standards of sustainable production with efficient use of natural

resources, as provided by the UN 2030 Agenda. Hydroponics also has its limiting factors, the biggest of which is the energy problem, because if the pump interrupts the circulation of water, depending on the temperature, the crop can suffer

serious damage and may even be lost, although one way to avoid these problems is by using alternative energy such as solar energy (MATSURA *et al.*, 2015).

The NFT hydroponic system has been studied also for the scope for recycling organic waste, for example using biochar in the nutrient solution, and indeed organic waste represents about 53% of urban solid waste according to Ricci-Jürgensen *et al.* (2020). This means that the NFT system may be a way to achieve sustainability. Hydroponics is also advantageous for preventing attacks of soil-borne diseases and the occurrence of sudden temperature fluctuations, which both contribute to the management of biotic and abiotic stresses (WANG *et al.*, 2019). This is possible because the plant has no contact with the soil and the nutrient solution has a buffering capacity, reducing the impact of temperature fluctuations (GOTO *et al.*, 1996).

Another object of study that has used the NFT technique is aquaponics. This technique integrates hydroponics and fish farming in order to recycle the waste produced by the fish. This is sent to hydroponics and, through the process of biofiltration, serves as a source of nitrogen for plants, which when feeding, purify the water, which is then returned to the fish tank (LU and GRUNDY, 2017). Thus, there is an economy of inputs and costs and a greater diversity of products to be consumed and/or traded. Yep and Zheng (2019) also found, in a study carried out on trends and challenges in aquaponics, that publications have increased exponentially in the last 3 years.

Furthermore, the hydroponic cultivation of tomatoes and other suitable vegetables can be facilitated and successful for space production, via hydroponic methods, and the soil-free technique is considered a promising tool for the production of space vegetables, since hydroponics is the most intensive method of agricultural production in the agricultural industry. This allows plants to achieve greater growth, larger fruits, flowers and other edible parts, because hydroponics provides greater absorption of water and nutrients and greater oxygenation of the roots, as well as optimizing

the pH (GHAZVINI *et al.*, 20007; WANG *et al.*, 2019).

The commercial and scientific application of hydroponics is growing, but further research is needed to see how different hydroponics techniques can perform optimally for different cultures and locations of application, as the commercial sector expands, and as more technological advances become increasingly necessary. Atzori *et al.* (2019) even point out that there are studies using sea water as a complementary source of irrigation when cultivating plants without soil.

According to Mohapatra *et al.* (2020), different NFT systems can be designed and developed, and may become simplified and portable, but the limitation of the size and number of plants used still needs to be studied further, according to each NFT system, because the number of plants used is dictated by the number of holes, thus showing that this technique will tend to present even more publications over the years.

Countries with published studies of Nutrient Film Technique Hydroponics

In addition to the evolution of the studies, the role of each country involved was observed (Figure 4). Through the analysis of the 180 NFT studies, 36 countries were found. It was seen that the country with the largest number of published studies was Brazil with 27 studies, which represents 15.1% of the total, followed by Italy with 19, the United States with 15 and Germany with 12. These four countries represent 40.8% of the total published studies.

The representation of Brazil may be related to the water crisis experienced in 2015, so much so that 16 of the 27 studies took place from 2015. The increase in vegetable consumption as presented by Silva and Claro (2019) in a study carried out in Brazilian capitals and in the Federal District is another factor that may be related to the prominence of Brazil, since hydroponics is a viable alternative for urban production of these foods that have a short shelf life.

