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The Analyses of the Medicinal Plants Growth in the Integrated Production System of Aquaponics (Experimental and Commercial)

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Abstract

Aquaponics means the integration of two technologies, which are represented by the Hydroponic System (growing plants in water) and Aquaculture Recirculating System (growing of aquatic organisms with interest for aquaculture sector). In an Aquaponic system, the aquatic animals excert ammonia based excrements, which are later converted by the bacteria into nutrients, where some of them are valuable for the plants; the plants are responsible for cleaning the water at the same time and later the water is brought clean by the pumps to the aquatic animals. The aim of the study was testing the growth of some medicinal plants in a commercial system and an experimental system created in house (stimulated by the pandemic situation). The comparison of the growth parameters (horziontaly and vertically growth was monitored during the experimental period) in a commercial farm located in Maminas and in the experimental system. The results showed that the mint plant (*Mentha piperita*) demonstrated a good growth just some days before the cutting by following a linear growth profile; differently happened with the commercial farm, where the horizontal growth was subject to an exponential accumulation of the plants. Further studies about the other characteristics (morphometric and organoleptic) are required in order to identify the effectinveness and advantages of these technologies, while it should be further adapted to the COVID19 pandemic situations.

Keywords: Aquaculture Recirculating System; Hydroponic system; mint.

1. Introduction

Aquaponics is the integration of recirculating aquaculture system (RAS) and hydroponics in one production system. In an aquaponic unit, water from the fish tank cycles through filters, plant grow beds and then back to the fish. In the filters, the fish wastes are removed from the water, first using a mechanical filter that removes the solid waste and then through a biofilter that processes the dissolved wastes. The biofilter provides a location for bacteria to convert ammonia, which is toxic for fish, into nitrate, a more accessible nutrient for plants. This process is called nitrification [1]. As the water (containing nitrate and other nutrients) travels through plant grow beds the plants uptake these nutrients, and finally the water returns to the fish tank purified. This process allows the fish, plants, and bacteria to thrive symbiotically and to work together to create a healthy growing environment for each other, provided that the system is properly balanced. In aquaponics, the aquaculture effluent is diverted through plant beds and not released to the environment, while at the same time the nutrients for the plants are supplied from a sustainable, cost-effective and non-chemical source [2].

Aquaponics is a technique that has its place within the wider context of sustainable intensive agriculture, especially in family-scale applications [2]. It offers supportive and collaborative methods of vegetable and fish production and can grow substantial amounts of food in locations and situations where soil-based agriculture is difficult or impossible. The sustainability of aquaponics considers the environmental, economic and social dynamics. Economically, these systems require substantial initial investment, but are then followed by low recurring costs and combined returns from both fish and vegetables [1]. Environmentally, aquaponics prevents aquaculture effluent from escaping and polluting the watershed.

At the same time, a quaponics enables greater water and production control. Aquaponics does not rely on chemicals

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for fertilizer, or control of pests or weeds, which makes food safer against potential residues. Socially, aquaponics can offer quality-of-life improvements, because the food is grown locally and culturally appropriate crops can be grown [1]. At the same time, aquaponics can integrate livelihood strategies to secure food and small incomes for landless and poor households. Domestic production of food, access to markets and the acquisition of skills are invaluable tools for securing the empowerment and emancipation of women in developing countries, and aquaponics can provide the foundation for fair and sustainable socio-economic growth. Fish protein is a valuable addition to the dietary needs of many people, as protein is often lacking in small-scale gardening [2]. The aim of this study was testing the growth of some medicinal plants in a commercial system and an experimental system created in house.

2. Material and Methods

The testing of medicinal plant was performed in the commercial system previously established by Engr. Jani Taci. In Albania, Mr. Taci created it for the first time and it represents the first aquaponics system in Albania; he designed and built this integrated aquaculture system by himself in 2012.

In this quaponics system, which is located in Kashar village (near Tirana, Albania), the most used fish species are represented by Koi carp and goldfish (*Carassus auratus*), which is known to be the most used in aquaponics systems.

Both species produce high levels of ammonia, which is good for maintaining nutrient levels for the aquaponic process. Both fish are also very resilient to changes in pH, pollutants, and temperature.

