Aquaponics

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Introduction

"Aquaponics" is the combination of two separate systems, aquaculture and hydroponics. The goal of this combined system is to simultaneously grow plants and fish in the same system. The main advantage of doing this is because it allows the nutrients produced by fish waste to be used by the plants, which in turn help filter the water making it suitable for the fish.

There are multiple approaches to aquaponics, as the term is broad. The focus of the Fact Sheet will be systems located within greenhouses and primarily aimed at crop production.

Aquaculture

The first part of "Aquaponics" is "aqua" meaning water and refers to the aquaculture (fish rearing) half of an aquaponics system.

This Fact Sheet is to give a basic overview into aquaponics with an emphasis on plant growth and does not go into the full system of aquaponics. If you are more interested with the fish side of aquaponics, see the additional reading list at the end. Whichever the interest (the aquaculture or hydroponic portion), it is a good idea to review and have an understanding of aquaculture, more specifically recirculating aquaculture systems, before creating an aquaponics system. As aquaponics is two combined agriculture techniques, only understanding one aspect is not an option.

Hydroponics (Soilless Systems)

The second part of "Aquaponics" is "ponics" which refers to the growing technique of hydroponics the plant half of an aquaponics system.

A brief warning, aquaponics is not hydroponics, just as it is not aquaculture, it is a combination of the two and creates a mini-ecosystem. While many aspects and parts of hydroponics are in aquaponics, it is important they be treated as separate systems with separate problems, benefits and methods.

Hydroponics is a method of cultivating plants in soilless systems. In hydroponic systems, the user has full control of the nutrients and environmental conditions of the plants, compared to traditional in-soil techniques. For more information about hydroponics, consult Extension fact sheet: HLA-6442 Hydroponics.

Aquaponics Advantages

- Requires less water quality monitoring than hydroponics
- Water-efficient
- No need for soil
- Media beds for plant growth double as surfaces for the nitrogen-fixing bacteria
- Nutrients come from fish, no added nutrient costs (no fertilizers)
- Limited to no pesticide use
- No weeding
- Flexibility in location
- Year-round production (in controlled environments)
- Less prone to disease than hydroponics

Aquaponics Disadvantages

- High upfront costs
- Higher operational costs than soil culture
- High energy requirements
- Requires daily maintenance
- Skill and knowledge from two separate agricultural fields required
- Requires testing of water quality for fish and plants
- Multiple ways entire system can fail
- Limited plant selection

Aquaponics in the Greenhouse

Aquaponics is not limited to greenhouse production, but putting an aquaponics system into a greenhouse has its advantages.

System Design

Like hydroponics, aquaponics systems have different designs that have with their own advantages and disadvantages. The four most common types are explained below.

Basic: Flood and Drain

This is the simplest and most straightforward of the aquaponics designs. It uses a 1:1 ratios of media bed volume to fish tank volume and it consists of a fish tank, pump and the grow bed. It works by directly pumping the water from the fish tank into the media bed and allowing the media bed to drain back into the fish tank.

The benefits of this system is its simplicity, but its downside is that it is fairly inflexible when it comes to ratios, as too much water will be drained from the fish tank if trying to fill two media beds, and the low water levels can be stressful to the fish.

CHIFT PIST or CHOP

(Constant Height In Fish Tank – Pump In the Sump Tank, Constant Height One Pump)

This system is very similar to the basic with the addition of a sump tank. As its name implies, the addition of the sump tank allows for the fish tank's water levels to stay at a constant height as the pump will be in a separated sump tank.

This system works by having water from the fish tank overflow into the growing beds, which drains into the sump tank. The sump tank contains the pump, which will pump the water back into the fish tank.

The benefit of this system is with the water levels staying at a constant height in the fish tank, there is no stress to the fish. The downside has to do with layout. A sump tank will need to be lower than the media beds, which in turn need to be lower than the fish tank. This might require more space or just be more difficult to find the supplies. Another thing to watch for is if the sump tank's water level ever gets too low, damage to the pump can occur.

