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THE INFLUENCE OF TECHNOLOGY ON CULTURE IN THE PRODUCTION OF LETTUCE IN THE NUTRIENT FILM TECHNIQUE SYSTEM: A REVIEW

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Abstract

The NFT (Nutrient Film Technique) technology is one of the hydroponic methods used for cultivating plants, including lettuce. In this system, the plant roots are suspended in a continuous flow of nutrient solution, which is pumped through an inclined channel or a thin tray. This thin flow of nutrient solution allows the roots to receive essential nutrients such as nitrogen, phosphorus, and potassium, along with other necessary substances for healthy plant growth. The system utilizes a minimal amount of water because the water and nutrients are constantly recirculated within the system, thus reducing waste and the need for irrigation. By precisely monitoring and adjusting the composition of the nutrient solution, growers can ensure that plants receive the optimal amount of nutrients to grow healthily and produce quality yields.

Key words: *hydroponic system, green salad, optimizing water input, recycling and resource conservation.*

INTRODUCTION

Lettuce, scientifically known as *Lactuca sativa* L., is a vegetable plant belonging to the Asteraceae family (previously known as Compositae). This plant family encompasses a variety of genera and species found worldwide. Among other plants in the same family, we can mention chicory (*Cichorium intybus* L.), sunflower (*Helianthus annuus*), and dandelion (*Taraxacum officinale*). Although numerous studies have demonstrated the superior performance of hydroponic systems compared to traditional ones, to date, only a few studies have compared different growth models in hydroponic systems. Additionally, hydroponic systems are often associated with protected cultivation, making it difficult to identify specific growth trends for these systems (de Anda & Shear, 2017). Researchers have concluded that hydroponic production can vary significantly depending on crops and environmental conditions (Gashgari et al., 2018). Lettuce is a cool-season crop with significant economic importance due to its capacity to generate income and is extensively cultivated worldwide, especially in temperate and subtropical regions (Mou, 2008; Kumar et al., 2010). Because of its nutritional value, lettuce can fetch higher prices in the market and, therefore, is traded extensively internationally (Abu-Rayyan et al., 2004). Despite the recent promotion of lettuce cultivation in protected conditions, production techniques have not yet been standardized (Kadayifci et al., 2004; Spehia et al., 2018).

The main challenge in lettuce production in greenhouses is standardizing growth systems to improve the quality and quantity of production while ensuring efficient water management and reducing environmental impact (Schwarz et al., 2009; Acharya et al., 2013).

Studies have shown that hydroponic growth systems can lead to an increase in leaf production (Barbosa et al., 2015; Petropoulos et al., 2016). However, there are concerns among consumers regarding nutritional quality, water consumption, and economic aspects that may hinder the expansion of hydroponics in the commercial sector. While the cultivated areas for lettuce have decreased in Romania, the interest in soilless cultivation systems remains high due to their numerous advantages. These include the ability to carry out multiple cropping cycles per year, achieving higher yields, improving economic efficiency, and ensuring food safety and phytosanitary standards (Drăghici et al., 2021). Circulating hydroponic systems are classified into three distinct categories. These include the Nutrient Film Technique (NFT), the Drip Flow Technique (DFT), and the New Growing System (NGS) (Resh, 2013; Goddek et al., 2019). The name of the NFT system derives from the abbreviation of the term "Nutrient Film Technique". This hydroponic system was developed in the late 1960s by Dr. Allan Cooper at the Glasshouse Crops Research Institute in Littlehampton, United Kingdom (Roberto, 2003). Over time, the NFT system has demonstrated its effectiveness and has been considered the most versatile in the field (Resh, 2022). The NFT cultivation system can be characterized as a network of channels (Shanmugabhavatharani et al., 2021), preferably made of plastic. Through these channels, the nutrient solution circulates in the form of a thin film, with a thickness of approximately 1-2 cm (Van Os et al., 2008), hence the name "nutrient film." In the channels of the NFT system, plant roots are integrated. In addition to plastic, the walls of these channels can also be made from other flexible materials to prevent light penetration and nutrient solution evaporation. The NFT system is designed as a closed-loop system, where the nutrient solution is recirculated within the culture using a supply reservoir (Sardare & Admane, 2013).

