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COMPARATIVE STUDY ON THE GROWTH AND DEVELOPMENT OF LETTUCE (*LACTUCA SATIVA LOLLOBIONDA*) IN AQUAPONIC SYSTEM AND HYDROPONIC SYSTEM

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Abstract

The study was designed to investigate the effect of the two systems (aquaponic and hydroponic) on lettuce yield and quality. The experiment was conducted within the laboratory C01 Environmental Sciences, FIFIM. The two systems were monitored weekly through the following parameters: pH, CE, NH4, NO2, NO3, KH, PO4 using colorimetric kits named, JBL test. Regarding the growth and development of the lettuce, the length of the lettuce was measured every three days. In addition to measuring the growth of the leaves, the lettuce was also analyzed in the form of dry substance. As a result, it was proved that at pH values were generally between 6.5-8.4 pH and CE between 1.37-1.43 dS / m-1. For the aquaponic tank, the concentration of nitrates decreased from 240mg / l to 60mg / l and phosphates at 3.6 - 2.0 mg / l. This results in a good absorption of the roots of the lettuce plant. In comparison to the hydroponic system, where the concentration of nitrates and phosphates was higher. in the hydroponic system, the lettuce had an average growth of two cm every three days, and in the aquaponic system it had an average growth of three cm every three days.

Keywords: *aquaponic, comparison, hydroponic, lettuce.*

INTRODUCTION

Plant cultivation integrated with fish farming in a water recirculation system, is an aquaponic production system. It is a technique successfully used in many countries, including the United States, Australia, and also in European countries. In Romania, there are no reports on commercial production in the aquaponic system, but there are three existing functioning systems in Focsani, Snagov and Timisoara. However, due to system characteristics such as low water consumption, reduction of environmental impact, production of two sources of income in a single system, it becomes necessary to carry out studies that provide information to enable implementation of the of this system.

Aquaponics is the combined fish and plant culture in recirculation systems (combines hydroponics with aquaculture), that is, it involves a method of plant growth in a soil-free system, but instead of element-added water, it uses natural nutrients from fish. In the aquaponics system, the characteristics of materials used as a substrate directly affect plant growth, because in addition to acting as a support base it must present a surface to fix microorganisms responsible for the conversion of nutrients into forms more easily accessible to plants. The aquaponic system is a way of cultivating vegetables in a non-nutritional bio-nutrient system in which plants take their nutrients from fish.

Aquaponics consists of a set of agricultural technologies that sustainably integrate intensive fish farming into a water recirculation system with hydroponics (Roosta and Afsharipoor, 2012). Such integration enables the conditioning of water for fish farming through the cultivation of plants and, at the same time, with water recirculation, the use of residues generated in fish farming and plant cultivation (Ihejirika et al., 2012; Geisenhoff et al. , 2016). This system behaves as a symbiotic relationship, in which fish provide the nutrients for plant cultivation (Martins et al., 2010; Roosta and Afsharipoor, 2012) and plants remove the metabolites present in the water, which are harmful to the fish, allowing their development (Hundley et al., 2013). Water recirculation between fish farming and plant cultivation provides conditions for optimization of both activities, so that, during recirculation, the characteristics of water and fish farming are monitored and conditioned (Dalsgaard et al., 2013). As a result, fish farming and plant cultivation occur under adequate conditions resulting in a product with a high standard of commercial quality (Dediu et al., 2012; Geisenhoff et al., 2016).

Hydroponics is a way to grow plants without using soil. In a hydroponic system rooting elements such as clay, vermicelli, perlite and gravel are used, because not all plants have the ability to grow in water due to the lack of oxygen in the roots. Also, there are other important parameters for plant development, such as light, CO2 levels, etc. The hydroponic system is a way of cultivating plants in a pool of water, in which the plants grow in a controlled environment. The difference being that in this system we need to add micro and macro elements to feed nutrient plants.

In the aquaponic system, the role of the substrate has a higher importance compared to the hydroponic system, because in contrast to the latter, in which the soluble nutrients added to the water are adequate for use by plants (Pôrto et al., 2012), in aquaponics , the nutrients need to be converted into easily available forms, such as organic nitrogen, which through the action of microorganisms is converted into ammonia, which is later transformed into nitrate through the action of nitrifying bacteria (Tokuyama et al. al., 2006). Thus, the substrate for aquaponics has an additional function acting as an adequate base for the fixation of microorganisms (Hoque et al., 2012). Considering the importance of the use of an appropriate substrate in aquaponic plant cultivation, this study aims to assess the effect of four growing substrates on the yield of lettuce cultivated in aquaponic systems.