CHOP2

CHOP2 is another way to set up the CHOP system. This system design does not require the fish tank to be the tallest component. The design is more or less a double loop system that has the growing beds and the fish tank run to the sump tank. The sump tank is then responsible for pumping the water into the growing beds and the fish tank.

This system is flexible because it essentially treats the fish tank as another growing bed. Where the fish tank and the growing beds differ is the growing beds make use of an auto siphon; whereas, the fish tank just needs a gravity feed overflow. The benefit of this system is adding growing beds is easy, as long as the pump is strong enough and the sump tank large enough. A negative is that the clean water from the growing beds is mixed with the dirty water from the fish tank, making the system less efficient at filtration.

Hybrid

The other systems mentioned here only deal with media-based growing beds, and not raft/DWC/NFT styles of growing beds. The hybrid system allows for these other beds to be implemented.

Hybrid systems are still being worked out, but in one scenario the media beds can be used as a solids filter. All hybrid systems need other filters and components to be used properly and effectively. If one wants to take advantage of the benefits of the raft beds, then a hybrid system would be the best choice.

Components

The following are basic components needed for an aquaponics system. Not all of these components are needed for every system design, but are important in others. It is important to check all components for clogging periodically, as all are susceptible to the buildup of solids.

Growing Beds

The growing beds are the areas designated to grow the crops. There are two different basic styles commonly used in aquaponics, media-based beds and beds that grow directly in water. Each style comes with its own advantages and disadvantages, but they both share common components.

Selecting the material for the growing beds is an early part of aquaponics design. When selecting the material to use as the growing bed, the first consideration is to find non-toxic and inert materials. Since aquaponics systems have both fish and plants, the material needs to be non-toxic for the health of the system and for the health of the consumer. The growing bed material should also be inert, which means the material does not leach or put materials into the system. This is important because leaching material it can gradually change the chemical composition in the system. It is a good idea to avoid unlined metals, uncoated concrete and some recycled plastics, which all have the potential to leach.

The growing beds are perhaps the best place to start when designing the aquaponics system. Generally, a 1:1 or 2:1 (growing bed to fish tank volume) ratio is used, depending on set design. The growing beds should take up most of the space in the greenhouse.

Media Beds

The media beds are the most common type of growing bed for aquaponics systems. These growing beds contain a soilless media in which the crops will grow. In the aquaponics systems, they play two roles – the space for plants to grow and to help filter out toxins in the water.

Media beds function better if they are 12 inches to 14 inches deep. This gives the plants more room to send out roots, lessens the risk of plant roots constantly sitting in water, and provides more area for bacteria to clean the water and provide the nutrients to the plants.

The advantage of media beds are the flexibility of the crops that can be grown. Media beds provide areas for roots to grow – they act similar to pots and traditional beds – making the watering style the limiting factor in what plants can and cannot be used.

One disadvantage of the media beds is they can be more difficult to work with on short growth crops, such as lettuce. This is because the crop becomes harvestable quickly and cleaning out the roots can be time-consuming. This is not a problem with crops that take a longer time to harvest such as peppers. Another disadvantage is crops such as carrots, potatoes and radishes can be deformed, depending on the media used. This does not mean they are not edible; just an unappealing appearance.

Media

In aquaponics, soilless media is used. This is where it is similar to hydroponics, but aquaponics have some other considerations that do not make all hydroponic soilless media techniques valid for aquaponics.

First, it is important to realize what the media does in aquaponics. The media is in charge of multiple factors. It provides structure, air space, temperature moderation and filters solid waste. When selecting the media, it is important to select media that will function within the entire system. Gravel and clay structure tend to work best. The media must not alter the pH of the water. This is for the health of the fish and the plants. The media also must not decompose with time. This is due to the chance of the media changing the pH while decomposing. Media containing soil, wood chips, peat moss or similar materials do not work in an aquaponics system. The material size also is important. The media should be large enough that it cannot be washed down and clog the drains and plumbing systems, but small enough to encourage root growth. This is usually about ½ inch to ¾ inch diameter in size.

