UF/IFAS Extension Orange County Fact Sheet 1-13

Sustainable Aquaponic Vegetable and Fish Co-production

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Producing vegetables and fish in a linked hydroponic plant and aquaculture fish co-production system is called aquaponics. Plants can use the water and nutrients from the aquaculture tank thus reducing water and fertilizer requirements and significantly reducing waste discharges from the aquaculture system. Producing plants hydroponically and farming fish using aquaculture have their own special requirements in order to properly manage each system. When combining the two, it adds a layer of complexity for the commercial grower when systems are maintained at plant and fish population levels recommended for maximum yields. This fact sheet provides general guidelines for operating aquaponic systems.

Aquaponic Systems

The most common aquaponic systems currently in use employ either a media-filled plant bed, nutrient-film technique(NFT), or a floating raft system for the plant growing area integrated with a recirculating aquaculture tank system (RAS) for the fish production area. Almost any type of vegetable production system can be linked to an aquaculture system, including open field production, if recycling water back to the aquaculture unit is not required. This technology is young and trialing is recommended, especially for untested systems.

Crop and Fish Choices

Any plant commonly grown in hydroponic systems will adapt to aquaponics including the most common types – leafy salad crops, herbs, tomato, pepper, and cucumber. The most common aquaponic fish is tilapia which grows well under a wide range of water quality conditions. Other fish adapted to aquaponics but requiring more stringent water conditions than tilapia are rainbow trout, largemouth bass, yellow perch, bluegills and koi. Catfish can be grown in aquaponics but would not compete economically with commercial pond culture. Barramundi is a common aquaponic fish species in Australia and also grows under a wide range of conditions but is rarely available in the United States.

System Water Quality

Maintaining the pH of system water between 7.0 and 7.5 is probably the best average pH for the growth of the 3 organisms critical to aquaponics - vegetables, fish, and nitrifying bacteria. The unseen nitrifying bacteria play an important role converting waste ammonia, which is toxic to fish, into nitrate nitrogen, which is not toxic at levels common to aquaponics and supplies nitrogen which is the nutrient required in the largest amount by plants. This process of nitrification produces hydrogen ions thus reducing system water pH. To increase pH and restore to recommended levels, add calcium or potassium hydroxide. If pH is stable, denitirfication may be occurring somewhere in the system resulting in a foul odor. Another reason pH may be stable or rising is that the uptake of nitrate ions by plant roots results in the secretion of hydroxide ions maintaining the electrical balance in the roots. This produces alkalinity. To reduce pH to recommended levels add sulfuric, phosphoric, nitric or hydrochloric acid.

Maintain oxygen levels at 5 ppm or higher. Flowing water is the mechanism that delivers oxygen to the system and removes wastes. Fish will die from lack of oxygen due to loss of water flow. Make sure to have backup systems including pumps and electric generators and plan and train to restore power quickly in the event of a power outage. Aquaponic production at commercial fish density levels of 0.25 - 0.5 lbs/gallon at harvest, requires 24 hour coverage at the farm site. Ammonia levels should be 1 ppm or less. Keep light from shining on the nutrient laden water in aquaponic systems, or algae will form,using up valuable nutrients and reducing water quality.

Soluble Salts

Recirculating Aquaculture Systems (RAS) are usually recommended for the aquaculture component of aquaponics since nutrient levels in ponds don't reach levels sufficient for the hydroponic production of plants. In RAS aquaponics, water exchange rates of less than 5% per day (aquaculture systems exchange rates – waste to clean water - can approach 20%) allows accumulation of nutrients to levels near those used in hydroponic nutrient solutions. Nutrients are continuously being generated through fish waste and mineralization of organic matter. However, this will take time to establish in new systems. Water nutrient levels can generally be monitored using soluble salt meters. This measure will not tell you what type of nutrients are in the water, only the total electrical conductivity. Calcium, potassium, and iron are not found in adequate amounts in fish feed and so must be added separately as nutrients.

It may be beneficial during startup to add a quarter strength full spectrum hydroponic nutrient solution to be sure adequate amounts are present for plant production and to provide nutrients for the nitrifying bacteria to become well established. Ammonia would only be applied to establish the food source for nitrifyers prior to addition of fish and should never be used in nutrient solutions where the nitrate nitrogen form is recommended. Hydroponic nutrients should not affect fish recommended for aquaponic systems provided their concentrations are within recommended ranges. Once in the system, the fish will produce enough ammonia to keep the nitrifying bacteria well fed. A rule of thumb to use for calculating this is that 10% of the protein in fish feed will become ammonia nitrogen in the recirculating water (Figure 1).

Aquaponic systems where roots are almost always in contact with recirculating aquaculture tank water need only about a third of the nutrient concentration normally recommended for hydroponics due to a continuous supply of nutrients passing by and available to the roots. Intermittent fertigation systems may require higher nutrient concentrations to avoid depletion of the root zone prior to application of the next nutrient cycle. Under the first scenario, total dissolved solids (TDS) should be around 500 – 1,000 ppm (mg/L). Leafy salad crops and herbs are grown at the lower end and fruiting crops, like tomato, at the higher end of the TDS range.

