Plant and Soil Science

Journal homepage: https://agriculturalscience.com.ua/en
Plant and Soil Science, 15(1), 41-51
Received: 02.11.2023 Revised: 05.02.2024 Accepted: 28.02.2024

UDC 635.5
DOI: 10.31548/plant1.2024.41

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Assessment of the development of Lactuca sativa Batavia Aficion in hydroponic and aquaponic systems

Abstract. The need to improve the methods of growing plants in hydroponic systems to ensure optimal conditions for their growth and achieve high yields is urgent. The purpose of this study was to compare the hydroponic production of Lactuca sativa Batavia Aficion using a conventional Knop nutrient solution compared to aquaponics using nutrient-rich fish water. Laboratory, potentiometric, and photometric methods were used for this purpose. The yield, biometric, and qualitative indicators of lettuce leaves were investigated. Despite the lower nutrient concentration in the aquaponic solution, the nutritional status of Lactuca sativa Batavia Aficion was within the optimal range. The nitrate content of lettuce grown in the aquaponics system was higher than in hydroponics, but there were no significant differences in the content of total N (3.24% and 2.97%), Mg (1,973 mg/kg and 1,943 mg/kg), Fe (93.91 mg/kg and 93.83 mg/kg), K (73.7 mg/kg and 73.6 mg/kg), and Ca (19.5 mg/kg and 20.1 mg/kg). The yield of Lactuca sativa Batavia Aficion on aquaponics was 2.8 kg/m^2 and 3.2 kg m^2 – on hydroponics, with a density of 36 plants per square metre. Water monitoring in the aquaponic system showed low concentrations of nitrates, phosphorus (P), potassium (K), and magnesium (Mg), but the proportion of mineral nutrients and pH were stable throughout the lettuce growing period. Lettuce leaves in the aquaponics system reached a fresh

Suggested Citation:

Poloviy, V., Kolesnyk, T., & Maiboroda, K. (2024). Assessment of the development of Lactuca sativa Batavia Aficion in hydroponic and aquaponic systems. *Plant and Soil Science,* 15(1), 41-51. doi: 10.31548/plant1.2024.41.

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weight of 80 g in 34 days, which is on average 13% less than lettuce leaves in the hydroponics system. The EC (electrical conductivity) values recorded in this study in a hydroponic system were between 1.2 and 1.5 cm/m. In the aquaponic system, EC has higher values due to the low rate of water replacement, contributing to greater growth and accumulation of solution ions. However, due to continuous recirculation in the water, the conditions become satisfactory for growing plants. The results obtained can contribute to the creation of more efficient and sustainable agricultural systems, reducing resource consumption and improving the resistance of cultivated crops to various stressful conditions

Keywords: electrical conductivity; yield; lettuce; nutrition; macro- and microelements

INTRODUCTION

Climate change on planet Earth, the devastation of fertile land in Ukraine caused by insufficient rainfall, and the use of pesticides, herbicides, and insecticides make it difficult to grow crops for food. Population growth and urban expansion create demand for products with less water and energy use. In urban areas, where there is a lack of available soil due to development, soil-free farming systems should be introduced.

During the period of military operations, most of the land is not suitable for agricultural use, which increases the demand for alternative types of crop cultivation. According to J. Lobo (2019), hydroponic cultivation improves crop growing technologies through minimal environmental impact, improved pest control, and high yields. As for aquaponics, compared to traditional agriculture, it produces 8 times more protein and vegetable crops. In addition, another advantage is the independence of production from environmental conditions, the possibility of an automated, controlled regime of growing conditions for almost any type of hydrobionts and agricultural plants (Singh, 2019).

One of the industries that produces food the fastest in the world is aquaculture. Between 2010 and 2018, global aquaculture production increased by 5.3% annually. Production increased from 57.7 million tonnes in 2010 to 82.1 million tonnes in 2018. It is expected that 186 million tonnes of fish will be consumed worldwide in 2030, and aquaculture will provide up to 50.2% of this demand (Summary report..., 2018).

