Management of Aquaponic Systems

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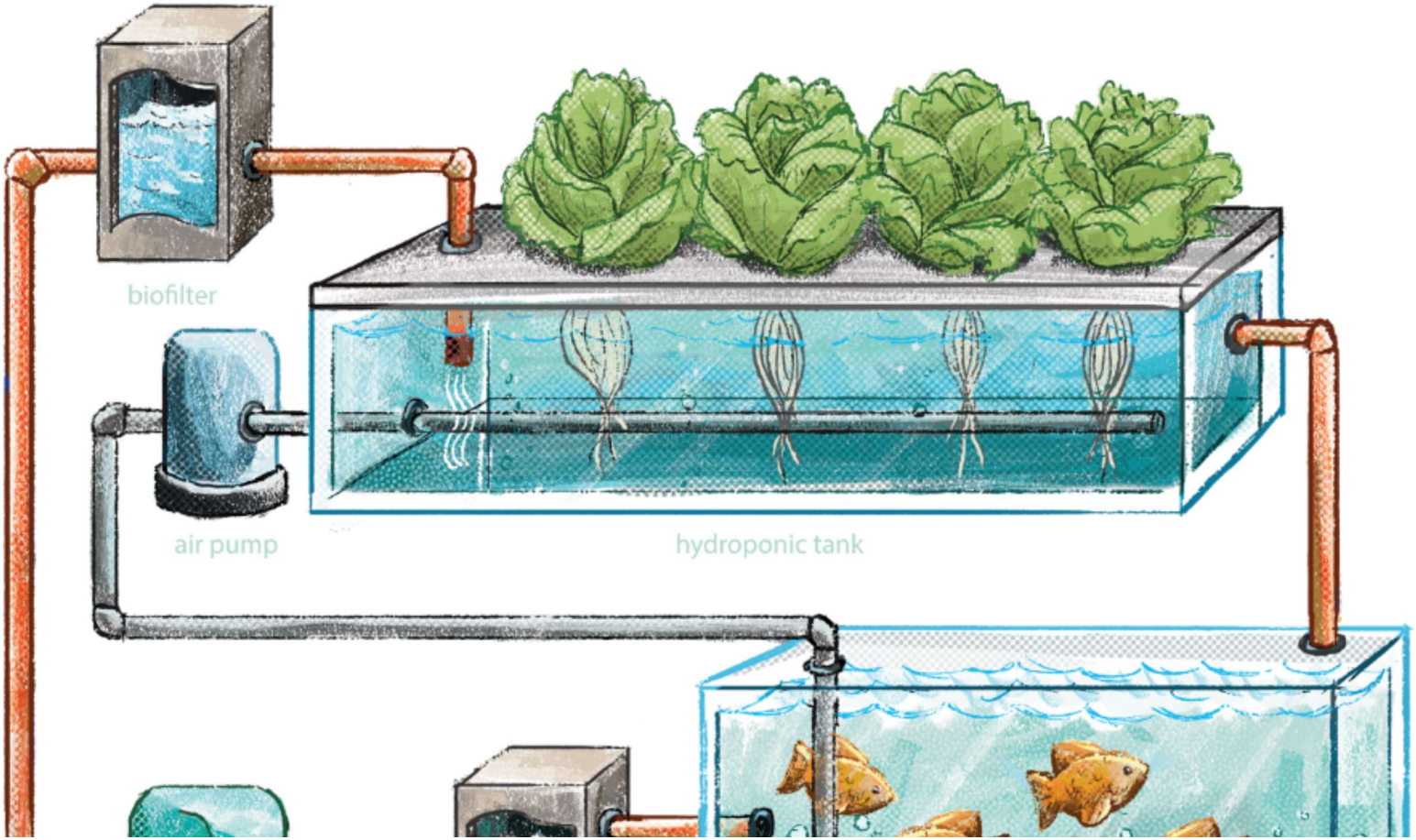
Aquaponics is the *integration* of recirculating **aquaculture** and **hydroponics** in one production system. Although the production of fish and vegetables is the most visible output of aquaponic units, aquaponics is the management of a complete ecosystem that includes three major groups of organisms: fish, plants and bacteria.



System balance

Aquaponic systems need to be **balanced**. The fish (and thus, fish feed) need to supply adequate *nutrients* for the plants.

The plants need to filter the water for the fish. The **biofilter** needs to be large enough to process all of the fish wastes, and **enough water volume** is needed to circulate this system.