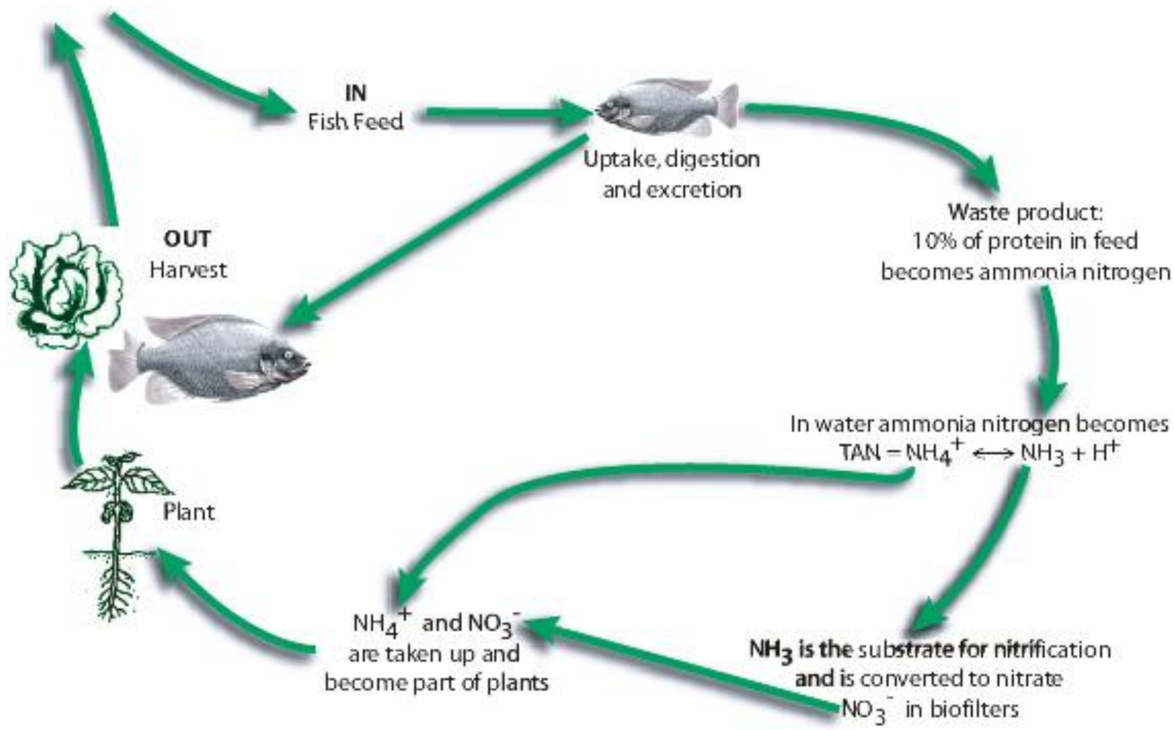

Figure 1. Nitrogen cycle in aquaponics.

System Sizing

The most researched (conducted by Dr. James Rakocy, Emeritus) aquaponic system is located at the University of the Virgin Islands. It utilizes a RAS system linked to a hydroponic floating raft system. Under those conditions, the ratio of hydroponic tank surface to fish tank surface area was 7.3:1. System sizing was based on the feeding rate ratio (the fish feed input in grams per square meter of plant growing area per day) which is 60-100 g with the lower end of this range for leafy salad crops and the higher end for fruiting crops like tomato. Under ideal conditions, it is best to have staggered production cycles so that feed input and

harvest output are relatively stable. Feed about 1-3% of fish body weight per day, with younger fish receiving the higher % and older fish the lower % of feed.

In Florida it may not be possible to grow certain crops like tomato through the summer due to excessive heat affecting yields so alternative summer crops like basil should be considered for year round production.

Marketing

Vegetables usually account for the majority of income in aquaponic systems. The United States Department of Agriculture (USDA) provides current wholesale price market commodity reports http://www.ams.usda.gov/AMSv1.0/ under their market news link. However, due to the increased expense of producing aquaponically compared to field grown production, targeting niche markets such as restaurants, high end food stores, farmer's markets, and on-farm sales, where one can get near the retail price, is recommended to get the maximum return.

If possible fish should be sold "whole pondside" to simplify marketing regulations and marketing expense since cutting fish in any way requires special food safety regulated processing facilities which can be expensive to build or rent. Another option not common in aquaponics, but could be considered, is to grow ornamental fish like Koi which eliminates the food safety considerations and simplifies marketing regulations provided the fish are not shipped out of state.

Resources

Growers Supply, Lynn Haven, FL

Crop King, Seville, OH

Hydro-Gardens, Colorado Springs, CO

Pentair – Aquatic Eco-Systems, Apopka, FL

Harbor Branch Oceanographic Institute, Ft. Pierce, FL