As it is shown in the Figure 1, the used method is floating raft method. The gold fish (*C. auratus*) and Koi carp (*C. carpio*) were bought from the Hatchery of Tapiza (property of Agricultural University of Tirana) and they (fingerlings with an average weight of 30g) were transferred in the tanks shown in Figure 1.

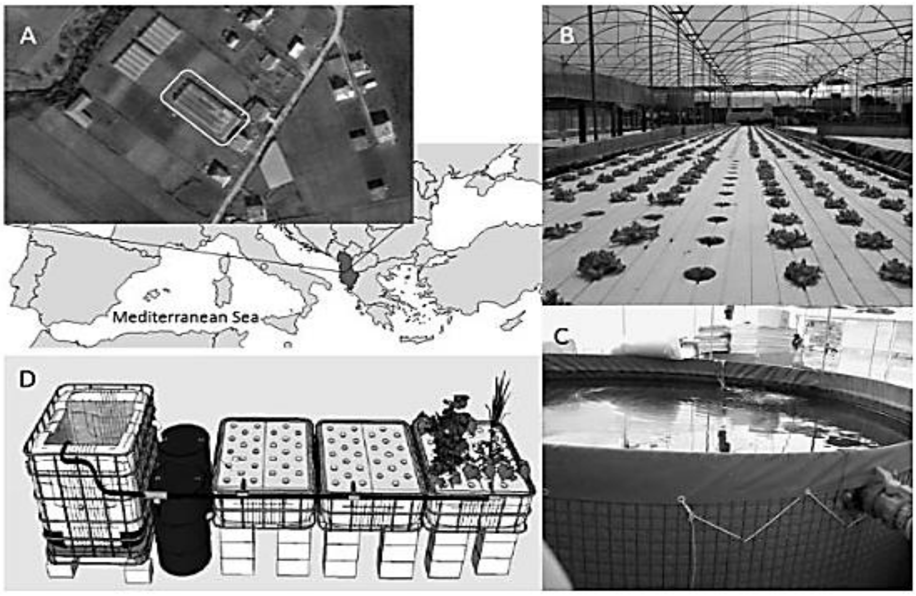

Figure 1. Location of aquaponics system farm in Albania (A) and some pictures (B and C) showing the components of the farms, together with a graphical representation of the used Aquaponic method (D); photos gently provided by Rigers Bakiu [1].

The first experimental system was builded by cutting into two pieces several plastic bottles of 20 liters (L) each and installing the relative part in a metallic schelet, as shown in Figure 2. In total were used 4 plastic bottles, where the medicinal plants should be planted on the top, while at the bottom (in the water) should stay at least 2 individuals of Koi carp with average dimensions of 250-300g.

Figure 2. The home builded experimental system for growing fish and medicinal plants.

In the other home builded experimental system, the aquaponics system was created by using a normal aquarium, where Koi carp of 250-300g were present in it. On the top of the aquarium were installed parts of the cutted plastic bottles, as it is shown in Figure 3. Inside these parts of the bottles were inserted the gravel and later planted the mint plants. The aquarium was filled with water and the relative pumb provided water to the plants and later the water returned to the aquarium by gravity.

Figure 3. The experimental system builded by using a normal aquarium, where are present mint plants and Koi carp individuals.

3. Results and Discussion

In order to evaluate the performance of the commercial system and the experimental systems, we performed a comparison related to plants average growth (height) between the aquaponics systems. It is important to note that we selected several medicinal plants to test in the different systems, but only the mint plant were able to grow well in all the systems.

In the commercial system the mint plants grew very fast and it was really impossible to measure the height of the stem in each of the plants. For this reason we analysed the horizontal growth by measuring the extension in surface of the mint plants. As it is shown in the graphic of the Figure 4, the horizontal growth was followed an exponential andament ($y = 0.0133e^{0.4589}x$). From 23 September to 7 July, the growth was slow, while later it was very fast and it obliged us to do the cutting of the plants.

