Increasing Tomato Plant Production Using Bato Buckets and Mineralization

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INTRODUCTION

Aquaponics is a closed sustainable system that reuses water from aquaculture tanks and nutrients from fish waste to further nourish plant growth. It aims to form a relationship between both vegetable and fish production, by combining aquaculture and hydroponics. Compared to traditional farming, aquaponics produces 150-200% more food per square foot. It only requires 5-10% of the water needed for soil-based agricultural production (Thomas 2017). Economically, aquaponics would reduce agricultural imports for The Bahamas, lifting some of the $3.1 billion trade deficit.

Aside from economical and sustainable benefits, aquaponics has the potential to improve food security and nutrition. Fish is the fastest growing industry for food globally. In 2009, it accounted for 17% of the global intake of animal protein. Fish contain essential micronutrients, minerals, and vital amino acids that help counter malnutrition (Béné et al. 2015). Fish are also a great resource for low-income families. Aquaponics has the potential to drastically improve food security with fewer environmental impacts.

Figure 1: Red Nile Tilapia

Figure 2: Aquaponics raft grow bed

The overarching goal in aquaponics is to be a model for sustainability and to improve food security at The Island School and throughout The Bahamas. The Island School imports 89% of their food, which means that The Island School is 89% food insecure. However, the aquaponics team has harvested approximately 500 pounds of lettuce since the start of the 2018 spring semester. One of the goals in aquaponics is to increase fruiting vegetables, like tomatoes. To increase production in tomatoes would decrease the need for importation, and therefore, lower the carbon footprint. In order to achieve these goals, we used two different methods: mineralization and the bato bucket system.

METHODS

Bato Bucket System

Sungold Cherry Tomatoes require structure for plant roots, making a media-based solution favorable. A Bato or Dutch Bucket system is a media-based form of growing plants. The media retains water and allows plants to grow deeper roots and pull nutrients from the media. The media's added surface area acts as an additional bio filter where more nutrients can be produced. The buckets are watered with an irrigation line that pumps water directly from the grow beds. Overflow pipes sit at the bottom of the buckets to let out any excess water back into the grow bed.

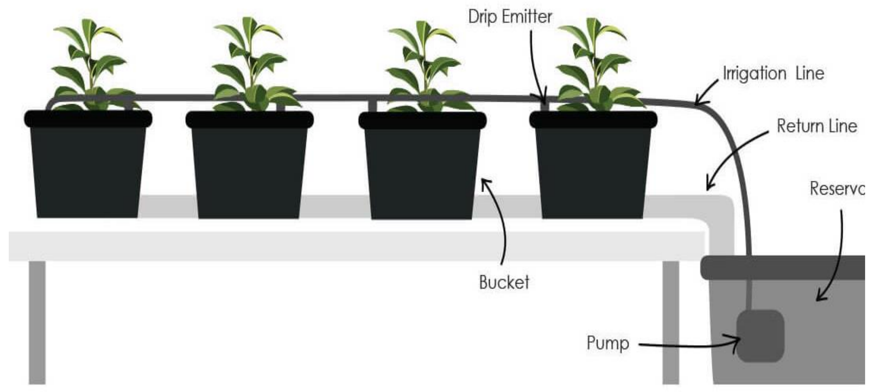

Figure 3: Diagram of a Bato Bucket System

Figure 2: The aquaponics team and their newly constructed Bato Bucket system. The six taller cherry tomato plants were previously grown in the raft system, and the twelve smaller plants in the Bato Buckets were seedlings that were started in their respective media.

Our system has nine consecutive buckets, each containing one of three different types of media: coconut husk, clay pellets and pumice. The coconut holds water extremely well but offers little aeration due to its density. Pumice and clay pellets must be mined and imported but offer great aeration due to the high surface area. Each bucket contains 2 plants. 6 of the buckets contain plants started in the buckets while the other 3 contain plants that were grown for a month in the raft system. In the raft system we have two control plants. The plants are measured weekly, flowers were counted as well as fruit to monitor development. The plants are then compared to the control to see if the experiment is working.

Figure 4: The three types of media; pumice, clay pellets and coconut husk

Mineralization

In an aquaponics system, nutrients are largely produced by converting ammonia fish waste into nitrates through a biofilter. However, this does not produce enough nutrients for fruiting vegetables. Therefore, the aquaponics team focuses on mineralization, the bacterial degradation of fish waste to liberate trapped nutrients using oxygen. After removing the two air stones from our vessel to allow solids settle to the bottom, the aquaponics team takes out one gallon of mineralized water daily. That one gallon is then manually emptied into the larger aquaponics system and put one gallon of fresh fish waste into the mineralization vessel. Background research by Rakocy (2007) suggests that mineralization can yield essential macronutrients for tomato growth. Every other day, the mineralization water is tested for ammonia, nitrite, nitrate, potassium, phosphorus and calcium.

