Is Aquaponics Right For You?

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Figure 1. Example of a raft-based aquaponic system with fish tanks in the background. Photo courtesy of R.C. Shultz, Santa Fe Community College.

There is a growing interest in aquaponics in New Mexico and in the United States as more people turn to locally grown food produced in an environmentally friendly and sustainable way. Many hobbyists take up aquaponics as an enjoyable way of growing their own food in simple backyard operations. Others pursue aquaponics on the commercial scale as a primary or supplementary source of income. For anyone who has been curious about aquaponics or who is considering taking it up as a hobby or business, the following guide is the first step to learning more on the subject. This guide is not comprehensive, but it will serve as a basic introduction and will help point you to the wealth of readily available information on the subject, including reading material, web resources, and classroom and online courses.

WHAT IS AQUAPONICS?

Aquaponics is a method of food production that combines aquaculture (the cultivation of aquatic animals, such as fish, shrimp, crayfish, or prawns, in tanks) and hydroponics (the growing of plants in water). The fish and plants are cultivated

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together in a recirculating ecosystem that utilizes natural nitrogen-fixing bacteria to convert fish/aquatic animal wastes into plant nutrients. The waste products of the aquaculture system serve as nutrients for the hydroponic system. With such a combined recirculating system, there is no need to discard any water or filtrate or add any chemical fertilizers, making it both sustainable and environmentally friendly.

In a traditional aquaculture system, animal waste by-products (in the form of ammonia) build up over time and become toxic to the animals being cultivated; as a result, 10 to 20% of the total volume of water must be discharged and replaced every day. However, in an aquaponic system, the water produced from the aquaculture portion of the system is fed into the hydroponic portion of the system, where plants are grown with their roots immersed in the effluent (waste) water. Bacteria convert the ammonia in the waste-water into nitrites, which are then further converted into nitrates. These nitrates serve as nutrients for the plant. Basically, aquaponics is an integrated system that utilizes the best attributes of both aquaculture and hydroponics while eliminating some of the challenges associated with each of these systems.

BENEFITS OF AQUAPONIC SYSTEMS

Waste nutrients produced by fish/aquatic animals are recovered by the plants. This eliminates the need to discharge water into the environment and minimizes the need to exchange water (other than topping off water that evaporates and goes into the plant biomass). Compared to traditional aquaculture, aquaponic systems use much less water, which is especially attractive in arid, water-scarce regions of the country like New Mexico. As an example, an aquaponic system uses 1% of the water required in pond culture to produce equivalent yields of tilapia.

- By minimizing the need to exchange water, overall operational costs are reduced. This is particularly important in arid climates like New Mexico, and in heated greenhouses where water or heated water can be a major expense.
- Because of the daily application of fish feed to the system, the plants receive a steady stream of nutrients, which eliminates the need to discharge and replace depleted nutrient solutions, as would be the case in hydroponic systems.
- Unlike hydroponic systems or recirculating aquaculture systems, aquaponic systems require substantially less water quality monitoring.
- Biofiltration is the process in which bacteria break down ammonia from fish waste into nitrate. Media-based and raft-based aquaponic systems (see section below) provide sufficient surface area for these nitrifying bacteria to thrive, thus eliminating the need for separate biofilters, which can be expensive. The plants being grown act as filters by removing the nutrients from the effluent water.
- Plants grown in aquaponic systems receive most of their required nutrients at no cost, thereby improving the profit potential of the system.
- Finally, by producing two crops (vegetables and fish) with the same system, the operational and infrastructural costs are shared, which increases the savings and profit margins.

Some aquaponics enthusiasts are primarily interested in the plants they cultivate and grow fish or other aquatic animals simply to provide the low-cost nutrients to their system. Others grow both plants and fish to sell or consume. Some growers culture edible fish, while others grow ornamental fishes such as goldfish. The plants and animals produced are locally grown and pesticide-free (aquaponic systems normally operate without the use of pesticides because of the risk of killing the fish), and plants require few if any additional fertilizers.

Figure 2. Raft-based system showing roots hanging down in water. Photo courtesy of R.C. Shultz, Santa Fe Community College.

COMPONENTS OF AQUAPONIC SYSTEMS

Aquaponic systems come in all shapes and sizes, from simple, low-tech backyard operations to large-scale, more sophisticated commercial operations. Regardless of the size, materials used, or level of complexity, all systems share the same basic design that consists of the same components:

1. Rearing tank: The tank or container where the fish/aquatic animals are raised and fed.
2. Settling basin/solids removal: Some sort of unit to capture all uneaten food, fish waste, and detached biofilm (the film or coating that nitrifying bacteria form on inert material or organic particles), and where fine particulates can settle out.
3. Biofilter: A place where the bacteria can grow and convert ammonia to nitrates and organic wastes to carbon dioxide, which are used as nutrients for plants.

4. Hydroponics portion of the system: This is where the plants are grown by taking up the excess nutrients from the effluent water.
5. Sump: This is the lowest point in the system and is where the water flows, after which it gets pumped back into the rearing tanks.

TYPES OF SYSTEMS USED TO GROW PLANTS

The three primary growing systems used to culture plants in aquaponic systems are raft-based or deep-water culture (DWC), media-based, and nutrient film technique (NFT).

