Suggested Management Guidelines for An Integrated Recycle Aquaculture – Hydroponic System

September 1998

Version 1.0

TCF-Freshwater Institute
1098 Turner Road
Shepherdstown, WV 25443

Introduction

The growing bed operator's guidelines were written for The Freshwater Institute designed integrated aquaculture-hydroponic system for use in high schools as an educational tool. The purpose of the operator's guidelines is to provide those interested in building an integrated aquaculture-hydroponic system an introduction to some of the critical system management issues.

In a closed-loop (or recycle) fish rearing system, nutrient levels build up over time as fish utilize less than half the nutrients put into the system as feed. The ambient nutrient level in the system will depend on the number and size of fish stocked in the system and how often the water is exchanged and / or is lost when the settleable solids are removed from the system (e.g. backflushing the beadfilter).

Integrating a hydroponic growing system with a recycle fish rearing system utilizes nutrients that would otherwise be discharged into the environment. Integrating the two systems can improve water quality in the system, reducing the need for water exchange. Other benefits include reduced capital and operating costs relative to either system in isolation (e.g. shared heating and monitoring and control units) and increased learning opportunities for students.

Integrating the two production systems, however, has several drawbacks - the primary being the difficulty in maximizing production of both fish and plants. As the two systems share a common water source and physical location, the operator is limited in the number of management options that can safely be used to treat disease/pest outbreaks. Some of the chemicals used to treat pest outbreaks in plants are toxic to fish and vice versa. However, good system management practices and implementation of comprehensive biosecurity practices will reduce the incidence of disease outbreaks in the system. A second constraint is the difference in ideal culture conditions for plants and fish. To optimize plant production, a grower needs to maintain a hydroponic solution with pH and nutrient levels than can adversely impact the fish.

A wide variety of plants can be grown in an aquaponic system. We recommend that plants with short life (e.g. lettuce) versus long life cycles (e.g. tomatoes) be grown in the gravel beds. Plants such as tomatoes tend to develop extensive root systems that can plug the drain lines and can also serve as a host for undesirable insects.

The following are reported to work well in a gravel bed system:

- Leaf Lettuce (salad bowl, diamond gem, Anuenue, mesculun mix, red romaine, red oak leaf))
- Spinach (Malabar)
- Basil (sweet, cinnamon, lemon)
- Mints (spearmint, peppermint, and pineapple mint)
- Oregano

- Parsley (both varieties)
- Watercress
- Chives (regular and garlic)
- Leaf Lettuce
- Turnips
- Mustard and Beet Greens
- Swiss Chard
- Nasturtium
- Upright Rosemary - does not like a lot of water
- Ornamentals such as papyrus
- Cucumbers

System Initialization

The following discussion assumes that the fish rearing system was constructed simultaneously with the hydroponic growing unit. The system should be started up one to two weeks prior to stocking with fish or plants. Running the system for several weeks prior to stocking and planting allows you to check for leaks and to properly calibrate the flow to the beds.

Set the 60-minute timers to open the solenoid valves for 5 to 8 minutes twice an hour. (During the summer, the beds may need to be flooded more frequently). Intermittent flow of water results in complete gas exchange in the air spaces of the gravel several times a day, maintaining aerobic conditions in the growing beds. The solenoid valve should be closed once the water level in the gravel beds reaches the top of the gravel.

The timers should be sequenced so that no more than one bed at a time is being flooded. The frequency of the ebb & flow cycle will depend on the variety of plants in the system and the system management objectives (e.g. compare and contrast the impact of different ebb & flow cycles on the grow rate of lettuce). If the bed does not flood within the 5-8 minute period, the 2' ball valves on the bed drain lines can be partially closed causing the water to build up in the beds.

Plant material and solids from the growth of microorganisms will build up over time in the gravel beds. The build up of solids can form anaerobic zones in the gravel bed and cause the beds to plug and fill more rapidly over time. We recommend that the beds are checked on a weekly basis to ensure that they have not plugged causing water to spill over the top of the bed. If the beds start to overfill the 2' ball valves can be adjusted or the excess solids removed. The excess solids and plant material should be removed from the gravel beds between replanting. We also recommend that the bed drain line (well screen) be cleaned out every other month. This can be accomplished by removing the ball valve and scraping out sludge and root material that will accumulate in the well screen over time.

