OPTIMIZING LETTUCE CULTIVATION IN THE NFT SYSTEM: INTEGRATIVE METHODS FOR SUSTAINABLE YIELDS. A REVIEW

OPTIMIZAREA CULTIVĂRII SALATEI ÎN SISTEMUL NFT: METODE INTEGRATIVE PENTRU RANDAMENTE SUSTENABILE

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Abstract. *Lettuce grown in the Nutrient Film Technology (NFT) system represents a significant evolution in modern agriculture, involving the continuous supply of nutrients and water to the plant roots through a thin film of nutrient solution in a controlled environment. Growing lettuce in the NFT system with additional water oxygenation is a significant advantage in high-quality food production. These systems combine hydroponic growth methods with additional water oxygenation to optimize plant development. To make the NFT system more sustainable, some producers have adopted renewable energy sources, such as solar panels, to power lighting and nutrient solution pumping, leading to a reduced carbon footprint of lettuce cultivation and minimized energy costs. To optimize the light cycle, LED lighting systems are used, which can be programmed to provide the plant with the exact amount and spectrum of light required at different growth stages. This allows cultivators to adjust the light spectrum to match the specific needs of lettuce plants, using red and blue LED spectra to stimulate vegetative growth and leaf development. By integrating LED lighting into the NFT system, lettuce producers can achieve consistent and high yields throughout the year. This approach ensures a constant supply of fresh lettuce and demonstrates how technology can play a crucial role in adapting agriculture to climate change and the consumption needs of society.*
Key words: hydroponic system, additional oxygenation, green salad, efficiency, sustainability

Rezumat. *Salata cultuvată în sistemul Nutrient Film Technology (NFT) reprezintă o evoluție semnificativă în agricultura modernă şi presupune furnizarea continuă a nutrienților și a apei către rădăcinile plantelor printr-un film subțire de soluție nutritivă, într-un mediu controlat. Creșterea salatei în sistem NFT cu oxigenare suplimentară a apei reprezintă un avantaj semnificativ în producția alimentară de înaltă calitate. Aceste sisteme combină metodele de creștere hidroponică cu oxigenarea suplimentară a apei pentru a optimiza dezvoltarea plantelor. Pentru a face sistemul NFT mai sustenabil, o parte din producători au adoptat surse de energie regenerabilă, precum panourile solare, pentru a alimenta sistemele de iluminat și pomparea soluției nutritive, acest fapt conducând la reducerea amprentei de carbon a culturii de salată și minimalizând costurile energetice. Pentru optimizarea ciclului de lumină sunt folosite sistemele de iluminare cu LED care pot fi programate pentru a*

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furniza plantei exact cantitatea și spectrul de lumină necesar în diferite stadii de creștere. Acest lucru permite cultivatorilor să ajusteze spectrul de lumină potrivit nevoilor specifice ale plantelor de salată, pot fi folosite LED-uri cu spectru roșu și albastru pentru a stimula creșterea vegetativă și dezvoltarea frunzelor. Prin integrarea iluminării LED în sistemul NFT, producătorii de salată pot obține randamente consistente și ridicate pe tot parcursul anului, Această abordare asigură aprovizionarea constantă cu salată proaspătă și demonstrează cum tehnologia poate juca un rol important în adaptarea agriculturii la schimbările climatice și la nevoile de consum ale societății.

Cuvinte cheie: sistem hidroponic, oxigenare suplimentară, salată verde, eficiență, sustenabilitate

INTRODUCTION

Lettuce is highly popular in global consumer markets, appreciated primarily for its leaves, often consumed raw in simple salads or in combination with various vegetables.

To maintain the nutritional value and properties of lettuce, it is essential to minimize its processing and consume it fresh (Cantwell and Kasmire, 2002).

The economic significance of lettuce stems from both modern technologies used to increase production per unit area, including the use of vertical farming, as well as the therapeutic benefits it offers (Despommier, 2010; Frazier, 2017; Avgoustaki and Xydis, 2020).

Regarding the therapeutic effects of lettuce, there is extensive research in the field. Indications suggest beneficial effects such as calming, diuretic, and laxative properties of lettuce (Targino *et al.,* 2019; Ribeiro, 2016).

The results of the research conducted by Harsha and his team in 2013 demonstrated that the extract of *Lactuca sativa* L. has a positive impact on free radicals and prevents oxidative damage to biomolecules.

Furthermore, the study conducted by Kim and his collaborators in 2016 revealed another important function of lettuce, namely its ability to contribute to lowering cholesterol levels and reducing markers specific to diabetes (Cheng *et al.,* 2014). It has also been found that lettuce can contribute to reducing the incidence of colorectal cancer (Qin *et al.*, 2018), both in traditionally cultivated lettuce and in hydroponic systems (Naseem and Ismail, 2022).

Additionally, lettuce extract plays a protective role against the hepatitis B virus (Cui *et al.,* 2017). The structure and content of vitamins and nutrients in lettuce vary depending on the cultivation environment and the stage of plant development, with maximum values reached in the early growth stages (Pinto *et al.,* 2014).