The prospects of using both technologies in Ukraine and the positive environmental and economic conditions were discussed by Y.-T. Chu *et al.* (2023). They noted that there are various methods of hydroponics, such as drip irrigation techniques, film systems and root immersion systems, which help to precisely control the nutrition of plants and create optimal conditions for their growth. Hydroponics can be classified according to the typology of systems, such as soil-free irrigation, aeroponics or aquaponics, opening up wide opportunities for improving agricultural products and creating sustainable and efficient plant cultivation systems.

Aquaponics, according to S.O. Lavrenko *et al.* (2019), helps to reduce the use of chemical fertilisers and water treatment chemicals, making this system environmentally friendly. It contributes to the conservation of water resources, as the water in the system circulates and is processed, providing optimal conditions for plant growth and fish health. In addition, aquaponics can be implemented even in limited spatial conditions, making it an excellent option for urban farming and sustainable development. This reasonable combination of fish and crop production contributes to the development of a balanced ecosystem approach to food production, where the interaction between components contributes to high productivity and reduces the negative impact on the environment.

Aquaponic nutrient solutions are not as easy to maintain as hydroponic solutions. Aquaponics is influenced by many factors, such as fish feeding rate, hydraulic loading rate, and pH. The study by B. Matysiak *et al.* (2023) showed that despite the low mineral content of aquaponic solution, the mineral content of medium-type lettuce leaves was within the optimal range. Z.M. Nadia *et al.* (2023) found that tilapia fish is commonly used in aquaponics to study yield.

T. Yang & H.J. Kim (2019) investigated the effect of hydraulic load velocity on spatial and temporal characteristics of water quality and crop growth and yield in aquaponics systems, which is an urgent problem in modern agroecology. The results have helped to improve plant cultivation technologies and aquatic bioresources, contributing to the efficient use of resources and environmental conservation. Understanding this impact helped to optimise the management processes of aquaponic systems to achieve more sustainable and efficient agricultural products. S. Wongkiew *et al.* (2017) proved that the use of aquaponic systems for sustainable resource recovery is a hot topic in modern science. Combining nitrogen transformation processes with microbial communities in such systems opens up opportunities for a deeper understanding of ecosystem processes and optimising their functioning. This ensures sustainable food cultivation and efficient use of resources, and reduces the negative impact on the environment. These technologies have potential and will play a significant role in food production in the future.

The goal was to compare the cultivation of Lactuca sativa Batavia Aficion on hydroponic and aquaponic systems. To achieve this goal, it was necessary to conduct an experiment to determine the possibility of obtaining a proper harvest and high quality of lettuce leaves.