Facts

- On average, the fish will consume 1 to 2 percent of their body weight per day during the grow-out stage.

This assumes that the fish are larger than 50 g because small fish eat more than large ones, as a percentage of body weight

- The recommended maximum stocking density is 20 kg of fish for 1 000 litres of water (fish tank).
- Higher stocking densities require more sophisticated aeration techniques to keep the DO levels stable for fish, as well as a more complex filtration system to deal with the solid waste

Disease, nutritional deficiencies and death are symptoms of an unbalanced system. Water testing will provide information on the balance of the system. High ammonia or nitrite indicates insufficient biofiltration. Low nitrate indicates too many plants or not enough fish.

Management practices for fish

It is best to wait until the initial cycling process is totally completed and the biofilter is fully functioning to add the fishes to the system.

If it is decided to add fish before cycling, then a reduced number of fish should be added.

This time will be very stressful for the fish, and water changes may be necessary

Species suitable for aquaponic farming include tilapia, common carp, silver carp, catfish, trout.

Acclimatizing fish

There are two main factors that cause stress when acclimatizing fish:

- changes in temperature and pH between the original water and new water.

If the pH values are more than 0.5 different, then the fish will need at least 24 hours to adjust. Keep the fish in a small aerated tank of their original water and slowly add water from the new tank over the course of a day. Slowly allow the temperature to equilibrate by floating the sealed transportation bags containing the fish in the culture water. This should be done for at least 15 minutes.

Fish feeding and growth rates

The feed rate ratio provides a way to balance the components of an aquaponic system, and to calculate planting area, fish feed, and fish biomass.

During the grow-out stage of the fish, it is recommended a fish feeding rate of 1 to 2 percent of their body weight per day.

Considering a fish stocking density of 10 to 20 kg per 1 000 litres, 200 g of feed per day can be provided.

During the first two to three months, the fish are small (50 grams weight for a fingerling tilapia) and eat about 3 percent of their body weight per day.

Therefore, an initial stocking of 40 fingerlings would weigh 2 000 g, and together they would eat approximately 60 g of fish feed per day.

After two to three months feeding at this rate, the 40 fish will have grown to 80 to 100 grams each and weigh a total of 3 200 to 4 000 g.

At this point, they should be able to eat 80 to 100 g of feed per day.

Make sure to divide the feeding into morning and afternoon rations. Moreover, juvenile fish benefit from an additional lunch–time feeding.

Splitting the ration is healthier for the fish and also healthier for the plants, providing an even distribution of nutrients throughout the day

Spread the feed across the entire surface of the water so all the fish can eat without injuring one another or hitting the side of the tank.

Avoid scaring the fish during feeding by refraining from sudden movements. Stand still and observe the fish.

Always remove any uneaten fish food after 30 minutes, and adjust the next feeding ration accordingly.

If there is no food left after 30 minutes, increase the ration. If there is a lot left, decrease the ration.

Fish health

The main indicator of fish well-being is their behaviour and it is important to recognize the signs of stress, disease and parasites.

The best time to observe fish is during their daily feeding, both before and after adding the feed, and noting how much feed is eaten.

Healthy fish exhibit specific behaviour.

- Fins are extended, tails are straight.
- Swimming in normal, graceful patterns. No lethargy. However, catfish often sleep on the bottom until they wake up and begin feeding.
- Strong appetite and not shying away at the presence of the feeder.
- No marks along the body.
- No discoloured blotches, streaks or lines.

- No rubbing or scraping on the sides of the tank.
- No breathing air from the surface.
- Clear sharp shiny eyes

Fish diseases

The three major groups of pathogens that cause fish disease are fungus, bacteria and parasites.

All of these pathogens can easily enter an aquaculture system from the environment, when adding new fish or new water, or could have previously existed in the unit.

Prevention is by far the best way to prevent disease in fish.

Daily observation of fish and monitoring for disease allows the disease, if present, to be treated quickly to prevent more fish from being infected.

If a significant percentage of fish are showing signs of disease, it is likely that the environmental conditions are causing stress.

In these cases, check the levels of ammonia, nitrite, nitrate, pH and temperature, and respond accordingly.

If only a few fish are affected, it is important to remove the infected fish immediately in order to prevent any spread of the disease to other fish.

Management of pests and diseases

One effective treatment options against some of the most common bacterial and parasite infections is a salt bath.