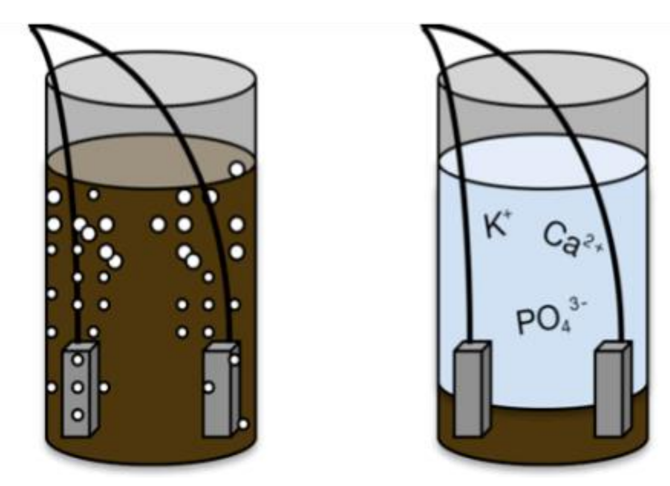

Figure 5: Crosscut view of mineralization vessel including essential minerals for fruiting vegetable growth

Figure 6: 15 gallon plastic mineralization vessel

RESULTS

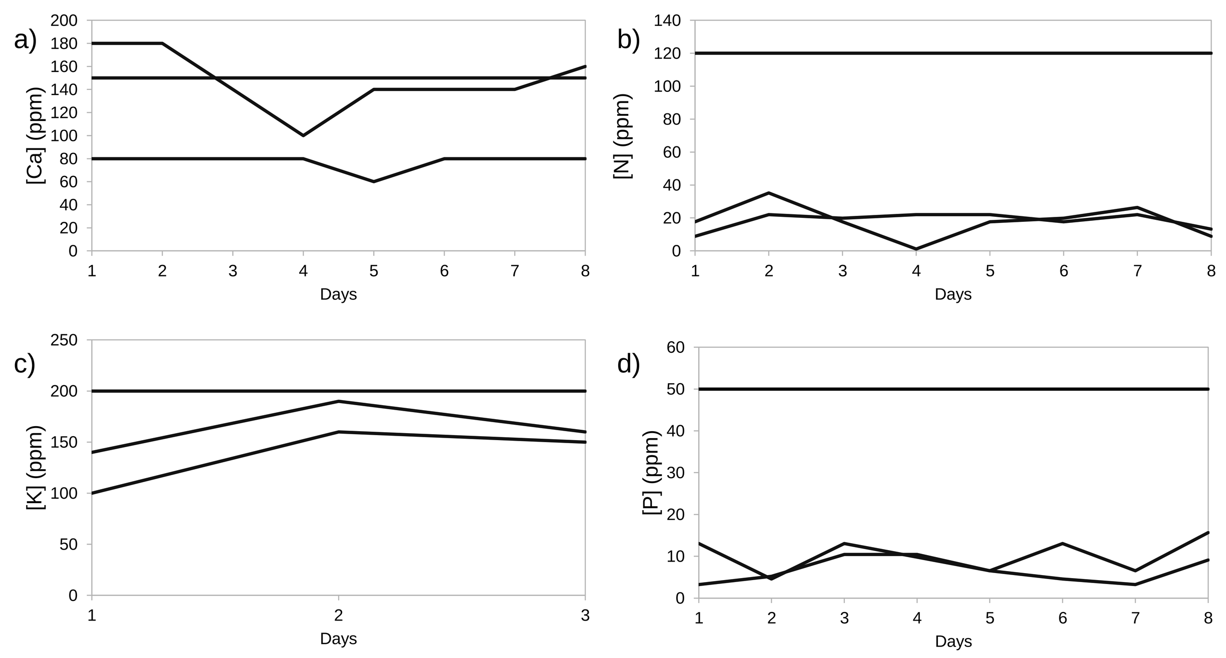

Figure 7: Concentrations of measured nutrients over days. a) Levels of calcium are invariably higher in the mineralized water than in the system water. b and d) There isn't a significant difference in the nutrient values of phosphorus and nitrogen between the mineralized and system water. c) There was only three days of measurement for potassium, so while the levels of potassium is consistently slightly higher in the mineralized water, there simply isn't enough data to make a thorough conclusion.