Some other factors to consider are porosity and how it handles. The porosity helps with keeping healthy nitrifying bacterial levels by increased surface area, as well as holding more air and water, while making the media lighter. Handling refers to the coarseness of the media and is only a concern regarding user comfort when working in the media beds. The smoother the media, the easier it will be when harvesting or working with the plants.

Before adding the media to the growing beds, it is important to test and wash it. Testing will ensure it is inert and pH neutral (some gravels contain limestone and other rocks and minerals which should not be used).

Table 1 shows some commonly used media for aquaponics and their characteristics.

Raft/Deep-Water Culture (DWC)/Nutrient Film Technique (NFT)

Raft beds are a hydroponic technique that saves time and effort when growing certain crops. Seedlings are generally grown in rock wool or other soilless media until about a month old, then placed on a raft that allows the roots to freely float in the water, have water constantly flowing through the roots or be sprayed by mist. The water used is highly oxygenated and contains the desired nutrients. Not all plants used in hydroponics or aquaponics can use this type of bed, but it does have its advantages.

The advantages of the raft beds are that quickly growing crops, such as lettuce, are easier to harvest, as they simply need to be pulled off the raft and roots can be trimmed off. Compare this to the media beds, where once the plant is pulled it needs the soilless media cleaned off the roots, so the media can be re-used.

Due to the nature of the raft beds, they can be modified to work in aquaponics. This can be done by having the water used flow through a media bed before going back to a sump tank or fish tank. This allows the water to go through the necessary filtration.

While raft beds can be used and many kits have them as an option, they do have a more limited range of crops capable of being grown using this technique.

Biofilters

Biofilters are used to clean out solid waste and toxic chemicals such as ammonia. In aquaponics, this is done through the media beds with the help of bacteria. More filters and water-holding tanks can be added to the system, but this is generally not necessary.

Rearing Tanks (Fish Tanks)

The rearing tanks depend a lot on the growing beds and have similar considerations. They are the location of the fish and the provider of the nutrient-rich water for the plants.

When selecting a rearing tank, it should be a similar process as for the growing beds. This is because inert, non-toxic, food-safe materials should be used. The size of the tank should be determined by the size of the growing beds. If using the 1:1 or 2:1 ratio in the system design, provide enough water to be drained from the rearing tank and put into the growing tanks without limiting the water available to the fish.

The design and placement of the tank should take into account the weight of the filled tank. Once a tank if filled, it is most likely going to remain in that location (water weighs about 8.3 pounds per gallon). Choose a location that limits the potential of people or things from falling into the tank. Try to find a shaded location or cover the fish tank. This will help prevent or limit algae growth in the tank.

The shape of the tank should be considered, depending on the overall size and stocking densities. For example, in large high-stocking density designs, it is better to use a round or oval design because it allows water to easily flow around, limiting dead zones of oxygen that are found in corners of square and rectangular tanks. If only a small tank is needed, square and rectangular designs are more space efficient and should be considered. In both cases, tanks with more exposed surface area to air helps with gas exchange and will help in keeping the tank well oxygenated.

Sump Tanks

The sump tank is a water-holding tank for CHOP/CHOP 2 and Hybrid designs. The holding tank it is the lowest component

Table 1. Media.