MATERIALS AND METHODS

The study was conducted in June-July 2023 in the educational and scientific laboratory of cyclic aquatic agroecosystems of the National University of Water and Environmental Engineering. One variety of lettuce was used – Batavia Aficion. Lettuce seedlings were grown in a coconut substrate for two weeks and placed on aquaponics and hydroponics on June 2, 2023, on specially designed floating expanded polystyrene boards (0.9 m×0.6 m) with holes (12 pcs. on a raft with a planting density of 36 seedlings per square metre. To meet the nutrient concentration targets, high-purity mineral salts were added to the hydroponics system according to the Knop recipe (Kotsyuba, 2006), which contained N – 200 mg/l, P – 62 mg/l, K – 150 mg/l, Ca – 210 mg/l, Mg – 50 mg/l, S – 70 mg/l, Fe – 2.5 mg/l, Mn – 0.62 mg/l, Mo – 0.03 mg/l, Zn – 0.09 mg/l, Cu – 0.5 mg/l, B – 0.44 mg/l, which was filled with settled water with a volume of 350 litres. The water used in both systems had the following levels: pH – 6.3; EC (electrical conductivity) ranged from 1.2 to 1.5 mmS/cm, remaining within the limits necessary for good salad development; hardness – 6.5 mmol/dm^3; nitrites – 0.18 mg/dm^3; sulphates – 11.6 mg/dm^3; chlorides – 7 mg/dm^3; phosphates – 1.04 mg/dm^3; nitrates – 9 mg/dm^3. HCl and Na_2CO_3 were added to regulate the pH. The temperature was at 25°C, the humidity was 75%, and the photoperiod was 17 hours. Dissolved oxygen was maintained at more than 6 mg/l to support nitrification and fish growth in the aquaponic system (Tyson *et al.*, 2004). *Clarias gariepinus* (African sharptooth catfish) was used in aquaculture because of its high productivity indicators, fastidiousness to the conditions of maintenance and easy adaptation to their changes, good consumption of any feed, and resistance to various diseases (Ola-Oladimeji *et al.*, 2016). With an average planting density of 90.6 kg/m^3 with a total volume for growing of 5.1 m^3, this resulted in a total fish biomass of 462.1 kg. Nitrates in fresh plant material were determined by the potentiometric method. The content of other components was determined from dried plant raw materials. The content of P, K, Ca, Mg, Fe, Mn, Cu, Zn, and B was determined photometrically. The nitrogen content was analysed using the Kjeldahl method (Latimer, 2012).

The macronutrient content in water was analysed using Lasa Agro 1900 spectrophotometer (Germany). The following methods were also used to study water quality: measuring the concentration of nitrate ions by photocolourimetric method (Measurement Methodology No. 081/12-0651-09, 2010), measurement of the mass concentration of ammonium ions by photocolourimetric method with Nesler reagent (Measurement Methodology No. 081/12-0106-03, 2010), measurement of the mass concentration of chlorides by titrimetric (Measurement Methodology No. 081/12-0653-09, 2010), and measurement of the mass concentration of calcium and magnesium by titrimetric method (Measurement Methodology No. 081/12-0644-09, 2010). During the first experimental week, only half the amount of salts was added to limit EC and allow the seedlings to adapt to the nutrient solution and avoid osmotic shock. Hydrogen pH and ppm mineralisation, electrical conductivity, and temperature were monitored regularly (every 4 days).

When harvesting lettuce from the systems, the weight of shoots and roots was analysed using one-way variance analysis (Anova). The plant growth index NDVI (normalised differential vegetation index) was also calculated. Lactuca sativa Batavia Aficion was collected when it reached commercial maturity, i.e., 34 days after transplanting, after which the air-dry and absolutely dry weight of the plant , the number of leaves, the height and width of the plant, the volume of the root system, and the biomass of the plant were determined. During the study, the Convention on Biological Diversity (1992) and Convention on the Trade in Endangered Species of Wild Fauna and Flora (1973) standards were observed.

RESULTS AND DISCUSSION

The assessment of development in hydroponic and aquaponic systems included a comprehensive investigation of various aspects of these innovative agricultural production methods. First, the key aspect is plant productivity, which is important to evaluate in terms of parameters such as height, number of leaves, root system weight, and yield. In hydroponic systems, it is important to consider optimal nutrient levels and control their concentration. In addition, in the case of aquaponics, where the interaction of fish and plants plays an important role, the influence of fish on plant development and the quality of the grown product should be evaluated. Water parameters such as pH, electrical conductivity, and nutrient concentration determine the effectiveness of these systems and their environmental safety. In addition, the assessment of development in hydroponic and aquaponic systems involves monitoring the biological environment, including the state of microorganisms in the root environment of plants. Understanding the diversity and activity of microorganisms helps to ensure optimal conditions for biological filtration and ecosystem maintenance, ensuring the sustainability and effectiveness of these innovative agricultural practices.