Crop Production Systems - Seed Stock and Planting Densities

The gravel growing beds should be planted over a several week period to ensure that there are adequate nutrients available for the plants and to facilitate a continuous harvesting schedule for the plants. Start all plant material from seeds to avoid introducing pests or diseases into the greenhouse via the plants. Plants can be started in peat pellets or Oasis cubes and then transferred to the system, after 3 weeks. Lettuce and basil can also be direct seeded in the gravel beds and then thinned (1/4" between plants) and / or transplanted. Basil and rosemary cuttings can be directly planted into the gravel beds. Plant spacing will vary with the type of leafy green vegetable or herb planted. Follow recommended planting densities for field crops.

To optimize growing space, we suggest that a separate bed be set up for seed germination. We also recommend a staggered planting and harvesting strategy as it allows you to optimize bed space and have a continuous supply of produce for the market. This also promotes a relatively constant uptake of nutrients, which is critical for systems that rely on the gravel beds for bio-filtration and minimizes the impact of a sudden change in water quality on the bacteria in the bead filter and gravel growing media.

Insect and Disease Control

As water from the plant is returned to the fish tanks, you cannot use most pesticides and or fungicides to treat your plants. Sunflower oil and blue sticky cards can be used for dealing with thrips. Lady bugs can be introduced into the greenhouse to deal with aphids.

We suggest that the system operator implement an integrated pest management plan (IPM) to reduce potential losses from insects and plant diseases. For further information on IPM and insect control in greenhouses, see the suggested references listed in the Appendix or contact your local extension agent.

IMP practices include:

- Install micro-screen on air intake vents
- Start with clean seeds
- Do not bring plant material into the house
- Eliminate vegetation around the greenhouse
- Clean hands, etc., prior to handling material
- Monitor pest levels and act before they become a problem

Disease Management for Fish

There are a limited number of options for treating sick fish in an integrated system. Because culture water is pumped to the plants, you cannot use salt, etc. to treat sick fish as it is toxic to plants. If treatment is required, the flow to the gravel beds must be shut

off during treatment. This will require watering the plants by hand until the theraputant is out of the system.

Nutrient and Water Quality Management Issues

The primary issues associated with nutrient management in integrated systems are:

- **Micro-nutrient Supplementation** - Fish effluent is deficient in most of the primary micro-nutrients, requiring some supplementation. Primarily iron (Fe) as iron chelate, potassium, and calcium. Supplemental micro -nutrients can be added nutrient by nutrient. However we recommend that you use a commercial micro-nutrient mix as it is expensive to purchase individual micro-nutrients. They can be purchased from a variety of sources. Depending on the hydroponic system, you can apply the nutrient supplement as a foliar applicant or add it directly to the culture water or to the growing media if nutrient deficiencies are observed.

- **Alkalinity Adjustment** – Baking soda cannot be used to increase pH in integrated systems as elevated sodium levels will kill plants. To adjust alkalinity, we recommend using potassium carbonate which can be purchased in bulk (600 lbs - 12 bags) from Van Waters and Roger in Pittsburgh.

- **Aeration** – Plant roots require DO levels that are comparable to those required by fish. DO levels should remain high throughout the gravel beds. Formation of anaerobic zones will cause root death. Rapid water exchange, intermittent dewatering and use of an aeration system in the fish tanks will minimize the formation of anaerobic zones in the gravel beds.

- **Water Exchange** – Water exchange should be minimized to maximize nutrient retention in the system.

- **Nitrate** – High nitrate levels favor vegetative growth in plants while low nitrate levels promote fruiting.

- **PH** – pH should be maintained at 7.0 for optimum nutrient availability.

- **Temperature** – The optimum water temperature is 24°C for vegetable production and 30°C for tilapia production.