MATERIALS AND METHOD

Our aquaponicsystems consists of (Figure 1):

- rearing tank for raising and feeding the fishes (47x30x42cm, V=62cm^3)
- biofilter, a place where the nitrification bacteria can grow and convert ammonia into nitrates; biofiltration material with a high specific surface(600 m^2/m^3), is represented by expanded clay aggregates
- a pump that flow back the water to the rearing tanks (model EHEIM compact 300, with following characteristics: capacity 150-300 l/h, total head- 0.5, power- 5W)

Figure 1. Aquaponic and hidroponic system

Our hydroponic systems consists of (Figure 1)

- tank of nutritional elements (59x30x20cm, V=35cm^3)
- biofiltermaterial with a high specific surface(600 m^2/m^3), is represented by expanded clay aggregates
- a pumpthat flow back the water to the rearing tanks (model EHEIM compact 300, with following caractetics: capacity 150-300 l/h, total head- 0.5, power- 5W)

Live components:

- *Animals* – freshwater fish – *Carassiusauratus* (5 pieces) and *Hypostomusplecostomus* (2 pieces);
- *Plants* – our hydroponic and aquaponic system will include lettuce (Figure 2).

Figure 2. Lactuca sativalollobionda

For the hydroponic system, a standard nutritional solution of micro and macro-elements was used with the following composition:

Macroelements:
- Calcium nitrate ($CaNO_3$) 2700g;
- Iron (Fe) 60g;
- Ammonium nitrate (NH_3NO_3) 75g;
- Potassium Nitrate (KNO_3) 1650g;
- Potassium Sulphate (KSO_4) 225g;
- Nitrogen, Phosphorus, Potassium (NPK) 240g;
- Magnesium Sulphate ($MgSO_4$) 930g

Microelements:
- Magnesium (Mg) 0.60g;
- Bor (B) 0.90g;
- Zinc (Zn) 0.30g;
- Copper (Cu) 0.45;
- Molybdenum (Mo) 0.30g

For both systems, the following parameters were determined and monitored weekly: pH and CE (potentiometric method with multiparameter kit WTW), NH_4 +, NO_2-, NO_3-, KH, PO_4 using the JBL colorimetric test kits. Regarding the growth and development of the lettuce, the length and length of the salad were determined. leaf, as well as dry substance.

The analysis of water in both systems was obtained with the help of a lab kit, "JBL Combisettest" (Figure 3), in which it was determined the following parameters: pH, NH_4, NO_2, NO_3, KH, PO_4.

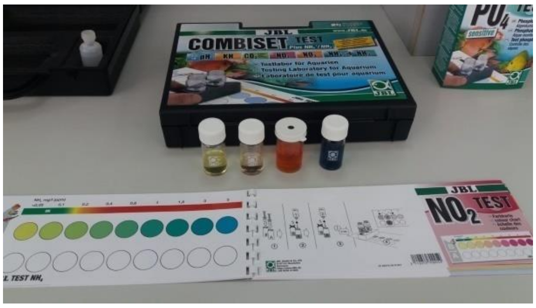


Figure 3. Determination with JBL Combiset test

RESULTS AND DISCUSSIONS

In the time frame of five weeks, the following results were obtained:

Table 1. Results obtained in the aquaponic system (B1)

B1	pH	C.E. dS/m	NH_4 mg/l	NO_2 mg/l	NO_3 mg/l	KH mg/l	PO_4 mg/l
Day 1	8.2	1.3	0.05	0.01	240	87.2	3.6
Day 6	8	1.4	0.05	0.01	80	109	3.4
Day 12	7.53	1.4	0.05	0.01	60	174.4	3.2
Day 18	6.8	1.4	0.05	0.07	100	109	2
Day 21	6.8	1.4	0.05	0.01	60	109	2.2

Ammonia and nitrites are toxic compounds for fish and require complete monitoring. However, nitrates are relatively harmless to them as well as the nitrogen form required for plant growth. They are easily absorbed.