In addition, it is important to evaluate the economic performance of hydroponic and aquaponic systems. Analysing inputs and outputs, determining the costs of maintaining the systems and the profitability of growing plants and fish, allows assessing the effectiveness of these methods in terms of financial decision-making. A significant part of the assessment should focus on sustainable development and environmental safety. Determining the impact of these systems on the environment, in particular water resources and biodiversity, helps to determine their suitability for sustainable use in practice. This assessment should also consider technological aspects, such as automation and monitoring of systems that can affect production efficiency and reduce risks in hydroponics and aquaponics systems. A comprehensive assessment of these aspects helps not only to understand the current state of hydroponic and aquaponic systems, but also to develop strategies to further improve their productivity, environmental safety, and economic sustainability.

Analysis of water in a hydroponic system showed a good balance of mineral nutrients, since the content of N-NH_4^+(at the beginning of the experiment – 0.29 mg/dm^3 and at the end – 0.14 mg/dm^3), P (respectively 0.34 mg/dm^3 and 0.16 mg/dm^3), K (3.5 mg/dm^3 and 3.1 mg/dm^3), Ca (142 mg/dm^3 and 143 mg/dm^3) and Mg (27.6 mg/dm^3 and 26.8 mg/dm^3) remained at the same level throughout the entire growing period of Lactuca Batavia Aficion. Relative to the aquaponic system, the average macronutrient content is NO_3 – 4 mg/l, P – 3 mg/l, K – 20 mg/l, Ca – 143 mg/l, Mg – 29 mg/l. Copper as a component of enzymes is involved in photosynthesis and the synthesis of carbohydrates and protein. The copper content of water in the hydroponic system was five times higher than in aquaponics. PH affects the solubility and toxicity of chemicals and heavy metals, and the ability of plants to absorb them, so it is necessary to adjust and control the ideal pH range.

At the beginning of the experiment, there was a normal pH, but there was a slight decrease (6.1) due to the addition of new water with a low pH. Then it rose again until it reached pH 7.1, which leads to precipitation of nutrients and other chemical compounds.

For an aquaponic system, the pH values range from (7.0-8.0). As can be seen from Figure 1, the pH starts at 7.0, which is normal and ideal for this system, after a while the PH increased sharply (8.2), which is associated with the accumulation of waste and chemicals in the water that are produced by fish and other microorganisms.

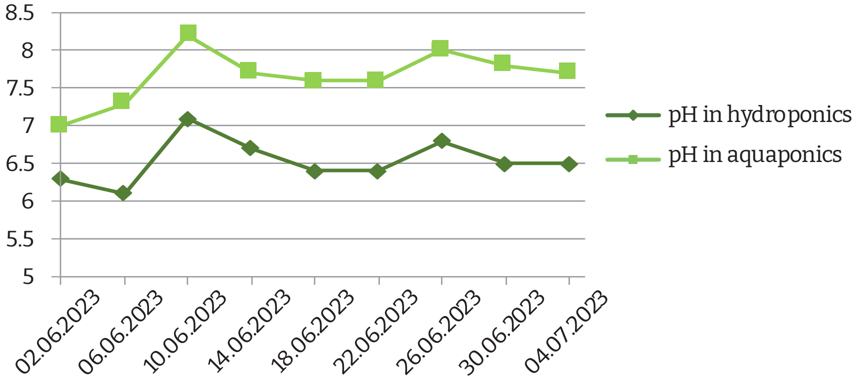

Figure 1. pH value of aquaponic and hydroponic systems

Source: compiled by the authors

From the hydroponic system, it ranged from (1.2-1.5 S/m). These values are in the ideal range, especially for growing lettuce. In fact, the EC was slightly high at the beginning (1.7), and to avoid any further increase, the solution was replaced and diluted. After about 12 days and with increased plant growth, the EC values decreased and remained stable. This can be explained by the absorption of chemicals and nutrients from the water, as plant growth has increased dramatically at this stage, which requires a large amount of nutrients and ultimately leads to low EC. In the aquaponic system, EC values ranged from (1.2-1.8 S/m).

