Introduction to Aquaponics Systems and Management

Patricia Duncan, Ph.D.
Georgia Center for Aquaculture Development
Cooperative Extension Program, Fort Valley State University
Fort Valley, GA

What is Aquaponics?

Aquaponics combines the culture of aquatic animals in recirculating aquaculture systems (RAS) with the hydroponic cultivation of plants.

Hydroponics is the soilless culture of plants in a nutrient solution.

Aquaponics vs Hydroponics

- In Hydroponics, a chemical nutrient solution is provided for the plants
- In aquaponics, by providing a nutritionally complete, formulated feed to the fish, the required nutrients and minerals will be supplied to the plants through the fish feeding and processing feed.
- As in all recirculating aquaculture systems (RAS), all the nutrients must be supplied to the fish in the feed since there are no pond organisms available as food.

Requirements to Grow Plants in Hydroponic Systems

- Support for the plant above the solution
- Aeration of the solution
- Prevention of light reaching the solution so there will be no growth of algae
- Proper pH balance
- Proper nutrients

Requirements to Grow Aquatic Animals in Recirculating Aquaculture Systems (RAS)

- Good Water Quality
- Optimum temperature
- Proper pH
- Sufficient Dissolved Oxygen
- Good Feed
- Means to treat animal waste

Water Quality Parameters Important to Aquatic Animal Growth and Health

- Dissolved oxygen
- Temperature
- Ammonia
- Nitrite
- pH
- Alkalinity/Hardness
- Carbon Dioxide/Carbonate Cycle
- Solids (Total Suspended Solids)

Aquaponic Systems which Support Dense Fish Production

- Usually made up of following components similar to recirculating aquaculture systems (RAS)

- fish culture tank(s)
- clarifier for solids removal
- biofilter for transformation of toxic ammonia to less toxic nitrite and nitrate
- pumps
- air blowers for aeration (dissolved oxygen)
- plant culture units (floating beds, NFT etc.)

Solids Removal

- Bottom drawing center drain
- Settling basins
- Clarifier
- Swirl separators/hydrocyclones
- Bubble bead filters
- 1 lb of feed ==0.30 lbs of solids
- 1 sq foot of basin per 1 gpm of flow entering basin

Clarifier for Solids Removal

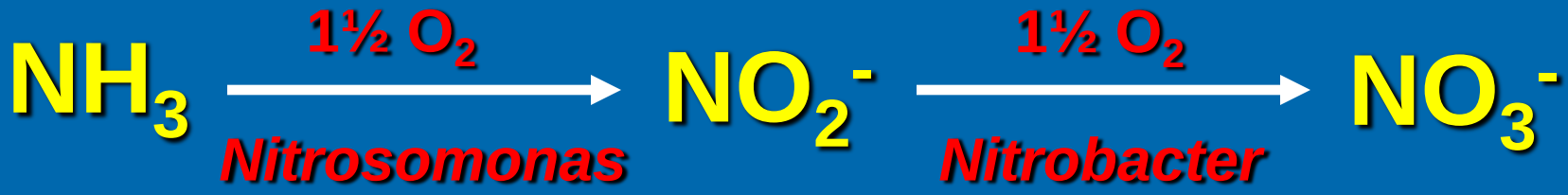
RBC with Tray Clarifier

Biofiltration

- Process where harmful ammonia (NH_3) is converted to nitrate (NO_3) by bacteria.
- Biofilters are designed to supply a large amount of surface area where the culture water can easily flow through and remain well oxygenated.
- *Nitrosomonas* and *Nitrobacter* bacteria need a good supply of oxygen, balanced pH, moderate temperature and no sudden water chemistry changes to maintain optimum metabolism.