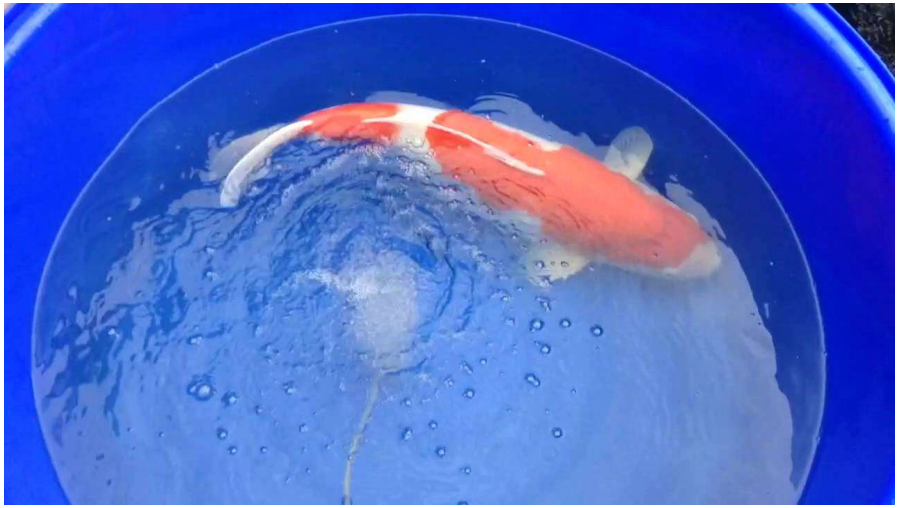
Infected fish can be removed from the main fish tank and placed into a salt bath.

This salt bath is toxic to the pathogens, but non-fatal to the fish.

The salt concentration for the bath should be 1 kg of salt per 100 litres of water.

Affected fish should be placed in this salty solution for 20 to 30 minutes, and then moved to a second isolation tank containing 1 to 2 g of salt per litre of water for another five to seven days.

The heating of the water in the aquaponic system can also shorten the parasite life cycle and make the salt treatment more effective.



Harvesting and staggered stocking

A constant biomass of fish in the tanks ensures a constant supply of nutrients to the plants.

To achieve a constant biomass in the fish tanks, a staggered stocking method should be adopted.

This technique involves maintaining three age classes, or cohorts, within the same tank.

Approximately every three months, the mature fish (500 g each) are harvested and immediately restocked with new fingerlings (50 g each).

This method avoids harvesting all the fish at once, and instead retains a more consistent biomass.

If it is not possible to obtain fingerlings regularly, an aquaponic system can be still managed by stocking a higher number of juvenile fish and by progressively harvesting them during the season to maintain a stable biomass to fertilize the plants.

If the fish are mixed–sex, the harvest must firstly target the females to avoid breeding when they reach sexual maturity from the age of five months.

Routine management practices

Daily activities

- Check that the water and air pumps are working well, and clean their inlets from obstructions.Check that water is flowing.
- Check the water level, and add additional water to compensate for evaporation, as necessary.
- Check for leaks.
- Check water temperature.
- Feed the fish (two to three times a day if possible), remove uneaten feed and adjust feeding rates.
- At each feeding, check the behaviour and appearance of the fish.
- Check the plants for pests. Manage pests, as necessary.
- Remove any dead fish. Remove any sick plants/branches.
- Remove solids from the clarifier and rinse any filters.

Weekly activities

- Perform water quality tests for pH, ammonia, nitrite and nitrate before feeding the fish.
- Adjust the pH, as necessary
- Check the plants looking for deficiencies. Add organic fertilizer, as necessary.
- Clear fish waste from the bottom of fish tanks and in the biofilter.
- Plant and harvest the vegetables, as required.
- Harvest fish, if required.
- Check that plant roots are not obstructing any pipes or water flow.

Monthly activities

- Stock new fish in the tanks, if required.
- Clean out the biofilter, clarifier and all the filters.
- Clean the bottom of the fish tank using fish nets.
- Weigh a sample of fish and check thoroughly for any disease.

Management practices for plants

Seedlings can be planted into the system as soon as nitrates are detected.

Expect these first plants to grow slowly and exhibit some temporary deficiencies because the nutrient supply in the water is temporarily small.

It is recommended to wait three to four weeks to allow the nutrients to accumulate.

Plant Selection

It is best to start a new aquaponic system with fast-growing robust plants with a low nutrient demand.