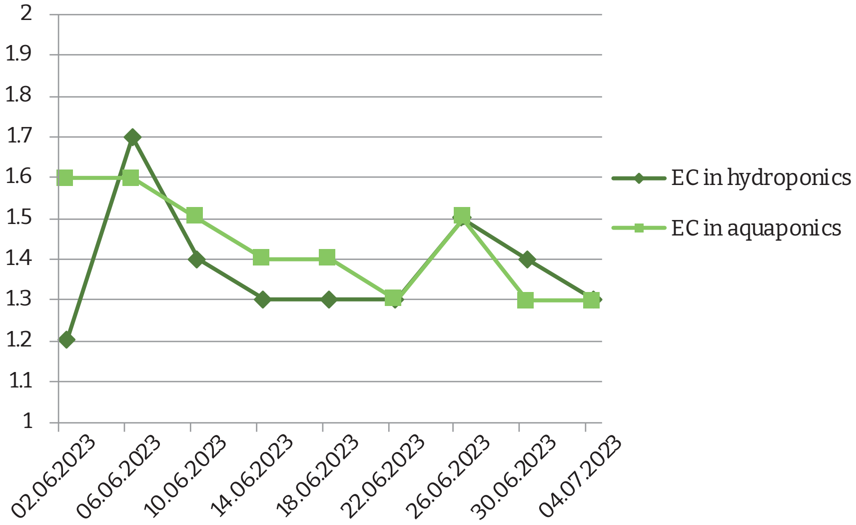

Figure 2. Electrical conductivity (S/m) in hydroponic and aquaponic systems

Source: compiled by the authors

The studied morphological characteristics of lettuce showed that the yield of leafy lettuce grown on hydroponics is better than on aquaponics. Lactuca sativa Batavia Aficion reached fresh weights of 93 g and 80 g in hydroponics and aquaponics and developed 20 and 17 leaves, respectively. The height of the largest (leaf length was taken into account together with the length of the root system) plant in hydroponics was 60 cm, aquaponics – 48 cm. The maximum volume of the lettuce root system in hydroponics was 55 ml, in aquaponics – 45 ml. The results of air-dry plant biomass with a maximum weight of 55 g in hydroponics and 44 g in aquaponics were also obtained, including absolutely dry plant biomass with a maximum weight (samples were dried in a drying oven at 65˚C for 4 hours for two days) in hydroponics – 54 g, in aquaponics – 42 g. Based on the calculation of the plant growth index, the average daily growth rate was established (the difference between measuring the plant size at the end of the experiment and at the beginning, divided by the number of days between measurements), in hydroponics lettuce grew – 2.2 cm, aquaponics – 1.9 cm daily.

The accumulation of nutrients by plants did not differ significantly between the systems. By nitrate content (2,742 mg/kg – hydroponics, 2,263 mg/kg – aquaponics), total N (3.24% and 2.97%), Fe (93.91 mg/kg and 93.83 mg/kg), K (73.7 mg/kg and 73.6 mg/kg), and Ca (19.5 mg/kg and 20.1 mg/kg) content. Magnesium is part of chlorophyll, the main pigment of green plants that provides photosynthesis, a process that is key to life on Earth. Magnesium is the leading atom in the structure of chlorophyll and plays a critical role in converting solar energy into chemical energy necessary for plant growth and development. In addition, magnesium is one of the most important mineral elements for many biochemical processes in living organisms, including the activation of enzymes and the regulation of cell function. Regarding its content, higher values were recorded in the hydroponic system – 1,973 mg/kg, compared to the aquaponic system – 1,943 mg/kg. The sulphur content in the leaves was almost twice as high in the aquaponic system (18.3 mg/kg) as in the hydroponic system (8.6 mg/kg). This is due to the fact that sulphur deficiency is rarely observed in aquaponic systems, and it is mainly present as a soluble sulphate anion (SO_4^{2-}). Sulphate is absorbed directly by the plant and plays an important role in the synthesis of numerous amino acids, proteins, and oils.