Biological Filter

- Function
  - nitrification
  - oxidizes ammonia and nitrite to nitrate



Types of Biofilters

- Submerged Biofilters
- Trickling biofilters
- Rotating Biological Contractors
- Fluidized sand biofilters
- Moving bed biofilters
- Low space bioreactors

Submerged Bed Filter or Low Space Bioreactor

Types of Circulating Aquaponic Systems

- Floating Raft
- Nutrient Flow Technique (NFT)
- Vertical Tower
- Aeroponics

NFT with tilapia

Floating raft with tilapia

Types of Non-Circulating Aquaponic Units

- Static Biobag culture
- Ebb and flow units

Biobag with perlite and soil

Ebb and Flow unit

Types of Aquaponic Systems

- **Floating Bed-**

  -roots extend into the water and nutrient solution

  - continuous aeration and continuous flow

- **Aggregate culture**

  -aggregates or pebbles help support the roots

  -ebb and flood so that the roots get aeration

  -gravel or smooth river bottom rock of ¼-3/8" diameter

  -can have anaerobic pockets due to lack of flow and circulation

Types of Aquaponic Systems

- **Nutrient Film Technique (NFT)**

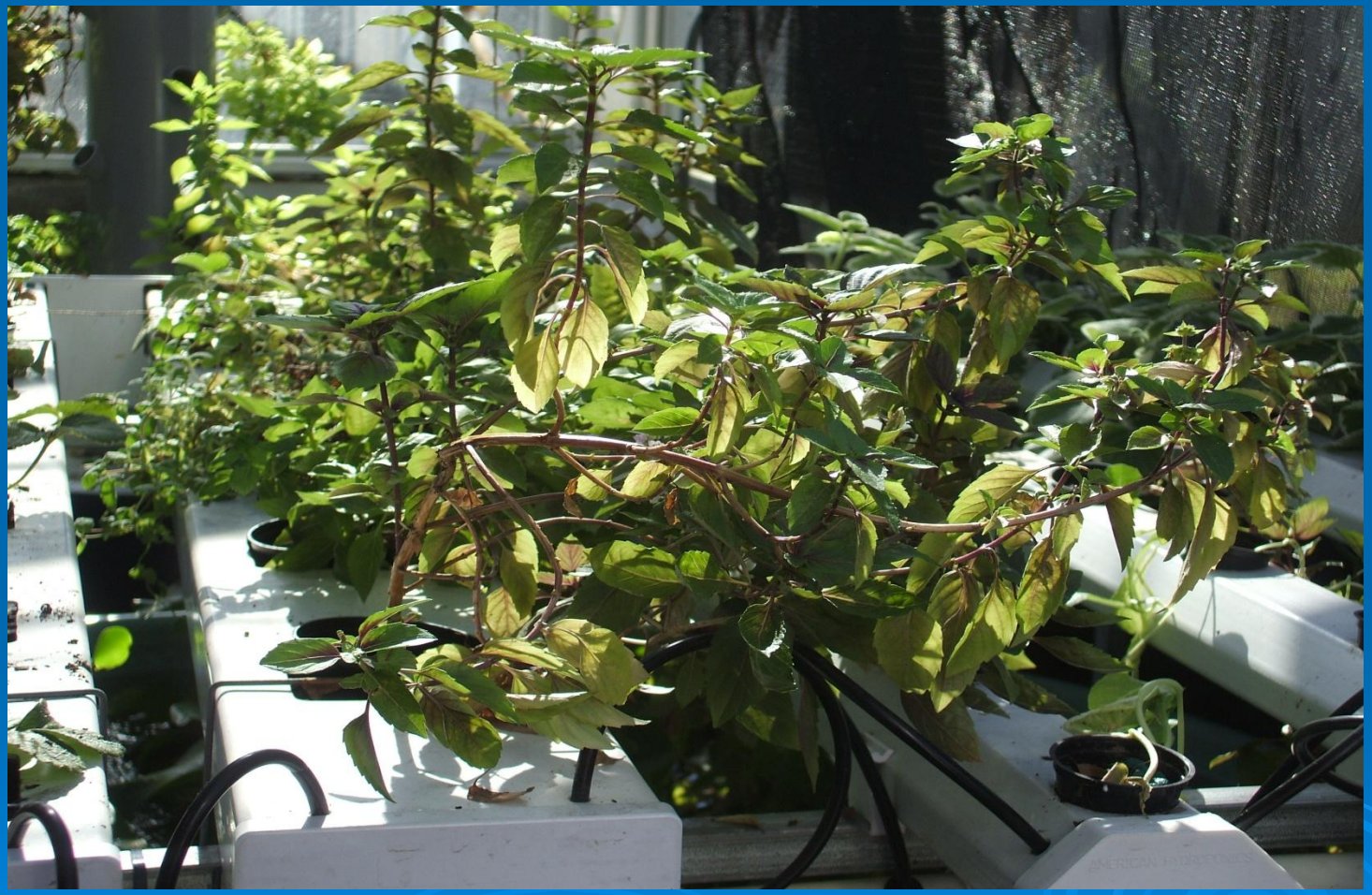
-flexible plastic tube supported by tray