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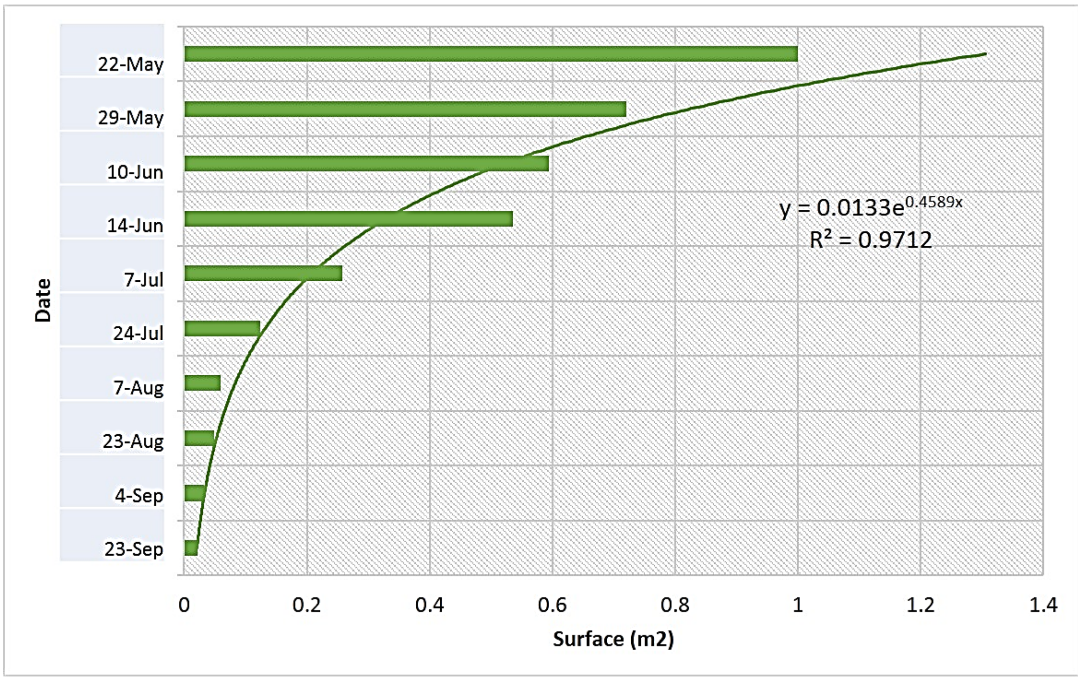

Figure 4. Graphical presentation of the horizontal growth of mint plants in the commercial aquaponics system.

From the two home builded experimental systems, just one of them passed the testing phase, because experimental system created with parts of plastic bottles of 20 L never resulted to be succesfull. It was not possible to establish a proper water speed to provide sufficient water quantities to the plants with proper water level in the gravel. Most of the water volume was not filtrated through the gravel and it felt down from the borders.

In the Figure 5 are shown the results of mint plants measurments from June to September, where it is shown a high variance between the measured plant stems in the aquarium based experimental system.