To ensure optimal access of lettuce roots to nutrients in the hydroponic system, it is recommended to keep the pH range in the range of 6.0-6.5, since even a slight increase in the pH level to 7.0 can lead to a decrease in the fresh and dry weight of plants. In aquatic aquaculture systems, the ideal pH is in the range of 7.0-8.0, and for nitrifying bacteria, the optimal pH is about 7.5 for efficient conversion of ammonia to nitrates (Suhl *et al.*, 2016). In aquaponics, the key step is nitrification, which converts toxic ammonia (NH_3) to nitrates (NO_3^-) for absorption by plants. When the pH level increases above 7.0, most phosphorus forms insoluble compounds, and from 30% to 65% of this element remains in fish sediments, which cannot be used by plants. In addition, if the pH values are higher than 6.5, plants will face a complicated process of absorbing trace elements such as iron, copper, zinc, boron, and manganese.

According to T. Asao (2012), the use of hydroponics as a standard methodology for research in plant biology is widespread. Hydroponics involves growing plants without soil, providing the necessary nutrients directly through the solution. This controlled and soil-free environment allows researchers to precisely regulate various factors, which contributes to the standardisation of methodologies in plant biology research.

T.S. Anderson *et al.* (2017) studied the growth response and elemental composition of Batavia lettuce fibres (Lactuca sativa, Flandria variety) under hydroponic conditions, in particular, by investigating changes in pH and alkalinity levels. By experimenting with different pH and alkalinity levels in a hydroponic environment, the researchers aim to understand how these environmental factors affect the overall growth and elemental composition of plant tissues. The experiment examines the effect of different levels of acidity (pH) and alkalinity on parameters such as plant height, leaf development, and the concentration of essential elements in lettuce fibres. This analysis is important for optimising hydroponic cultivation practices, as it provides conclusions about ideal conditions for maximising the growth and nutritional quality of Batavia lettuce.

The aquaponics system is considered to be one of the most productive in agricultural production, but its efficiency and yields are still insufficiently studied compared to hydroponics, which is one of its alternatives. Researchers, including B. Delaide *et al.* (2016), conducted a comparative study that analysed the yield of shoots and roots, and the nutrient content of lettuce grown in conventional hydroponic solutions and under aquaponic conditions. They concluded that aquaponics systems can outperform hydroponics in terms of growth and productivity. This study compared aquaponics with hydroponics to test this, because a number of studies have shown that a nutrient solution in hydrocultural media is better and more successful in growing lettuce and plants are mostly stress-free because water and nutrients are always available.

This study found that the water in the aquaponics system was deficient in nitrogen, phosphorus, and potassium, but at the same time had adequate levels of calcium and magnesium, which came from tap water used to fill aquariums. According to A. Graber & R. Junge (2009), aquaponics solution contains three times less nitrogen, 10 times less phosphorus, and 45 times less potassium compared to hydroponics solution. G. Rafiee & C.R. Saad (2005) and Z. Schmautz *et al.* (2015) confirm that the main source of phosphorus in aquaponics is fish feed, although only 15% of the phosphorus from the feed is consumed by fish, and plants can absorb phosphorus from aquaculture.

J.E. Rakocy (2012) and H.R. Roost (2014) argue that fish feeds also contain certain trace elements, but the amount of potassium (K), iron (Fe), magnesium (Mg), manganese (Mn), and copper (Cu) in them is limited. Despite this, it was possible to achieve a satisfactory yield of lettuce – 2.8 kg/m^2 in the aquaponics system and 3.2 kg/m^2 in the hydroponic system, with a density of 36 plants per square metre. This demonstrates the effectiveness of both systems in growing plants and highlights the potential of aquaponics to provide a sustainable crop with a limited content of certain nutrients in the water.