-tube made of black plastic with holes punched at specified intervals

-plants are placed in troughs where they are bathed in continuous flow of nutrient solution

Vertical Aeroponic Unit at GCAD, FVSU

NFT with Aquaponics



Floating Rafts

Ratios of Fish to Plants in Aquaponics systems

- Each system will have fish:plant ratios based on the efficiency of the filters and the amount of media per volume area.
- Component ratios: matched the volume of fish tank water to the volume of hydroponic media
- Current aquaponics 1 : 2 or 1: 4
- Speraneo system 1 cubic ft. of water to 2 cubic ft of bed (pea gravel) material

Aquaponic Systems

- Size of plant beds and number of plants are directly related to the amount of feed input into the system
- For every 57 g (2.01 oz) of feed, you can support 1 sq. meter (10.76 sq. ft.) of floating bed surface area in lettuce production (Univ. of Virgin Islands)
- Fish feed supplies all of the fertilization except for iron, potassium and Calcium
- Following UVI protocols by adjusting pH with potassium hydroxide and calcium hydroxide, only chelated iron will usually be needed to boost deficient iron concentrations

Speraneo's Aquaponic System S and S Aquafarms, W. Plains, Missouri

Ebb and Flow gravel beds with pea size gravel

50' X 80' solar greenhouse with six 1,200 gallon fish tanks and six one foot deep aquaponic trays per tank

Photos by Steve Diver, NCAT

Speraneo or S and S system

- Six 1,200 gallon fish tanks each one linked to six hydroponic grow beds
- 45-70 pounds of produce for every pound of tilapia
- 7-12 months to raise tilapia in Missouri

Linking Hydroponics to a 880 gallon recycle fish rearing system TCF-Freshwater Institute

- Gravel ebb and flow system
- Bank of timers for different beds to flow 5-8 min. several times/hr
- Several good manuals to download
- Diagrams and cost of system- details of piping and plumbing
- Operations and Management manual

Linking Hydroponics to a 880 gallon recycle fish rearing system TCF-Freshwater Institute

Rakocy and Univ. of the Virgin Islands Floating Raft System

- 4 fish rearing tanks at 7,800 liters each
- System with clarifier, filter, degasser, base addition and 4 rafts.
- pH maintained at 7.0-7.5 by alternating potassium hydroxide and calcium hydroxide
- Fish fed 3 times daily
- Nile tilapia stocked 77 fish/cubic meter
- Red tilapia stocked at 154 fish/cubic meter

University of the Virgin Islands Aquaponics Systems

Rakocy and Univ. of the Virgin Islands Floating Raft System

- Tilapia cultured for 24 weeks but with staggered harvest every six weeks
- Fed 3 times a day , 32% protein feed
- Annual production 4.16 metric tons Nile tilapia
- Annual production 4.76 metric tons red tilapia
- Yields of aquaponic basil 3 times greater than field grown