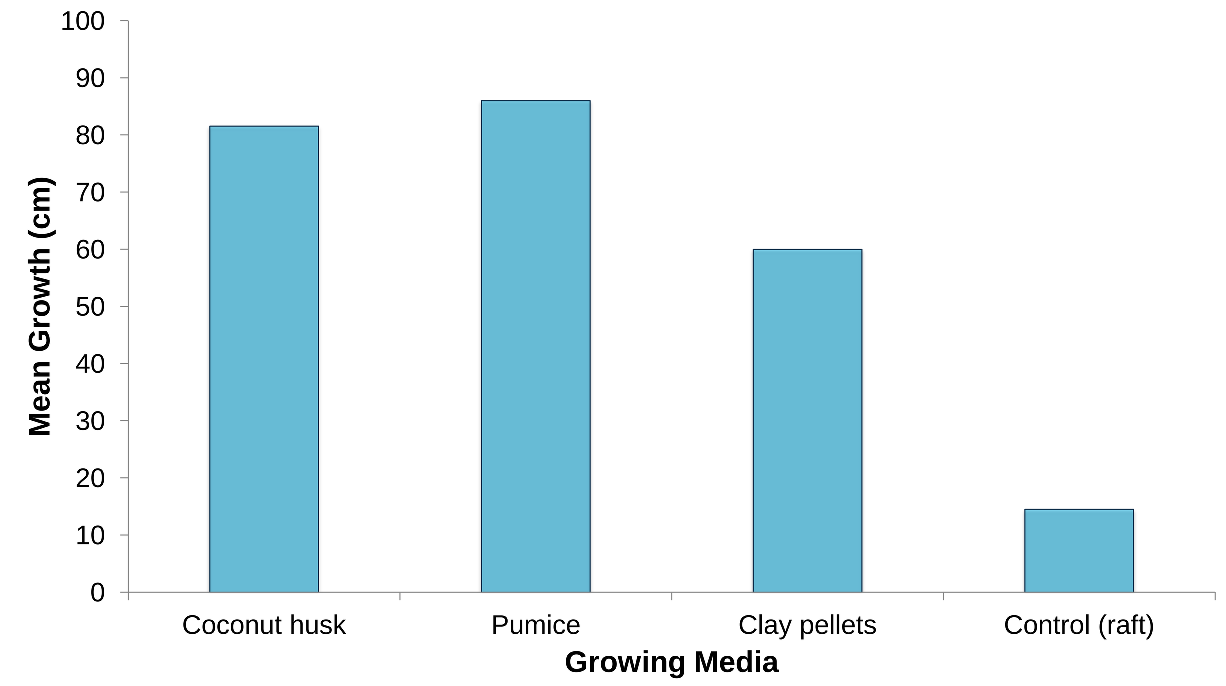

Figure 8: Mean Growth (cm) between each growing medium. The plants in the three medias exhibited significantly more plant growth than those in the raft system.

DISCUSSION

The tomatoes grown in the Bato Bucket system were much more successful than the plants grown in the traditional raft system. However, these plants were bullish, meaning they were vegetative, and lacked fruit. This is potentially due to a nutrient imbalance, specifically the ratio between nitrogen, phosphorus and potassium (N:P:K). Through the process of mineralization, this ratio could have been corrected, however, that was not the case. As illustrated in figure 7, the nitrogen and phosphorus levels did not meet the recommended nutrient concentrations. However, for nitrogen specifically this is not such a bad thing, because if the nitrogen levels were at the recommended nutrient concentration it would not sustain fish life, which is an integral part of an aquaponics system.

The calcium and potassium levels were in line with the recommended nutrient concentrations. The potassium levels were surprisingly high, especially considering that aquaponics systems are typically potassium deficient. The high calcium levels were expected because the water in the aquaponics system is hard well water, and therefore contains many dissolved minerals.

Figure 9: Bullish tomato plants grown in Bato Buckets

One possible reason that mineralization was not entirely successful could be due to the time during which the vessel sat untouched. The vessel had one gallon of mineralized water emptied everyday. An experiment conducted by Rakocy et al. (2007) let the vessel sit untouched for 29 days before any mineralized water was removed, and the desired nutrients (phosphorus and potassium) were produced.

CONCLUSION

Based on the data collected and presented, the Bato Buckets and the mineralization vessel have not produced the anticipated results. This might be the result of an incorrect nitrogen, phosphorus, potassium (N:P:K) ratio. In the future, the Aquaponics team hopes to make improvements upon the existing systems to produce tomatoes, as well creating a system that will improve the N:P:K ratio. This might mean implementing a foliar spray, to supply the plants with the correct ratio of nutrients. Aquaponics will also continue being the main supplier of lettuce at The Island School, as well as continuing research into other forms of plant production to further food security on campus.

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