E. Pantanella *et al.* (2012), E. Alcarraz *et al.* (2018) previously reported higher yields in aquaponics compared to hydroponics, even at lower concentrations of mineral nutrients. However, the current study found that the growth and yield of lettuce grown in aquaponics was lower than in hydroponics. Factors that can affect the yield of aquaponic lettuce include the level of electrical conductivity (EC), pH, concentration and ratio of nutrients in the water for fish, water quality, water temperature, and the composition of the nutritious diet for fish. T. Yang & H.J. Kim (2020) investigated the effect of different levels of hydraulic loading on the spatial and temporal characteristics of water quality, and on plant growth and yield in aquaponics systems. By changing the hydraulic load, researchers aim to study its effect on the distribution of water quality parameters in the system in space and time. In addition, the paper examines how these changes affect the overall growth and productivity of plants in aquaponics. E.A. van Os *et al.* (2002) described that the method of hydroponic cultivation of vegetables and ornamental plants can effectively control the growth environment of plants, providing them with the necessary nutrients in optimal concentrations.

W.A. Lennard & B.V. Leonard (2004) compared two methods of fluid circulation mutual movement and constant flow in an integrated aquaponics system with a gravel bed. These two methods were evaluated for their effectiveness and impact on the growth and health of plants and fish. As a result of the study, it was found that the system with mutual fluid movement showed better indicators of plant growth and fish development compared to the constant flow system. The analysis showed that the mutual movement of fluid contributes to better circulation of nutrients and oxygen, which contributes to an overall increase in system performance. These results highlight the importance of optimising fluid circulation to improve the efficiency of aquaponic gravel bed systems.

S. Wongkiew *et al.* (2017; 2018) focused on aquaponic systems as a means of sustainable resource recovery, in particular, investigating the relationship between nitrogen transformations and microbial communities to uncover the complex relationships between nitrogen transformations, which are key to nutrient cycling in aquaponic ecosystems, and diverse microbial communities. Nitrogen plays an important role in aquaponics, being converted from fish waste (ammonium) to forms that can be absorbed by plants (nitrate), which contributes to the overall stability and efficiency of the system.

Leafy vegetables such as lettuce contain significant amounts of natural nitrates, which can pose a risk to human health. The study by M. Iammarino *et al.* (2014) includes systematic monitoring of nitrite and nitrate levels in leafy vegetables, particularly spinach and lettuce, to contribute to the risk assessment associated with their consumption. Nitrites and nitrates are essential components for plant nutrition, but their accumulation in the edible parts of vegetables can pose a potential health risk to consumers. By regularly evaluating and quantifying the levels of nitrites and nitrates in spinach and lettuce, researchers aim to understand changes over time and identify possible factors that affect their concentrations. This monitoring process is important for assessing the safety of consuming these leafy greens, as increased levels of nitrites and nitrates are associated with negative health effects, especially in certain cancers.

Comparing both systems, this study showed that aquaponics produces lower yields. In the future, special attention should be paid to the microbiota present in both water and the rhizosphere; it can be assumed that they contain effective rhizobacteria and/or fungi that promote growth and supplement the aquaponic solution with minerals for greater yield. In addition, it can be concluded that the effectiveness of aquaponics without additional minerals depends on plant genotype.

CONCLUSIONS

Under optimal conditions in the laboratory, including light and temperature, a satisfactory yield and quality of Lactuca sativa Batavia Aficion was obtained in the aquaponics system with a deep culture module after 34 days of aquaponics cultivation – 2.8 kg/m^2 and in hydroponics – 3.2 kg/m^2. Production of Lactuca sativa Batavia Aficion using a hydroponic system with a nutrient solution according to Knop's recipe yielded a 40% higher yield. This is conditioned by free access to nutrients and easy root growth in a hydroponic solution. The development of Lactuca sativa Batavia Aficion in the aquaponic system requires a slightly longer period due to the fact that it mainly depends on the amount, quality, and rate of transformation of fish waste by the microbiome, which are organic materials and usually take time to decompose by microorganisms. The aquaponic solution had a low mineral content,but despite this, the mineral content of lettuce leaves was within the optimal range (the nitrate content of lettuce grown in the aquaponic system was higher than in hydroponics, but there was no significant difference in the content of total N (3.24% and 2.97%), Mg (1,973 mg/kg and 1,943 mg/kg) and Fe (93.91 mg/kg and 93.83 mg/kg), K (73.7 mg/kg and 73.6 mg/kg) and Ca (19.5 mg/kg and 20.1 mg/kg), and the nutritional value was similar to lettuce, which was traditionally grown in a greenhouse).