In the NFT system, plant roots are maintained in direct contact with the nutrient solution, which is constantly distributed using a submersible pump from the supply reservoir (Pradhan & Deo, 2019). In 1920, Dennis R. Hoagland developed a formula that forms the basis of the nutrient compositions used today, providing all the essential nutrients required for a nutrient solution compatible with the NFT system (Spehia et al., 2018). In modern times, soilless crops stand out due to their advanced technology and the diversity of systems used, which gives them versatility and the ability to produce remarkable results across a variety of plant cultures. The benefits of soilless systems are numerous and include efficient water usage, the possibility of water recycling, efficient fertilizer utilization, the creation of a controlled growing environment, increased disease and pest management capability, and reduced water consumption through recycling (Wignarajah, 1995; Jensen, 1981; Bradley & Marulanda, 2000; Resh, 2013).

The growing medium plays a crucial role in influencing production, leaf texture, and physiological characteristics of plants, as well as the importance of interaction between substrate and nutrient solution (Samarakoon et al., 2020). In unconventional cultivation systems, it is crucial for the nutrient solution to contain all essential nutrients for lettuce plant growth. A deficiency of these elements can lead to the onset of physiological issues that ultimately affect the quality of lettuce plants (Henry et al., 2019).

Various research studies have highlighted the adverse effects of salinity on lettuce plants, manifested by decreased leaf density (Al-Maskri et al., 2010), reduced leaf surface area and even photosynthetic capacity, as well as decreased fresh plant mass and root system impairment (Neocleous et al., 2014). Additionally, it has been found that the pH of the nutrient solution has a significant impact on plant development and growth (Al Meselmani, 2022). In cases where the temperature of the nutrient solution exceeds or falls below the permissible limits, it is observed that the growth and development of lettuce plants are affected (Thakulla et al., 2021).

In the context of hydroponic lettuce cultivation, it is recommended that nutrients be present in the nutrient solution at the following concentrations: 200 mg/L (ppm) of nitrogen (N), 50 mg/L (ppm) of phosphorus (P), 300 mg/L (ppm) of potassium (K), 200 mg/L (ppm) of calcium (Ca), and 65 mg/L (ppm) of magnesium (Mg) (Schon, 1992).

Lettuce plants develop optimally when the dissolved oxygen content in the nutrient solution reaches at least 6 ppm. Oxygenation of the nutrient solution can be achieved through its recirculation or by aeration using air pumps. The amount of dissolved oxygen in the nutrient solution can be monitored using specialized sensors. The absence or decrease in the level of oxygen in the nutrient solution can lead to the disruption of root respiration, causing their suffocation and ultimately the death of the plants (Libia et al., 2016). There are several factors that influence the root respiration of plants, including high temperature and salinity (Zinnen, 1988). In hydroponic crops, high temperatures of the nutrient solution and periods of elevated temperatures have a negative impact on plant development (Al-Rawahy et al., 2023). The oxygen deficiency in the root zone is a crucial factor (Fagerstedt et al., 2023). The lack or insufficiency of oxygen can affect the development of the root system and may even lead to its deterioration, resulting in plant drying (Boru et al., 2003). The additional addition of oxygen to the nutrient solution has increased the yields of plants cultivated in hydroponic systems (Soffer et al., 1991). A low oxygen content in the root zone can create favorable conditions for the occurrence of plant diseases (Cherif et al., 1997) and can promote infestation of the root system with pathogens such as *Phytophthora infestans* (Lal et al., 2018). It has been demonstrated that there is a direct connection between increasing the flow rate of the nutrient solution and increasing the concentration of oxygen in the root zone of plants.

MATERIALS AND METHODS

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

RESULTS AND DISCUSSIONS

Head, romaine, and leaf lettuce varieties are successfully cultivated in hydroponic systems (Kaiser & Ernst, 2012). Lettuce is the most cultivated plant in the greens category in hydroponic systems (Ohse et al., 2009; Ryder, 1999). In these systems, the lifespan of lettuce is shorter compared to traditional cultivation systems.

