Decoupled aquaponics – Innovative food production systems for a sustainable nitrogen management

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Abstract

Aquaponics offers an innovative approach to reduce nitrogen emissions and the use of N-fertilizer for the combined production of fish and plants in closed production systems. Here, the savings potential of a conventional hydroponic lettuce production using conventional nutrient solution in comparison with decoupled aquaponics using the nutrient rich fish water as basis for the nutrient solution was evaluated. The use of fish water saved 85 % CAN fertilizer in comparison to the control without differences in growth. This study clearly demonstrates the huge potential of decoupled aquaponics to foster the transformation of conventional agriculture towards sustainable production systems saving resources and minimizing emissions.

Keywords: lettuce, Nile tilapia, reuse, fertilizer savings

1. Introduction

Decoupled aquaponic systems have the potential to become one of the most effective production systems for the combined production of animal protein and plant crops. Here, recirculating aquaculture systems for fish production are combined with hydroponics for soilless plant production thereby recycling dissolved nutrients derived from metabolism of the fish (Monsees et al. 2019).

2. Material and methods

The experimental setup is presented in Fig.1. The temperature, electrical conductivity, pH, and the mineral composition of the fish water were evaluated. After nutrient analysis, fish water was supplemented with missing nutrients. Plant growth (fresh and dry weight, number and area of leaves) and quality parameters of lettuce leaves (nitrate, mineral content, phenolic compounds) were examined. In addition, one aquaponic treatment became disinfected in order to assess any occurring advantage of the aquaponics derived fish water.

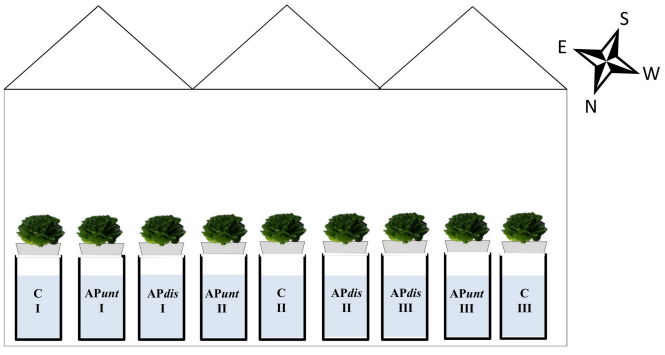

Fig. 1: Schematic description of the arrangement of the experiments. C = control, fresh water based nutrient solution; AP*unt*—untreatend aquaponics, fish water based nutrient solution with supplemented nutrients; AP*dis*—like AP*unt*, but fish water was disinfected before use.

3. Results

The use of fish water saved 63% mineral fertilizer, more specifically 85 % CAN fertilizer and fully substituted the required water for the nutrient solution in comparison to the control (Tab. 1).

Element	Unit	Control	AP*unt* / AP*dis*	Reduction (%)
Fresh water	**L**	375	0	100
CAN	**g L^{-1}**	117	18	84.6
KNO_3	**g L^{-1}**	19	6	68.4
$MgSO_4$	**g L^{-1}**	44	28	36.4
KH_2PO_4	**g L^{-1}**	27	25	7.4
Total fertilizer supply / reduction	**g L^{-1}**	**207**	**77**	**62.8**

Tab. 1: Resource utilization of butterhead lettuce grown in nutrient solution formulated with fresh water (control: 50:50, v/v fresh and rain water), fish water (AP*unt*) and disinfected fish water (AP*dis*). The control represents 100%.

4. Discussion

As one of the most important and obvious results of the present study, the fresh weight (FW) of butterhead lettuce did not differ significantly between both aquaponics treatments and the conventional hydroponic control, although 63% less mineral fertilizer was used. Similar observations were reported by Suhl et al. (2016). Except for some differences in the mineral content of the lettuce leaves, all other quality parameters were not significantly different.

Additionally, the reduced fertilizer demand using decoupled aquaponics can contribute to reduce greenhouse gas emissions of an annual lettuce production site per ha by 72% due to saving the energy for fertilizer production. Aquaponic systems provide the opportunity to foster the transformation of conventional agriculture towards sustainable production systems saving resources and minimizing emissions.

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