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Short Communication

Basil and Nile tilapia Production in a Small Scale Aquaponic System

Stathopoulou P[1], Berillis P[1*], Levizou E[2], Sakellariou-Makrantonaki M[2], Kormas AK[1], Angelaki A[2], Kapsis P[4], Vlahos N[3] and Mente E[1]

[1]Department of Ichthyology and Aquatic Environment, School of Agricultural Sciences, University of Thessaly, Greece
[2]Department of Crop Production and Rural Environment, School of Agricultural Sciences, University of Thessaly, Greece
[3]Department of Fisheries and Aquaculture Technology, School of Agricultural Technology Sciences, Technological Educational Institute of Western Greece, Greece
[4]ATC Automation Systems, Nikomachou, Athens, Greece

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Introduction: Aquaponics combines the culture of aquatic animals and the cultivation of plants in recirculating systems, integrating aquaculture and hydroponics in a soil-less system (Racocy et al., 2004). Toxic ammonia produced by unutilised feed, fish faeces and excreted urea is oxidized by nitrifying bacteria (microbial breakdown) (mainly by *Nitrosomonas* and *Nitrobacter* spp.) into vital and usable nitrate for plants (Cebron and Garnier, 2005). Plants absorb nitrate and other nutrients, permitting purified water recirculate back to fish tanks. Aquaponics promotes an innovating system as a solution to possible environmental impacts of aquaculture (Tyson et al., 2011), shortage of drinking water, climate change, loss of soil fertility and biodiversity. Aquaponic system vitality and prosperity is based on fish, plant and bacterial interactions and welfare. The interrelatedness between these are highly complex and are in direct association with water quality (Yildiz et al., 2017). Aquaponics food products are chemical-free (no use of hormones, pesticides/fungicides or antibiotics).

Keywords: Aquaponics; Basil plants; Nile tilapia; Soil fertility; Biodiversity

[*]**Correspondence to:** **Panagiotis Berillis,** Department of Ichthyology and Aquatic Environment, School of Agricultural Sciences, University of Thessaly, Greece, Tel: (+30) 2421093248; E-mail: pveril@uth.gr

Material and Methods

Two aquaponics systems of 720L total water capacity and 6900 cm^3/min water flow were designed and constructed (**Figure 1**). Thirty-four Nile tilapias (*Oreochromis niloticus*) of 50g mean body weight were reared in each of the two aquaponics systems. Fish were fed 2.3% of their body weight daily, two times per day a pelleted diet (**Table 1**). In each system nine basil plants (*Ocimum basilicum*) were cultured at 0.7m^2 growing area. Calcium carbonate ($CaCO_3$), potassium hydroxide (KOH), phosphoric acid (H_3PO_4) and nitric acid (HNO_3), were periodically dosed into the aquaponic system to maintain the pH at a neutral range. Fe-DTPA was supplemented on a weekly basis according to basil nutrient requirements (Saha et al., 2016). Evaluation of the relationship between water quality parameters and fish and plant growth ratios during a 55 days trial took place.

Results and Discussion

pH values during the trial were 7.1 ± 0.4 for system I and 7.04 ± 0.4 for system II. Temperature in both systems maintained at 25.7 ± 0.81°C. According to Danaher et al. (2013) temperature between 26-27°C is ideal for the growth and reproduction of tilapia. Cerozi & Fitzsimmons (2016) support that pH between 6.5 and 7.2 is the optimum for the process of nitrification, fish growth and maximum plant biomass production. Total ammonia nitrogen (TAN) during the experimental trial was 0.79 ± 0.11 for system I, and 1.13 ± 0.17 for system II (**Figure 2**). The NO_3^- concentration was 91.9 ± 9.8 for system I and 92.4 ± 9.9 for system II (**Figure 3**). All the water physicochemical parameters for the two systems are presented in **Table 2**.

No fish mortality occurred. Weight gain was statistically significant higher in the first aquaponics system (system I) (WG) (95.8 ± 13.62 g) in comparison to the second system II, where it was 51.7 ± 9.90 g. Specific growth rate was higher in system I (SGR%/day, 1.8 ± 0.17) in comparison to system II 1.2 ± 0.16%/day but no statistically significant. The results are related with

Figure 1: 3D Visualization of the aquaponic system. 1: Plants hydroponic tank (raft system) 2: Fish tank 3: Mechanical filter 4: Biological filter 5: Sump 6: Lamp.

Table 1: Diet composition (BIOMAR).