The NFT cultivation system is ideal for growing lettuce (*Lactuca Sativa* L.), even allowing for up to eight harvests within a calendar year (Fussy & Papenbrock, 2022). Research has shown that using the NFT cultivation system can lead to a 6% - 10% increase in lettuce yield (Frasetya et al., 2021). Various studies demonstrate that the lettuce plant is remarkably adaptable to different hydroponic cultivation systems (Jones, 2005; 2007 & Ryder, 1999). Additionally, it is important to note that in recent years, the areas dedicated to lettuce cultivation in soilless systems have seen a significant increase globally, according to data provided by the Food and Agriculture Organization of the United Nations (FAO).

The NFT hydroponic system is the most widespread in growing greens. Lettuce is particularly well-suited for cultivation in the NFT system. This system helps reduce problems associated with excessive water uptake by the plant, which is especially important for lettuce, a plant sensitive to salinity, regardless of the cultivation system used (Tabaglio et al., 2020). The presence of the nutrient solution at the root level can act as a barrier to gas exchange between roots and the environment (Suhl et al., 2019). Although oxygen deficiency may affect only certain parts of the root, it can disrupt its function (Morard & Silvestre, 1996). However, based on the results obtained, there is no justification for using a higher flow rate of the nutrient solution than 2.5 l/min (Stoica et al., 2022).

Considering the continuous flow of the nutrient solution in the NFT system, changes in the concentration of dissolved salts in the solution can occur. One of the advantages of the NFT system is its ability to allow plant cultivation at higher concentrations of salts compared to traditional soil-based crops (Dias et al., 2011; Burrage, 1998).

For growing lettuce in a hydroponic system, it is feasible to use nutrient solutions prepared with low-quality water or to recycle nutrient solutions. The use of alternative water sources

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and fertilizers can lead to a reduction in production costs in the hydroponic system (Azad et al., 2013), but there is a lack of information regarding proper nutrient solution management (Bugbee, 2003). Although liquid residues contain macro and micronutrients, the contents found can be limiting for plant growth,

CONCLUSIONS

In the context of modern agriculture, soilless cultivation systems, especially the Nutrient Film Technique (NFT) hydroponic system, represent an increasingly attractive solution for growing plants such as lettuce. Interest in these systems remains high as they offer numerous advantages, including the ability to conduct multiple cultivation cycles per year, achieving higher yields, increasing economic efficiency, and ensuring food and phytosanitary safety. In the NFT system, the nutrient solution circulates in the form of a thin film within the channels where plant roots are integrated. This system allows for efficient distribution of nutrients while maintaining a controlled growing environment. Furthermore, the recirculation of the nutrient solution contributes to efficient water usage and reduces fertilizer consumption. However, proper management of the nutrient solution is crucial for achieving quality production. The concentration of dissolved salts in the solution must be monitored and adjusted accordingly to avoid the adverse effects of salinity on plants. In conclusion, soilless cultivation systems, especially the NFT system, represent a promising technology for modern agriculture, offering significant benefits in terms of efficiency and sustainability of agricultural production. However, it is important to pay attention to aspects related to managing the nutrient solution and controlling the growing environment to ensure the success of growing plants such as lettuce. Cultivating lettuce in a hydroponic system offers multiple advantages, including the possibility of using nutrient solutions prepared with low-quality water or recycling nutrient solutions, which can reduce production costs. Indeed, there are still deficiencies in the proper management of the nutrient solution, which can have an impact on plant development. It is crucial to give special attention to this aspect to guarantee optimal plant growth and to prevent excessive accumulation or deficiency of nutrients. In conclusion, studies highlight the importance of proper management of the nutrient solution in hydroponic lettuce crops. Temperature, nutrient concentration, and oxygen level are critical factors for healthy plant development. The lack or decrease of oxygen level can lead to serious root system problems and can negatively affect plant growth and production. Additionally, it is essential for the nutrient solution to be adequately oxygenated to ensure optimal nutrient absorption by the roots. The study also highlights that a nutrient solution flow rate greater than 2.5 L/min is not justified and may lead to resource wastage. Overall, proper management of the growing environment and nutrient solution is crucial for achieving high-quality lettuce production in hydroponic systems.

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