Furthermore, lettuce seeds also have therapeutic benefits and are used in traditional medicine for their anti-inflammatory properties (Sayyah *et al*., 2004). Varieties of lettuce, such as head lettuce, romaine, and leaf lettuce, are successfully cultivated in hydroponic systems (Kaiser and Ernst, 2012). Ohse *et al*. in 2009, along with Ryder in 1999, found that lettuce is the most cultivated vegetable in hydroponic systems. In these systems, the lettuce's life cycle is shorter compared to traditional cultivation systems. The Nutrient Film Technology (NFT) cultivation system is suitable for lettuce (*Lactuca sativa* L.) cultivation, and it is possible to achieve up to eight harvests in a calendar year (Fussy and Papenbrock, 2022). Research results have shown that the use of the NFT cultivation system can increase lettuce production by 6% - 10% (Frasetya *et al.,* 2021).

In Romania, although the cultivated areas for lettuce have decreased, the interest in soilless cultivation systems is on the rise because they offer multiple advantages, including the ability to achieve multiple cultivation cycles per year, higher yields, increased economic efficiency, guaranteed food safety, and phytosanitary security (Drăghici *et al.,* 2021). The most widespread hydroponic system for growing greens is the Nutrient Film Technology (NFT) system (Tabaglio *et al*., 2020). Lettuce is well-suited for cultivation in the NFT system, which helps reduce issues related to excessive water absorption by the plant. This is particularly important, given lettuce's sensitivity to salinity, regardless of the cultivation system used (Targino *et al.,* 2019).

Circulating hydroponic systems are divided into three categories: the NFT (Nutrient Film Technology) system, the DFT (Drip Flow Technique) system, and the NGS (New Growing System) system. The name "NFT" is derived from the abbreviation of the English term "Nutrient Film Technology," which translates into Romanian as "tehnica pe peliculă de nutrienți" (Resh, 2013; Goddek *et al.,* 2019).

The NFT (Nutrient Film Technology) cultivation system can be characterized as a network of channels, preferably made of plastic, through which the nutrient solution circulates in the form of a thin film, typically around 1-2 cm in thickness, hence its name "nutrient film" (Shanmugabhavatharani *et al.,* 2021).

MATERIAL AND METHOD

This literature review covers publications on hydroponic lettuce cultivation and is based on the Science Direct, Scopus, and Web of Science databases, as well as relevant books. The main criteria for publication selection were focused on the subject of improving modern technologies used to enhance production per unit area, including the use of vertical farming techniques.

RESULTS AND DISCUSSIONS

Various studies have highlighted the negative effects of salinity on lettuce plants, including a reduction in the number of leaves, leaf surface area, as well as the rate of photosynthesis; moreover, it affects the fresh plant weight and the roots (Al-Maskri *et al.,* 2010; Neocleous *et al*., 2014; Soares *et al*., 2015). Additionally, it has been found that the pH of the nutrient solution also has a significant impact on the development and growth of plants (Al Meselmani, 2022). Extending the lighting period from 16 to 24 hours, with an intensity of 100-200 $\mu mol/m^2/s$ (equivalent to 17 $mol/m^2/day$), during the winter season, results in increased plant biomass. This measure leads to a reduction in the crop cycle duration by approximately 25%. Additionally, extending the lighting period has been shown to reduce nitrate content in lettuce by 10-26% (Gaudreau *et al.,* 1994).

LED lighting allows for the adjustment of the light spectrum to match the plant's needs. Red (R) and blue (B) lights are beneficial for photosynthesis. Various studies have investigated the effect of spectral components R and B on physiological, biochemical aspects, and resource use efficiency in lettuce plants (Panter *et al*., 2016; Drăghici *et al.,* 2013). Based on research conducted using red and blue light spectra (RB) at levels of 0.5, 1, 2, 3, and 4, provided by LED lamps, compared to reference light from fluorescent lamps (with RB = 1) in six experimental variants, under controlled conditions (with PPFD = 215 µmol m−2 s−1) and a 16-hour day duration, it was found that LED lighting led to a 1.6-fold increase in biological yield and a 2.8-fold improvement in energy consumption efficiency compared to fluorescent lamps (Pennisi *et al.,* 2019). Lettuce plants thrive under optimal conditions when the dissolved oxygen concentration in the nutrient solution is at least 6 ppm.

Oxygenation of the nutrient solution is achieved through two main methods: nutrient solution recirculation and the introduction of air using air pumps. The level of dissolved oxygen in the nutrient solution can be measured with specialized sensors. The absence or reduction of oxygen concentration in the nutrient solution disrupts the root respiration process, which can lead to root suffocation and ultimately, plant death (Libia *et al.,* 2016). It has been observed that a nutrient solution flow rate of 1.5 liters per minute resulted in a greater increase in the vegetative mass of lettuce plants compared to flow rates of 0.75 liters per minute (Al-Tawaha *et al.,* 2018). Bateer *et al.* (2021) highlighted that moderate nutrient solution velocities did not have a negative effect on the roots, leading to better nutrient absorption.

CONCLUSIONS

1. The NFT (Nutrient Film Technology) system can be an efficient option for cultivating lettuce, providing multiple advantages in terms of resources, product quality, and environmental control. However, it must be managed carefully, and the initial costs and the need to acquire technical knowledge must be taken into consideration.

2. By continuously monitoring environmental parameters and system efficiency, opportunities for enhancing sustainability can be identified. This may involve adjusting nutrient concentrations, optimizing the lighting schedule, and improving water usage efficiency.

3. Sustainability in lettuce cultivation within the NFT (Nutrient Film Technology) system can be achieved through responsible resource management, the use of eco-friendly technologies, and the adoption of environmentally friendly farming practices. This approach not only reduces environmental impact but can also contribute to the production of healthier and more accessible long-term food options.

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