Some examples are leafy green vegetables, such as salads, or nitrogen fixing plants, such as beans or peas.

After two to three months, the system is ready for larger fruiting vegetables that demand a greater amount of nutrients

Plant spacing

Seedlings can be planted using a slightly denser spacing than for most vegetables in soil because in aquaponics the plants do not compete for water and nutrients.

Some new aquaponic units experience iron deficiencies in the first two to three months of growing as iron is important during the early stages of plant growth and is not abundant in fish feed.

Thus, it may be necessary to initially add chelated iron (soluble iron in powder form) to the unit to meet the requirements for plants.

The recommendation is to add 1 to 2 mg per litre for the first three months of starting a unit,

Iron can also be supplemented by using aquaponics-safe organic fertilizers such as compost or seaweed tea, as iron is abundant in both.

Plant nutrition

Successful aquaponic systems are balanced. The feed rate ratio is the main guideline to balance the amount of fish feed to plant growing area, which is measured in grams of daily feed per square metre of plant growing space.

The feed rate ratio for leafy vegetables is 20 to 50 g per m^2 daily; fruiting vegetables require 50 to 80 g per m^2 daily

If deficiencies do occur, it is necessary to add outside nutrients. Organic liquid fertilizer can be used as either diluted foliar feed for plant leaves or poured straight into the root zone.

Deficiencies often occur when there are too many plants for the number of fish, or when feeding is reduced.

Pests and disease

Be sure to try to prevent pests using the integrated production and pest management (IPPM) techniques (e.g. physical barriers, trapping, companion planting, crop rotation, among others).

If pests remain a problem, begin by using the mechanical removal techniques before considering sprays.

Only use aquaponic-safe remedies, such as plant extracts or repellents, biological insecticides (Bacillus thuringiensis and Beauveria bassiana), soft soaps, ash, plant oils or extracts of essential oils, chromatic/attractant traps, and external attractant plants treated with insecticides.

Regardless, avoid letting the spray enter the water

Harvesting plants

In one to two months, leafy green vegetables should be ready to harvest. After three months, the unit should also have enough of a nutrient base to begin planting larger fruiting vegetables.

Staggered planting and harvesting

It is worth staggering the planting over time in order to prevent harvesting the entire crop all at once.

If this were to happen, nutrient levels would decrease just before harvest, which might create nutritional problems for the plants, and spike after the harvest, which would stress the fish.

Staggered planting allows for continual harvest and transplant of vegetables and ensures constant nutrient uptake and water filtration.

Harvesting approaches

When harvesting full plants from media beds (e.g. lettuce), make sure the entire root system is removed.

In addition, shake the gravel stuck in between the roots and place the gravel back in the media bed

Place the discarded plant roots into a compost bin to recycle the plant waste. Leaving roots and leaves in the system can encourage disease.

When harvesting vegetables use a sharp clean knife. To prevent any bacteria contamination, ensure that aquaponic water does not wet the leaves.

Follow seasonal planting advice

To an extent, aquaponic food production methods provide a means to extend planting seasons, particularly if the unit is housed inside a greenhouse.

However, it is still strongly recommended to follow local seasonal planting advice. Plants grow better in the season and environmental conditions to which they are adapted.

System cycling and starting a biofilter colony

Bacteria are a crucial and pivotal aspect of aquaponics, serving as the bridge that connects the fish waste to the plant fertilizer.

The nitrifying bacteria convert the fish waste, which enters the system mainly as ammonia, into nitrate, which is fertilizer for the plants. This is a two-step process, and two separate groups of nitrifying bacteria are involved.

A good establishment of the bacteria colony is crucial for a new aquaponic system.

System cycling is a term that describes the initial process of building a bacterial colony when first starting any aquaponic unit

Overall, the process involves constantly introducing an ammonia source into the aquaponic unit, feeding the new bacterial colony, and creating a biofilter.

The progress is measured by monitoring the nitrogen levels using the nitrate test kit.

AOB and NOB COLONIZATION

Once introduced into the unit, the ammonia becomes an initial food source for the ammonia-oxidizing bacteria (AOB), a few of which are naturally occurring and recruit to the system on their own.

In good conditions, this takes about 25 to 40 days, but if the water temperature is cool, complete cycling may take up to two months to finish. At this point, a sufficient bacterial colony has formed and is actively converting the ammonia to nitrate.

THANK YOU