	Expanded Shale	*Expanded Clay*	*River Stone*	*Crushed Stone*	*Synthetic*
Weight	¾ the weight of stone	½ the weight of stone	Heavy	Heavy	Light – tends to float
Source	Quarry	Quarry	Rivers	Quarry	Petroleum
Origin	U.S.	China/Germany	Local	Local	China
Inert	Yes	Yes	May have Limestone	May have Limestone	Yes
Easy to Handle	Yes	Yes	Yes	No	Yes
Expense	Middle-range	Expensive	Cheap	Cheapest	Most expensive

Adapted from Rob Torcellini, Bigelow Brook Farm, LLC in the system. It is needed when the system is not directly flowing from the rearing tank to the growing beds back into the rearing tank.

The purpose of the sump tank is to hold water, allowing the water levels of the rearing tank to remain unaffected. Its main purpose is to store and hold water, but it may provide areas for temporary fish storage, depending on the water's oxygen and fish species.

Sump tanks are typically small and stored on the ground. They usually can be placed underneath the growing beds, saving space. Remember, if a pump is located in the sump tank, it is important that the water levels are never allowed to get low enough to cause a problem for the pump.

Plumbing

Plumbing is very important in aquaponics as they are the connections between the other components. First, the material used needs to be approved for use with fish and plants. You do not want any plastics or metal plumbing that can be toxic. Polyvinyl chloride (PVC) and chlorinated polyvinyl chloride (CPVC) both are common and safe to use. An alternative for pipes is high-density polyethylene pipe (HDPE), but it has less options in fittings and is harder to find.

When setting up the plumbing system, be sure to prevent leaks from areas where the plumbing meets the next component. This can be accomplished using things such as, marine-grade silicon, Uniseals® or bulkhead fittings. The cheapest would be the silicon, but it is also the least effective and needs to be periodically reapplied. The other two are very effective but will have higher costs.

Mechanical and Electronic Timers

When using a flood and drain design system, a timer of some type is needed to control the system. Mechanical and electronic timers use a set interval to trigger flooding and draining systems to turn on.

The mechanical and electronic timers are usually set to work in one-hour intervals split between on and off. In most cases the system should spend 15 minutes in the "on" position (filling the media bed) and the other 45 in the "off" position (draining). These are just typical numbers and by using mechanical and electronic timers, adjustments can be made until the most effective intervals are being used. If this type of control is not desired there is the autosiphon that works automatically and not in set intervals.

Autosiphon (Bell Siphon)

The autosiphon is an automatic, always on, method to control the flood and drain system in the media beds. It works by having an overflow spout. Once the water level starts filling the overflow, it creates a low-pressure area within the siphon, triggering the siphon to open. This quickly drains the water from the media beds until the bed is drained and air fills the siphon again. The siphon closes and the bed slowly begins to fill with water again.

A similar system that uses a flood tank and a flood siphon can also be used. It works similarly, but instead of filling the media bed it fills a flood tank that once filled, flows into the media bed. (This system works in a similar way to how a toilet works.)

Autosiphons are a good choice for media beds and those not wanting to work with timers. They are not difficult to construct and operate. They do, however, need to be checked regularly with the rest of the system.

Pumps

Pumps are needed to keep the system circulating. Most pumps used in aquaponics are usually submersible pond pumps, but other types are available. It is very important the pumps do not leak anything into the water, therefore, it is a good idea not to cut costs when selecting pumps.

Things to consider when selecting the pump are its power in regards to flow rate and head pressure. It is generally recommended to select a flow-rate that can cycle the entire system in about an hour and also make sure the head pressure is high enough to pump water to the height needed. To fill two 10-gallon beds once an hour, a pump capable of moving 20 gallons of water in one hour is needed just for the beds. In aquaponics, take the number of beds times the size of the beds and add it to the size of the fish tank times two (to cycle the fish water twice every hour) to get the gallons per hour needed. For example, for two 10-gallon beds and a 20-gallon fish tank, (2 x 10) + (20 x 2) = 60 gallon per hour needed.

The head pressure refers to height the water needs to be pumped to, or the highest point in the system to the top of the water surface. If the tallest bed is 5 feet off the ground, and the top of the water surface is at 1 foot off the ground, then the head height is 4 feet.