Table 2. Results obtained in the hydroponic system (B2)

B2	pH	C.E. dS/m	NH_4 mg/l	NO_2 mg/l	NO_3 mg/l	KH mg/l	PO_4 mg/l
Day 1	7.2	2.2	5	0.6	240	152.6	7.2
Day 6	7.2	2.3	0.05	0.6	120	65.4	3
Day 12	7.5	2.7	0.05	0.05	120	87.2	2.4
Day 18	6.8	1.5	4	1	120	109	2.2
Day 21	7.2	1.6	0.05	0.03	40	65.4	2

The pH value determines the availability of nutrients for plants. As a result, the aquaponics system balances the pH for plants, fish and nitrifying bacteria. Nitrification prevents accumulation of ammonia (toxic to fish) by conversion to nitrate (NO3-).

The obtained results show a very good absorption of nitrate in the water system, the NO3 concentration being the lowest, compared to the hydroponic system where the concentration was higher (Figures 4, 5).

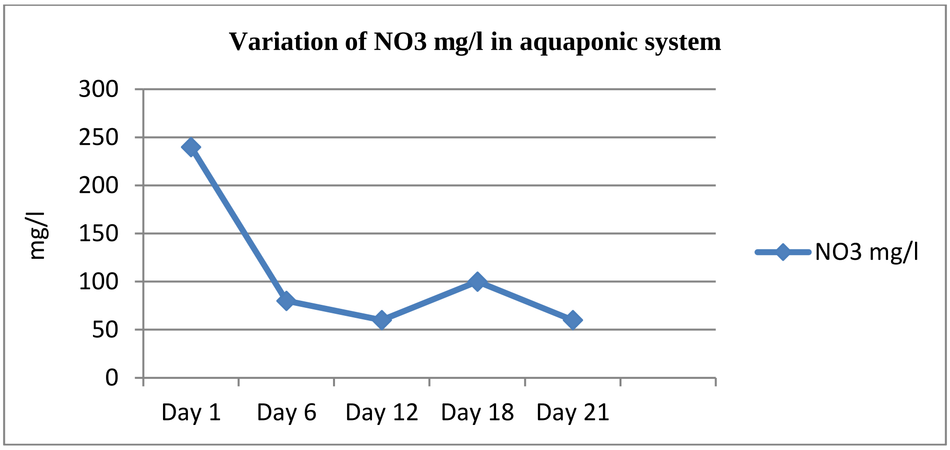


Figure 4. Evolution of nitrates in the aquaponic system

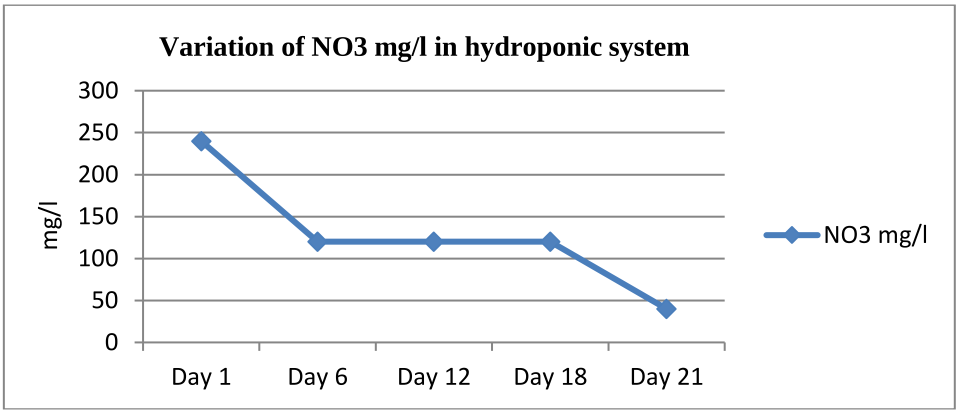


Figure 5. Evolution of nitrates in the hydroponic system

In the cultivation of lettuce in the hydroponic system, the corresponding CE is about 2.5 to 2.6 dS / m-1 (Costa et al., 2001; Gondin et al., 2010). However, EC values for hydroponic systems vary between 1.5 and 2.5 dS / m-1. A high EC value prevents the absorption of nutrients by increasing osmotic pressure, while the lower EC can seriously affect the health and yield of plants (Samarakoon et al., 2006).

The EC values recorded in this study were between 2.23 and 2.67 dS / m-1. In aquaponic systems, EC has higher values due to a low rate of water replacement, promoting greater growth and accumulation of solution ions. However, due to continuous recirculation of water, the conditions become satisfactory for plant cultivation.

Ph and electrical conductivity were monitored at 3 days (from 3 in 3) to maintain values between 6.5-8.5 pH and 1.9-2.2 dS / m-1, thus preventing saline stress in plants during periods of high perspiration and reduction the growth rate due to the low availability of mineral nutrients (Table.1).