Further study may include expanding the research area to other plant varieties or species to determine whether the approaches and results obtained remain effective across crops. It is also worth investigating the effect of other nutrient solutions or aquaponic systems on the cultivation of Lactuca sativa Batavia Aficion and studying the optimal conditions for better growth and yield. In addition, a detailed analysis of the interaction between plants and fish in the aquaponic system can be performed to improve relationships and optimise processes. Such further research will help to expand the understanding of the optimal conditions for hydroponic and aquaponic cultivation of Lactuca sativa Batavia Aficion and may be important for practical applications in agriculture.

ACKNOWLEDGEMENTS

The authors express their gratitude to the managers, experts, participants and organisations that funded the TENOR (Towards the circular EcoNomy in Organic faRming) project, which funded the establishment of the educational and scientific laboratory of cyclic aquatic agroecosystems at the National University of Water and Environmental Engineering, which became the basis for the research presented in this paper.

CONFLICT OF INTEREST

None.

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Оцінка розвитку Lactuca sativa Batavia Aficion в гідропонній та аквапонній системах

Анотація. Потреба удосконалення методів вирощування рослин у гідропонних системах забезпечення оптимальних умов для їхнього росту та досягнення високих врожаїв є актуальною. Мета цього дослідження полягала в тому, щоб порівняти гідропонне виробництво Lactuca sativa Batavia Aficion з використанням звичайного поживного розчину Кнопа в порівнянні з аквапонікою з використанням багатої поживними речовинами рибної води. Для цього були використані лабораторний, потенціометричний та фотометричний методи. Досліджено врожайність, біометричні та якісні показники листя салату. Незважаючи на нижчу концентрацію поживних речовин в аквапонічному розчині, поживний статус Lactuca sativa Batavia Aficion був у межах оптимального діапазону. Вміст нітратів в листі салату, вирощеного у системі аквапоніки був вищим ніж у гідропоніці, проте не було виявлено істотної різниці за вмістом загального N (3,24 % та 2,97 %), Mg (1973 мг/кг та 1943 мг/кг) та Fe (93,91 мг/кг та 93,83 мг/кг), вміст K (73,7 мг/кг та 73,6 мг/кг) і Ca (19,5 мг/кг та 20,1 мг/кг). Врожайність Lactuca sativa Batavia Aficion становила на аквапоніці – 2,8 кг/м^2 та 3,2 кг/м^2 – на гідропоніці, при щільності 36 рослини на метр квадратний. Моніторинг води в аквапонічній системі показав низьку концентрацію нітратів, фосфору (P), калію (K) і магнію (Mg), але частка мінеральних поживних речовин, а також pH були стабільними протягом усього періоду вирощування салату. Листя салату в системі аквапоніки за 34 дні досягли свіжої ваги 80 г, що в середньому на 13% менше, ніж листя салату в системі гідропоніки. Значення ЕП (електропровідність) зареєстровані в цьому дослідженні у гідропонній системі були між 1,2 і 1,5 См/м. В аквапоній системі, ЕП має вищі значення через низьку швидкість заміни води, сприяючи більший ріст і накопичення іонів розчину. Однак за рахунок безперервної рециркуляції в воді, умови стають задовільними для вирощування рослин. Отримані результати можуть сприяти створенню більш ефективних та стійких агрокультурних систем, зменшуючи споживання ресурсів і покращуючи стійкість вирощуваних культур до різних стресових умов

Ключові слова: електропровідність; врожайність; салат листовий; живлення; макро- та мікроелементи