A pump chart can be used to determine if the pump meets the required gallons per hour and head pressure/height requirements. Remember the pump is a very important aspect of the aquaponics systems and it is recommended not to cut costs in this area.

Aeration Devices

A good aquaponics design should provide adequate oxygen for the fish and plants. One design of an aeration device uses diverted water coming directly off the growing beds and flowing back into the rearing tank through a drip system. This works by allowing the surface of the water to absorb some air and then falling back into the main body of water. The combination of flowing water and a drip system should provide adequate oxygen, but other devices to provide supplemental oxygen are recommended.

The aeration pipes and similar systems can be used to supplement oxygen in the rearing tank. Other aeration devices are small pumps that can be placed within the rearing tank itself. These are just common fish aeration devices that send little bubbles throughout the tank. Consider putting an aeration system on a separate or back-up power supply, to ensure the fish have adequate oxygen even in the case of a power failure.

Other considerations

Other components to consider would be things such as indexing or sequencing valves and backup pumps.

The indexing or sequencing valves can be used to give more control of water flow and levels if the ratio of the systems is greater than 1:1. The indexing valve interrupts the flow of water and the sequencing valve redirects water after every stoppage of water flow into a new pipe. These systems help keep water levels safe for the fish.

The backup pumps are exactly what they sound like. These are pumps only activated if another pump fails. Although not required, it is a good idea to have backup pumps ready in case a problem arises.

Water

Water is the backbone of the entire aquaponics system. It provides the media for the fish to live in, is a necessity for plant growth and is the method in which nutrients are spread throughout the system.

Water source is important when establishing the system. For example, if using city water, first the pH needs to be checked and the method of cleaning the water needs to be known.

Many municipalities use chlorinated water. To remove the chlorine, run the system for a couple of days; most of the chlorine will off-gas and be removed from the system. Once the system is run to remove the chlorine, remember to check the water's pH once more, as it may have changed. Although it is important to remove chlorine at the start of the aquaponics system, if some water is needed just to top-off the system, chlorinated water will be fine. When topping-off the system, the chlorine will be at such a low rate it will have relatively little, if any effects. If desired, a chlorine filter can be purchased to filter the tap water prior to be using in the system.

If the water being used contains chloramine, a different approach is necessary. Chloramine does not off-gas like chlorine and requires an activated carbon filter or a UV filter to break it down. This water should be filtered before filling the fish tank or find an alternative source for water.

Water pH is important no matter what the source. The fish in the system will prefer a neutral pH, so it important to monitor the water pH and help maintain it at a near-neutral level. The reason to base the pH needs off the fish is because they are the most sensitive to the pH level. For optimal levels, fish like a pH from 6.5 to 8.0, bacteria from 6.0 to 8.0 and plants 5.0 to 7.0. This means a pH in the range of 6.8 to 7.0 is a good optimal target.

Action to adjust the pH should be taken when it drops below 6.4. To adjust the pH levels, slowly add calcium hydroxide (hydrated lime) or calcium carbonate (agricultural lime) alternatively with potassium carbonate, bicarbonate or potassium hydroxide. Slowly add and check the pH every few hours adding more if necessary. It is important to do this process slowly to avoid a pH spike from adding too much too quickly.

Action to adjust the pH should be taken when it rises above 7.4. When adjustment is needed, check with your local hydroponic or aquaponics store for some nitric or phosphoric acid-based products. Again, it is important to add the product slowly to prevent a sudden change in pH.

The last factor of water to consider is the dissolved oxygen content. The correct level is determined by the fish species, and in most cases, it is better to be a little high than low. Dissolved oxygen can be monitored using a dissolved oxygen meter and can be added into the system by aeration devices or flowing water.

Temperature

There are two separate temperatures that are very important to monitor in aquaponics. Both are determined by the species of fish and plants chosen, but they differ in the way they are controlled.