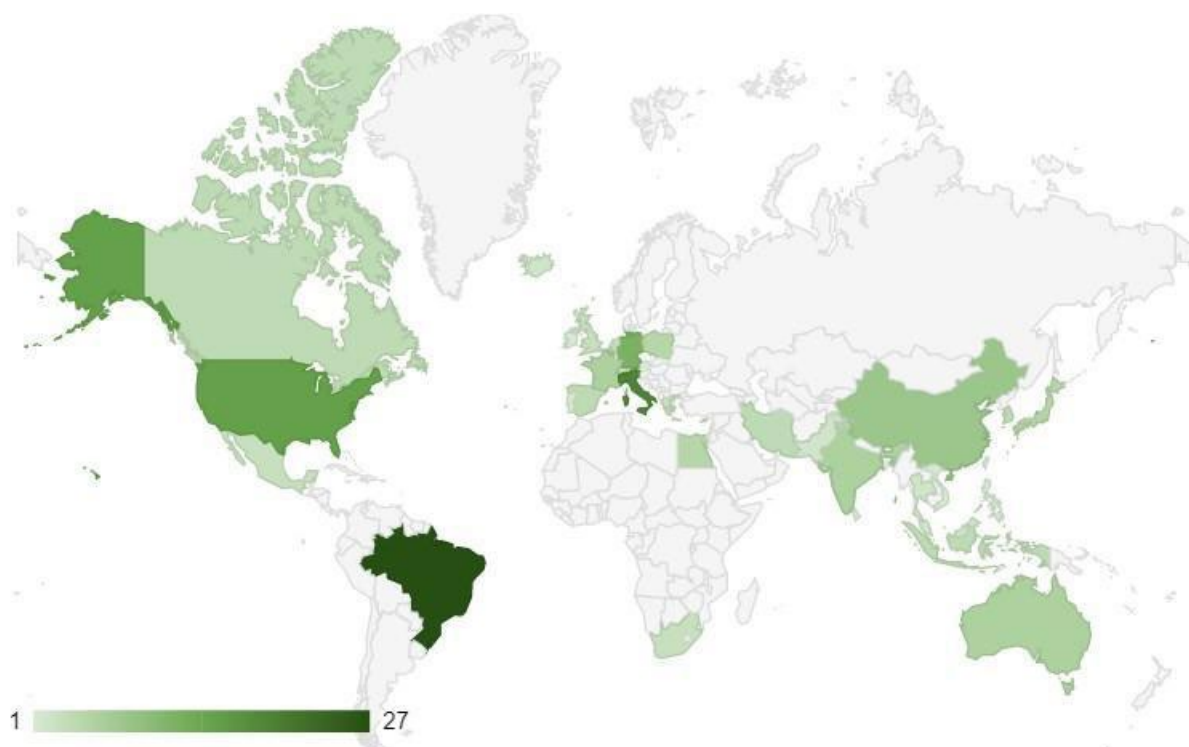


Figure 4. Number of studies selected and measured in the screening with the term “Nutrient Film Technique Hydroponics” worldwide from 2010 to 2019

CONCLUSIONS

- An increase in the number of international studies of NFT was observed in the last four years of the analyzed period, from 2016 to 2019, thus representing an increase in the interest in hydroponics, especially the NFT type.
- The NFT hydroponic system proves to be of great value in urban agriculture, due to its benefits, such as recycling water and nutrients, increasing productivity and reducing the carbon footprint. Furthermore, Brazil has shown itself to be largely responsible for the development of new studies on NFT.

AUTHORSHIP CONTRIBUTION STATEMENT

SILVA, M.G.C.: Conceptualization, Data curation, Formal Analysis, Investigation, Project administration, Resources, Visualization, Writing – original draft, Writing – review & editing; HÜTHER, C.M.: Conceptualization, Funding acquisition, Methodology, Project administration, Resources, Supervision, Validation, Visualization,

Writing – original draft, Writing – review & editing; RAMOS, B.B.: Conceptualization, Data curation, Formal Analysis, Investigation, Resources, Visualization, Writing – original draft, Writing – review & editing; ARAÚJO, P.S.: Conceptualization, Data curation, Formal Analysis, Investigation, Resources, Visualization, Writing – original draft, Writing – review & editing; HAMACHER, L.S.: Funding acquisition, Resources, Validation, Visualization, Writing – review & editing; PEREIRA, C.R.: Funding acquisition, Resources, Validation, Visualization, Writing – review & editing.

DECLARATION OF INTERESTS

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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