TOMATO PRODUCTION IN AQUAPONICS: MASS BALANCE AND NUTRIENT RECYCLING IN NFT CHANNELS, RAFT CULTURE AND DRIP IRRIGATION SYSTEMS

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Introduction

Aquaponic offers an option for a sustainable food production system, combining hydroponic with aquaculture in a symbiotic relationship [1], as fish feed provides most of the nutrients required for plant growth. The nutrient-rich water is pumped through the hydroponics part of the system, where plants use aquaculture waste metabolites for growth and thereby clean the water, which flows back to the aquaculture component for reuse [2]. Nutrient removal from aquaculture effluents is essential to protect receiving natural waters from eutrophication. Using an aquaponic system is an excellent way to achieve this, make use of aquaculture wastewater by providing fertilizer to agricultural crops and thus save water [3].

Purpose

The purpose of this study was twofold:

1. Analyze nutrient flows in Aquaponic by calculating a mass balance for C,N,P,K,Ca,Fe.
2. Compare tomato production in three different hydroponic sub-systems (NFT = nutrient film technique, raft culture and drip irrigation).

Examining the distribution and potential losses of nutrients will deliver new insights about the nutrient flows in Aquaponics and efficiency of the tested plant systems. Would it be possible to use aquaculture effluents for drip irrigation systems currently used in the horticulture industry worldwide without having to change the these systems? This would open new doors for Aquaponics.

Methods

SYSTEM SETUP: Three identical Aquaponic RAS systems were installed in a foliar greenhouse at the ZHAW Campus in Waedenswil, covering 250 m² in total. Each system was composed of a fish tank, drum filter, moving bed biofilter, oxygenation cone, and three hydroponic systems (Figure 2). Total system water was 4.7m³. Three different hydroponic sub-systems (NFT channel, raft system and drip irrigation) were compared. Tomato seedlings were planted on 31 March 2014, mass balance recording started on 11 June and will continue until 5 November. 300 tilapia were stocked to each system, feed input being 600-1200 g daily. Each plant channel hosted 7 tomato plants with 22 shoots. Tomatoes were cultivated according to the "Dutch" method along a rope, removing side branches and old leaves weekly.

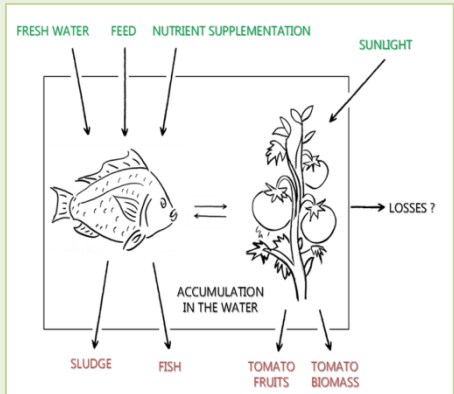

Fig. 1: Nutrient flows in Aquaponic (target flows in capital letters)

MASS BALANCE: Water consumption, fish feed and fertilizer applications were summarized as system inputs. As output parameters, harvest of tomato fruits and green parts, tomato roots, fish number and biomass as well as daily extracted fish sludge were recorded. To regulate the amount of nutrients in the system additional fertilizers were used. Therefore water analysis was made once a week using spectrophotometry, fertilizer demand was calculated using HydroBuddy [4] and fertilizers added to the biofilter during the following days.

Interim Results: Average harvest per week

Data for one system covering 7.9 m² of greenhouse	NFT CHANNEL	RAFT BASIN	DRIP SYSTEM
Tomato harvest	5,708 g	5,570 g	5,696 g
Weight per tomato	21.5 g	21.4 g	21.3 g
No. of tomatoes	254	248	262
Total tomato harvest 11 June - 18 August (69 days)	79.9 kg	77.9 kg	79.7 kg
Average removed green biomass per week	3.04 kg	3.39 kg	3.04 kg

Average fresh water input was 0.55 m³/week (1.6% of system volume/day). In NFT channels part of the roots had to be removed because they blocked the water flow. Oxygen problems occurred in raft systems because of aeration pipes clogging. Drip systems proved to be a major consumer of pumping energy but worked without any technical problems so far.

System scheme

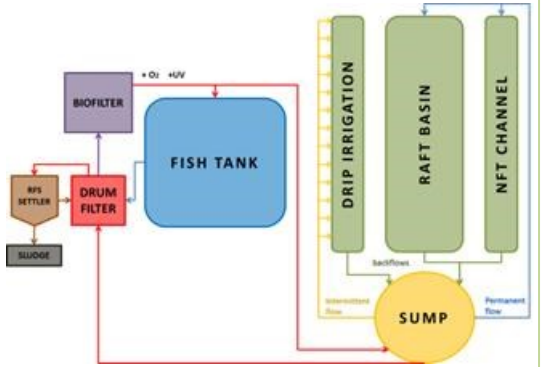

Fig. 2: Aquaponic RAS system setup in summer 2014

Literature

[1] Rakocy E, Masser P, Losordo M (2006): Recirculating Aquaculture Tank Production Systems: Aquaponics—Integrating Fish and Plant Culture. SRAC Publication No. 454.

[2] Rakocy JE, Bailey DS, Shultz RC and Thoman ES (2004): Update on tilapia and vegetable production in the UVI aquaponic system. In: New Dimensions on Farmed Tilapia: Proc 6th Intl. Symposium on Tilapia in Aquaculture: 12-16.

[3] Endut A, Jusoh A, Ali N and Wan Nik WB (2012): Nutrient removal from aquaculture wastewater by vegetable production in aquaponics recirculation system. Desalination and Water Treatment, 32(1-3): 422 – 430.

[4] freeware tool from http://scienceinhydroponics.com

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