The first temperature to keep track of is the air temperature of the greenhouse. The air temperature is determined by the plant needs at the seasonal conditions. Air temperature can be controlled using common greenhouse practices of heaters, fans, shade cloth and other methods. Refer to information on the crops being grown to determine best cultural practices to have the greenhouse set at the right temperature.

The second temperature to keep track of is the water temperature. This is determined by the fish species. Some species of fish will prefer warmer or cooler environments, so it important to know in what conditions the selected species thrives. It may also be a good idea to select fish species from similar climatic zones as the greenhouse. This is simply because it can be easier to keep water temperatures close to the surrounding areas. Fish that thrive in those temperatures should require less temperature inputs. Providing the ideal water temperature removes a potential stress for the fish. To control water temperature in smaller fish tanks, a traditional aquarium heater can be used. Larger tanks will require different methods such as swimming pool heaters or in-floor heating. It also is important to look at ways to retain heat by insulating the fish tank and areas where cold spots might develop. Like many components in aquaponics, doubling up and having a back-up is a good way to help prevent problems in the case of one heater malfunctioning.

Avoid overheating the water in the aquaponics system. It is easier and more affordable to heat water than it is to cool water. Another reason to avoid excessive temperatures is warmer water holds less dissolved oxygen.

Bacteria

Bacteria (*Nitrosomonas* and *Nitrospira*) play an important role in aquaponics systems, as they are responsible for nitrifying ammonia (toxic to fish) into nitrate, which is safe and more readily available to plants. These nitrifying bacteria are aerobic autotrophs and require oxygen to survive, they need a surface to colonize, are very efficient at their conversion of ammonia to nitrites and they need a moist environment to survive. The *Nitrosomonas* create nitrites from their consumption of ammonia. Nitrites are still toxic to fish, so *Nitrospira* is needed, which consume the nitrites and create the wanted nitrates.

How to care for these bacteria is not overly complex. If the right conditions are provided, the bacteria should be able to thrive. The main component in keeping the bacteria alive is the presence of ammonia. So if there is a low stock level of fish, there will be lower levels of ammonia, leading to lower levels of bacteria. The reverse is also true, meaning high stocking levels can lead to higher ammonia levels, which provide more food for the bacteria, leading to more bacteria.

Oxygen levels are also very important in keeping the bacteria healthy. If oxygen is cut off, the bacteria will die off slowly. If oxygen becomes low, the bacteria will reverse their process and turn the nitrates into ammonia in a process known as dissimilation. This is easy to identify when it occurs, due to a clog in the grow bed, it begins to produce an ammonia odor.

A critical thing to control is dramatic temperature changes, which affect fish activity. If the temperature drops, the fish activity can drop, leading to less ammonia. If the temperature rises rapidly, the fish activity and feeding rise and can overwhelm the bacteria with ammonia. This is something to monitor if owning an outdoor system. In a greenhouse setting, the controlled environment should prevent dramatic temperature swings.

The ideal temperature range for healthy and actively reproducing bacteria is 77 F to 86 F, with activity dropping below this range and stopping at 39 F. Death of the bacteria will occur below 32 F and above 120 F.

Monitoring and controlling pH is also an important factor to the bacteria's health. For the *Nitrosomonas* bacteria the optimal range is 7.8 to 8.0 and for the *Nitrospira* bacteria it is between 7.3 to 7.5. Levels below 7.0 will slow the *Nitrosomonas* and lead to increases in ammonia in the system. Nitrification becomes inhibited if the pH is allowed to drop below 6.0. (Hill, 2008)

Bacteria play an important role in providing nutrients to the plants and cleaning out ammonia for the fish. They are essential to a functioning aquaponics system and need to be cared for properly.