Rakocy and Univ. of the Virgin Islands Floating Raft System

- Yields of aquaponic grown okra 18 times greater than field grown
- $22/kg for fresh basil
- Aquaponic system 515/m3 per yr or $110,210 per system per yr
- Field based 172 per m3 per yr or 36,000 per yr for same area
- Aquaponic system yields $134,245 per yr. (Rakocy er al. 2004)

Mineral Deficiency for Plants in Aquaponics

- Feed a nutritionally complete feed to fish
- This feed contains almost all of the minerals and nutrients required by plants
- Iron (Fe) deficiency will most often occur
- Fe deficiency indicated by plants with yellow leaves
- Chelated Iron (Fe) should be added- 2mg/L is required
- DTPA chelated Fe is better at high pH

Nutrient Toxicity for Plants

- When one nutrient is in toxic concentrations it causes other nutrients to be deficient due to antagonistic actions of the nutrients
- Flouride and Chloride toxicity-wilting of marginal plant parts and leaf tip necrosis
- Sodium toxicity- causes calcium, Magnesium and K deficiencies

Nutrient Deficiency for Plants

- Nitrogen

  Plants use nitrate and ammonium

  deficiency—reduced leaf size, stunted growth and yellowing of leaves with leaf dropping
- Phosphorus

  bronze, red or pumpkin coloration, plants stunted
- Potassium

  on older leaves yellowing then dead leaves
- Fe

  yellowish and eventual bleaching

Aquaponics

- Fish should be in the system a month before any plants are put in- this is for the biofilter to become established to break down ammonia to nitrate
- 60-100 g of fish feed per day per square meter area of plant growing area for the staggered production of leaf lettuce (Univ. of the Virgin Islands)
- 11.5 to 1 ratio of plant bed to fish tank surface area in high density fish system 120 kg/m2

Management of Aquaponic Systems

- Manage the pH to be around 7.0 using calcium hydroxide or potassium hydroxide.
- Ensure adequate oxygen for fish, bacteria and plant roots

- In ebb and flow valve should be set to open water flow for 5-8 minutes twice every hour

Management of Aquaponic Systems

- Plant material builds up on tanks and pipes-it's best to clean out bed drain line every month
- Staggering harvesting and planting results in more constant nutrients and constant nutrient uptake

Ph Requirements in Aquaponics

- Fish optimum pH is 7.5
- Plant optimum pH is 7.0
- Aim for plant pH optimum
- In aquaculture systems usually use Sodium Bicarbonate to balance pH, but makes too much Sodium build up for plants
- In aquaponics, alternate calcium hydroxide (CaOH) and potassium hydroxide (KOH)
- Plants need calcium and potassium for growth

Management of Aquaponic Systems

- Try ladybugs and other beneficial insects.
- Don’t bring in different plant material
- Wash hands before and after handling plants or fish

Management of Aquaponic Systems

- Manage the system with the amount of feed compared to plants.
- Amount of feed is also based on stocking rate and size of fish

- Can’t use pesticides since raising fish. Need to use integrated pest management

Management of Feed in Aquaponic Systems

- Feeding rate ratio for aquaponics is the amount of feed fed to fish daily per square meter of plant surface area

- For floating rafts, feeding rate ratio= 60-100 g/m2/day
- For nutrient film technique feeding ration should be 25% less
- Dissolved oxygen should be at least 5 mg/L in water for fish and for plant roots

Conclusion

- In aquaponics it's critical to manage the pH for optimum growth and health of fish and plants
- Feed a formulating, nutritionally complete floating feed to ensure animal health and provide nutrients for the plants
- Observe fish while feeding to catch any water quality or disease problems early
- Maintain dissolved oxygen levels for the fish, biofilter and plants for the best growth
- Monitor and learn about the water quality of your system