Crude protein (%)	48
Crude lipid (%)	27
Carbohydrates (%)	10
Fiber (%)	0.2
Ash (%)	10.6
Total phosphorus (%)	1.4
Gross energy (MJ/Kg)	23.8
Digestible energy (MJ/Kg)	21.1

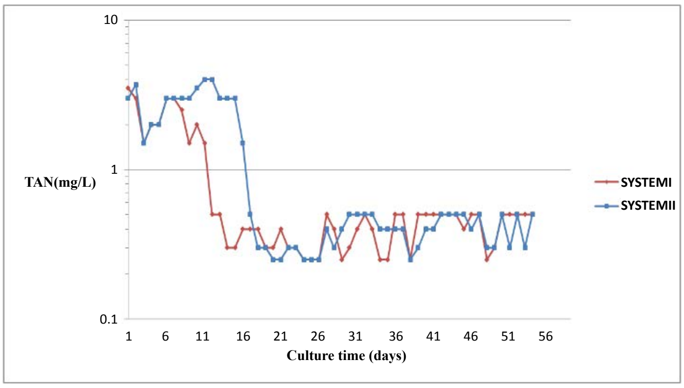

Figure 2: Variation of total ammonia nitrogen (TAN) concentrations during the study period (55 days). TAN values are presented on logarithmic scale.

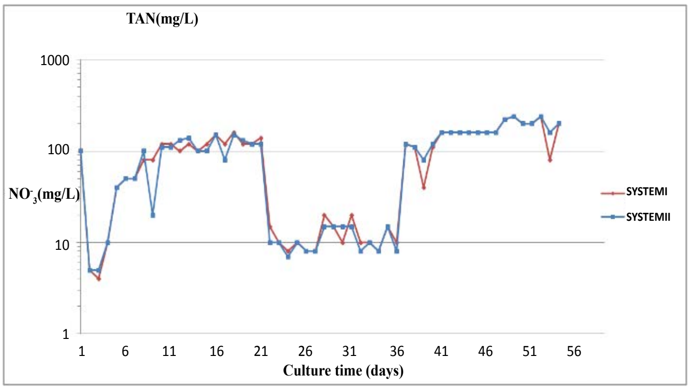

Figure 3: Variation of nitrate concentrations during the study period (55 days). NO_3^- values are presented on logarithmic scale.

the high TAN values in system II, where there was a delay in the bacteria establishment in the biofiltre. This initiated a reduction in fish food offered in comparison to system I. Chowdhury (2011) showed that total weight gain and daily growth rate of tilapia are higher at higher dietary levels. Feed consumption rates (FCR) were 0.7 and 1.1 for system I and system II, respectively, values that are found in tilapia aquaculture (Naylor et al., 2000).

During the study period, plant survival rate was 100%. Total plant biomass (g), height increase (%) and growth rate were higher in system I (147.1 ± 28.15 g, 45.7 ± 12.42% and 0.2 ± 0.06, respectively), in comparison to basil cultivated in system II (131.1 ± 16.7 g, 38.8 ± 7.46% and 0.1 ± 0.03, respectively). There wasn't a significant difference between plant growth in the two systems.

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Table 2: Water physicochemical parameters for the two aquaponic systems. Results are given as mean ± S.E.

	T (°C)	DO (mg/L)	Oxygen (%)	pH	EC (μS)	TDS (ppm)	TAN (mg/L)	NH_3^-	NO_2^-	NO_3^-
System I	25.7 ± 0.8	7.0 ± 0.2	84.2 ± 2	7.1 ± 0.4	1009 ± 193	554 ± 83	0.79 ± 0.11	0.78 ± 0.83	0.82 ± 0.13	91.9 ± 9.77
System 2	25.7 ± 0.8	7.0 ± 0.2	84.2 ± 2	7.0 ± 0.4	985 ± 189	540 ± 81	1.13 ± 1.22	1.11 ± 0.16	0.73 ± 0.09	92.44 ± 9.91

This is due to the varied level of fish nutrition between systems in order to control high ammonia levels. Thus, the introduction of nitrogen into the system II was delayed, compared to system I, resulting in smaller amounts of nitrogen absorbed by the plants (Hu et al., 2015). Thus, a smaller increase in basils height was observed. Interestingly, basil cultivated in system II developed more lateral stems (9.3 ± 1.08) in respect to those cultivated in system I (8.9 ± 1.39). This may be attributed to the different microclimatic conditions (temperature, humidity) occurred between the two systems. However, there was no statistically significant difference between the two aquaponics systems in relation to plant lateral stems.

In conclusion, the present study showed that a three-week period is necessary for the establishment of bacteria in the biofiltres of the aquaponics system as described above. Higher abundance of nitrifying bacteria leads to higher oxidization of toxic ammonia. Varied level of fish nutrition between systems in order to control high ammonia levels delayed the introduction of nitrogen into the system II resulting to reduced Nile tilapia weight gain and smaller basil's height increase. Nitrogen uptake by basils increased with their growth. Basil plants removal from the system lead to NO_3^- accumulation.

Additional research is necessary to investigate the complex inter-relationships between fish, bacteria and plants in future aquaponic systems designed for potential food production.

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