Plants for Aquaponics

Many plants can be used in aquaponics, although choices are limited or guided by stocking density, choice of growing beds and other environmental factors. Due to the nature of the system, many plants that do well in hydroponic systems can do well in aquaponics. These include vegetables such as tomatoes, lettuce, cucumbers and peppers, as well as ornamentals such as herbs, roses and foliage plants. Table 2 (on page 7) shows 10 commonly used aquaponics crops and their preferred conditions. When selecting plants, it is important to know the nutrient requirements and how they correspond with the fish stock levels.

Low-nutrient plants require only a low or normal stocking density of fish. These plants include herbs, lettuce, broccoli and more.

High-nutrient plants can also be used in aquaponics. These require a higher stocking density to provide adequate nutrient load for the plants. Tomatoes, peppers and cucumbers fall into this category.

Environmental conditions also play an important role in an aquaponics system. Although the aquaponics systems discussed here are for greenhouses, which have controlled environments, it is a good idea to grow plants with higher temperature and light requirements in the summer and lower temperature and light requirements in the winter. An example of this would be to focus on tomato and pepper production during the spring and summer months and lettuce and cauliflower in the winter.

Fish for Aquaponics

There are many factors to consider when selecting the type of fish to use. These include water temperature and tank needs (are heaters and other supplies needed?), purpose of having the fish (just a nutrient source for the plants or are they a food source as well?), state laws (some states have restrictions on certain fish) and availability.

Fish commonly used in aquaponics are tilapia, trout, catfish, bass, goldfish, koi and pacu. Each have their own preferred temperature range, food preferences, size and oxygen needs. Table 3 has a list of common fish for aquaponics and some of their traits. For example, trout typically like cold water and need high oxygen levels compared to the others mentioned. This makes them a bit more complicated to care for, but trout can obtain a higher selling price in the right market.

Nutrients

How nutrients are handled in aquaponics differs from traditional soil gardening and hydroponics due to the presence of fish.

In aquaponics, the fish tanks supply the nutrients through the fish waste. Nitrogen is provided through the nitrifying bacteria and the other nutrients are deposited in the media. In a functioning aquaponics system, new supplemental nutrients do not need to be added as in other soilless systems.

Many of the nutrients may take some time before they build up to significant levels in the system, so when beginning an aquaponics system, it is important to choose plants that are not high nutrients users (such as cucumbers and tomatoes). Once the system has become established and nutrients have been allowed to build, high nutrient plants thrive.

It is the build in nutrient supply that makes aquaponics unique to soilless systems. This system relies on fish, bacteria and plants to create a complete aquaponics system.

Fish and System Sources

Organics OKC Garden Supply
2800 N. Penn
Oklahoma City, OK 73107
http://www.organicsokc.com/

Tulsa County Hydro-Organics
1928 W. Albany
Broken Arrow, OK 74015

Table 3. Fish.

	Tilapia	*Trout*	*Catfish*	*Bass*	*Goldfish*	*Koi*	*Pacu*
Edible	Yes	Yes	Yes	Yes	No	No	Maybe
Temperature range (°F)	60 - 90	35 - 68	35 - 95	40 - 90	35 - 90	35 - 90	60 - 95
Optimal Temperature (°F)	74 - 80	55 - 65	75 - 85	74 - 80	65 - 75	65 - 75	74 - 80
Carnivore or Omnivore	O	C	O	C	O	O	O
Mature Size	1.5 lb.	0.8 lb.	1.25 lb.	1 – 3 lbs.	4"	20 lbs.	60 lbs.
Time to maturity	9 – 12 mos.	12 mos.	12 – 18 mos.	15 – 18 mos.	3 yrs.	3 yrs.	4 yrs.
Oxygen Needs	Low	High	Low	Low	Low	Low	Low

Adapted from Sylvia Bernstein's Aquaponic Gardening: A Step-by-Step Guide to Raising Vegetables and Fish Together

Table 2. Common Crops for Aquaponics.