On inert substrates, the highest amount of P available in a nutrient solution is when the pH is slightly acidic (pH 5). In alkaline and very acidic solutions, the P concentration decreases to pH = 5, 100% of P is present as H2PO4-; this form is converted to HPO4 at pH 7.3 (pKa2), reaching 100% at pH 10.

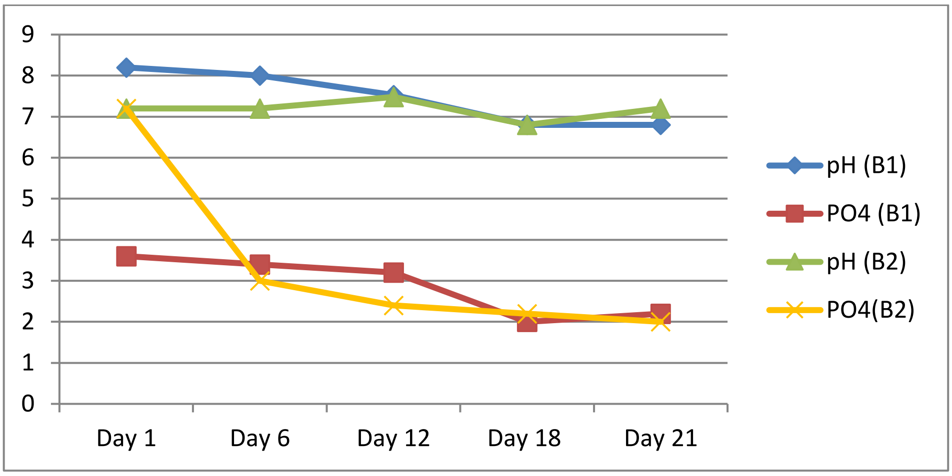


Figure 6. Evolution of PO4 by pH

Comparing the two cultivation systems, similar results were obtained for the number of leaves, with average values of 1-2 leaves per plant at 3 days and an average increase of 2-2.5cm.

Regarding the dry matter of the lettuce leaves cultivated in the two systems, the highest value was obtained for the aquaponic system of 46.3% compared to the hydroponic system of 28.8% and the lettuce in the soil with the lowest dry substance 24.6%

Thus, at pH values between 6.5-8.4 pH and CE between 1.37-1.43 dS / m-1, for aquaponic, the nitrate concentration decreased from 240mg / l to 60mg / l and phosphates from 3.6-2.0mg / l, which results in a good absorption of the roots of the lettuce plant, compared to the hydroponic system where the concentration of nitrates and phosphates was higher. In the hydroponic system, lettuce had an average growth of 2 cm. at 3 days, and in the aquaponic lettuce had an average growth of 3 cm. within 3 days.

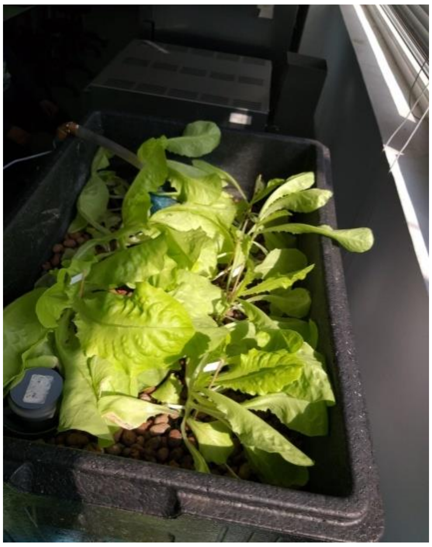
CONCLUSIONS

The fundamental component of the hydroponic system is the nutritional solution. Moreover, precise control of the nutrient supply of the plant is the main advantage of the soilless culture. In addition, adjusting the pH, root temperature among other factors leads to increased yield and quality.

Hydroponics is a versatile technology, suited to both village production systems, extreme ecosystems such as deserts, mountain regions or Arctic communities.

In addition to economic advantages, the waterworks system involves reducing the impact on the environment through the recirculation and reuse of nutrients, water conservation, cogeneration and improving the quality of life.

In conclusion, this study highlights the fact that, for lettuce, the aquaponic system helps absorb nutrients and increase biomass, compared with the addition of micro and macronutrients in a hydroponic system that has improved growth speed and has reached a commercial size over the same time span.



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