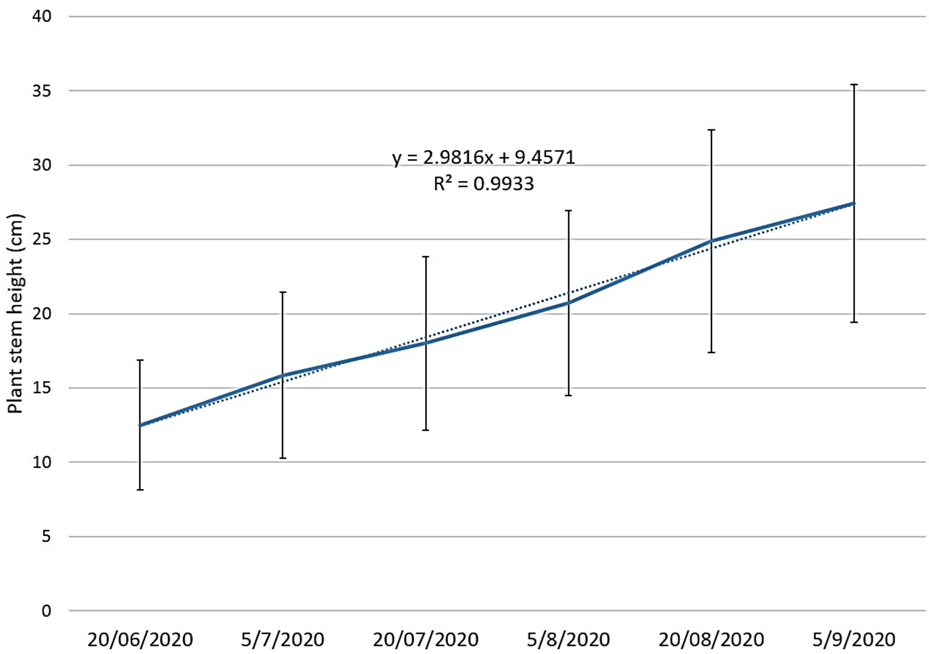

Figure 5. Graphical presentation of the vertical growth of mint plants in the functional experimental aquaponics system.

In order to identify the statistically significant differences, it was performed a statistical t-test for a p-value < 0.05 for comparing group of plants with different variance and the relative results are shown in Table 1. To the coloured cells correspond the coloured lines in the graphic of Figure 6.

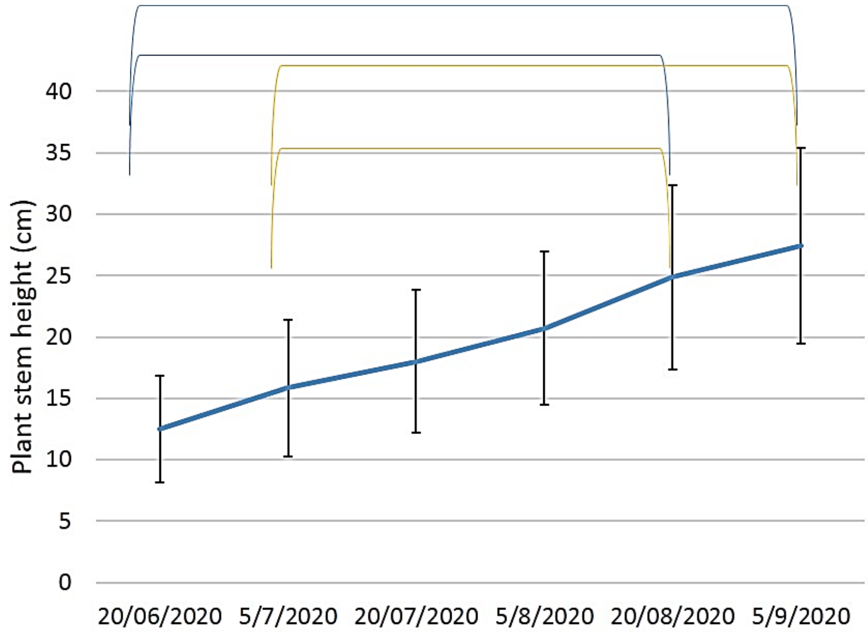

Figure 6. Graphical presentation of the vertical growth of mint plants in the functional experimental aquaponics system; the statistical significant difference between the plant stems are indicated by the differently coloured lines.

Table 1. Results of t-test ($p < 0.05$).

	20/06/2020	05/07/2020	20/07/2020	05/08/2020	20/08/2020	05/09/2020
20/06/2020		0.2498754	0.078855035	0.018195	0.00427471	0.00187667
05/07/2020			0.818442493	0.276455	0.04872058	0.01728436
20/07/2020				0.725255	0.14870214	0.05123953
05/08/2020					0.49877802	0.19295554
20/08/2020						0.91076971

The plants, which stem was measured on day 20/08/2020 and 05/09/2020 showed a statistically significant difference during their comparisons with the plants measured on day 20/06/2020 and 05/07/2020, respectively. presentation of the vertical growth of mint plants in the functional experimental aquaponics system. By comparing these results to the previous results coming from measurements of other plants in the commercial aquaponics system [3], it is interesting to note that the growth of mint plants followed a linear andament similarly to the eggplants and peppers from another published work [3].

Other plants, including medicinal plants should be tested for longer time period in experimental and commercial systems in order to have sufficient results for promoting the use of these integrated technologies in Albania.

4. References

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