Crop	*pH*	*Spacing*	*Growth Time*	*Temperature*	*Light*	*Plant Size (Height x Width)*	*Aquaponics Method*	*Stocking Density*
Basil	5.5-6.5	6"-10"	5-6 weeks	65°F - 86°F Optimal: 68°F - 77°F	Full* DWC, and NFT	12"-28" x 12"	Media beds,	High
Broccoli	6.0-7.0	16"-28"	60-100 days	56°F - 65°F	Full	12"-24" x 12"-24"	Media beds	Normal
Cabbage	6.0-7.2	24"-32"	45-70 days	59°F - 68°F	Full	12"-24" x 12"-24"	Media beds	Normal
Cucumbers	5.5-6.5	12"-24"	55-65 days	72°F - 83°F (day) 65°F - 68°F (night)	Full	8"-80" x 8"-32"	Media beds, and DWC	High
Eggplant	5.5-7.0	16"-24"	90-120 days	72°F - 79°F (day) 59°F - 65°F (night)	Full	24"-48" x 24"-32"	Media beds	High
Lettuce	6.0-7.0	7"-12"	24-32 days	59°F - 72°F Flowering over 76°F	Full*	8"-12" x 10"-14"	Media beds, DWC, and NFT	Normal
Parsley	6.0-7.0	6"-12"	20-30 days	59°F - 77°F	Full*	12"-24" x 12"-16"	Media beds, DWC, and NFT	Normal
Peppers	5.5-6.5	12"-24"	60-95 days	72°F - 86°F (day) 58°F - 61°F (night)	Full	12"-36" x 12"-32"	Media beds	High
Swiss Chard	6.0-7.5	12"	25-35 days	61°F - 76°F	Full*	12"-24" x 12"-16"	Media beds, DWC, and NFT	Normal
Tomatoes	5.5-6.5	16"-24"	50-70 days on to 8-10 months	72°F - 79°F (day) 56°F - 61°F (night)	Full	24"-72" x 24"-32"	Media beds, and DWC	High

*Plants need to be shaded in high temperatures.

Adapted from Appendix 1 of Somerville, C., and et. Al. 2014. Small-scale aquaponic food production. Integrated fish and plant farming. FAO Fisheries and Aquaculture Technical Paper No. 589.

Willow's Garden Supply
11630 E. 51st St.
Tulsa, OK 74146
www.theaquaponicsource.com
www.backyardaquaponics.com
http://urbanfishfarmer.com/

Additional Reading

Aquaponic Gardening: A Step-By-Step Guide to Raising Vegetables and Fish Together by Sylvia Bernstein
http://www.aquaponic.com.au/
http://afsic.nal.usda.gov/aquaculture-and-soilless-farming/aquaponics
NM State: Is Aquaponics Right For You?
Oklahoma based: Symbiotic Aquaponic http://www.symbioticaquaponic.com/
FAO Fisheries and Aquaculture Technical Paper No. 589 (Small-scale aquaponic food production. Integrated fish and plant farming.)
Range, Paul, and Bonnie Range. Simplified aquaponics manual. Backyardaquaponics.com/Travis/Simplified-Manual.pdf
Measuring for pumps: https://www.brightagrotech.com/pumps-for-aquaponics-or-hydroponics/

Factsheets on Aquaculture from OSU and resources from the Southern Regional Aquaculture Center (SRAC) are listed below:
NREM-9201, Getting Started in Aquaculture
NREM-9207, Recirculating Aquaculture Systems: Questions to Ask Before You Invest
SRAC 451, An Overview of Critical Considerations
SRAC 452, Management of Recirculating Systems
SRAC 454, Integrating Fish and Plant Culture

Issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Director of Oklahoma Cooperative Extension Service, Oklahoma State University, Stillwater, Oklahoma. This publication is printed and issued by Oklahoma State University as authorized by the Vice President, Dean, and Director of the Division of Agricultural Sciences and Natural Resources and has been prepared and distributed at a cost of 42 cents per copy. 0116 GH.