Raft-based systems consist of Styrofoam rafts floating in troughs filled with fish effluent that has been filtered to remove solid wastes. Plants are placed in holes in the raft with their roots hanging down in the water (Figure 2). In media-based systems, plants are grown in inert planting media, such as gravel, rock wool, sand, or clay pellets, held in containers that are flooded with water from the aquaculture portion of the system (Figure 3).

Nutrient film technique (NFT) is commonly used in hydroponics. In this system, plants are inserted into the top of shallow troughs or channels, and filtered water trickles through the troughs along the rootzone of the plants (Figure 4). NFT systems require a separate biofilter, as the channels do not provide enough surface area for the nitrifying bacteria to grow sufficiently.

Figure 3. Example of a media-based aquaponic system. Photo courtesy of R.C. Shultz, Santa Fe Community College.

FISH SUITED TO AQUAPONICS

There are several species of both warmwater and coldwater fish that are well adapted to growing in recirculating aquaculture systems. These include tilapia, channel catfish, rainbow trout, perch, common carp, Arctic char, goldfish, and largemouth and striped bass.

The most common species grown in both home and commercial aquaponic systems is tilapia, which is a warmwater species that grows well in recirculating systems and can tolerate crowding and fluctuating water conditions. However, it should be noted that tilapia is a species that is not native to New Mexico, and the culture of tilapia or any exotic, non-native species is controlled by the New Mexico Department of Game and Fish. Before importing or beginning to culture any non-native species in New Mexico, an "Application for Importation of Exotic Species" must be made to and accepted by the Department. However, there are other options to growing tilapia, including other fish species, non-edible ornamental species such as goldfish, or freshwater shrimp or prawns.

PLANTS SUITED TO AQUAPONICS

Many plants can be grown in aquaponic systems, and the choice of plants will depend on the stocking density of the fish being grown because this will influence the concentration of nutrients in the fish effluent. Plants that have low to medium nutrient requirements that are well adapted to aquaponic systems include lettuce, basil, spinach, chives, herbs, and watercress (Figure 5). Other plants, such as tomatoes, cucumbers, and peppers, have higher nutrient requirements and will only do well in aquaponic systems that have high stocking densities of fish.

Figure 4. NFT growing system. Photo courtesy of R.C. Shultz, Santa Fe Community College

IMPORTANT CONSIDERATIONS

While there are many benefits to growing vegetables and fish using aquaponics, it is not without its challenges. Depending on the size and sophistication of your system, it can require a substantial capital investment.

They also require some energy inputs, and because of the highly technical nature of aquaponics, a certain level of skill is necessary to manage the systems adequately.

Prospective growers need to thoroughly research the different production methods to determine which are best suited to their needs. If your goal is to produce aquaponic products to generate income, you also need to identify and develop niche markets to ensure profitability. As with any new venture, embarking on a commercial aquaponic operation is not without financial risk and should be thoroughly researched before undertaking. There are several sources of information available to learn more on the subject. Furthermore, there are a number of excellent courses taught by world-renowned experts offered throughout the year on all aspects of aquaponics. The following is a list of some of the resources available to those interested in learning more about aquaponics.

Figure 5. Aquaponic vegetable bed. Photo courtesy of R.C. Shultz, Santa Fe Community College.

AVAILABLE RESOURCES

Publications and eBooks

There are several excellent publications written by aquaponics experts that provide in-depth overviews of aquaponic systems with details about design and management, as well as extensive lists of technical and popular literature, aquaponics training materials, and design manuals. The following is a selected list of publications.

1. Goddeck, S., Joyce, A., Kotzen, B. & Burnell, G. (Eds). (2019). Aquaponics Food Production Systems: Combined Aquaculture and Hydroponic Production Technologies for the Future. Springer Open. https://link.springer.com/book/10.1007/978-3-030-15943-6
2. Hager, J., Bright, L. A., Dusci, J. & Tidwell, J. (2021). Aquaponics Production Manual: A Practical Handbook for Growers. Kentucky State University School of Aquaculture and Aquatic Sciences. https://www.ksuaquaculture.org/PDFs/Aquaponics%20Handbook%202021%20Updated%20.pdf
3. Pattillo, D.A. An Overview of Aquaponic Systems: Hydroponic Components (123). (2017, March). North Central Regional Aquaculture Center Technical Bulletin Series Publication. http://lib.dr.iastate.edu/ncrac_techbulletins/19
4. Pattillo, D.A. An Overview of Aquaponic Systems: Aquaculture Components (124). (2017, October). North Central Regional Aquaculture Center Technical Bulletin Series. http://lib.dr.iastate.edu/ncrac_techbulletins/20/
5. Rakocy, J.E., Masser, M.P., & Losordo, T.M. (2006). Recirculating Aquaculture Tank Production Systems: Aquaponics—Integrating Fish and Plant Culture (0454). (2017, March). Southern Regional Aquaculture Center Fact Sheets. https://srac.tamu.edu/fact-sheets/serve/105
6. Sallenave, R. & Shultz, R.C. (2022). Hydroponics: Water-saving Farming for New Mexico's Arid Environment (H180). New Mexico State University Cooperative Extension Service. College of Agricultural, Consumer and Environmental Sciences. https://pubs.nmsu.edu/_h/H180/index.html
7. Sallenave, R. & Shultz, R.C. (2019). Decoupled Aquaponics: A comparison to Single-loop Aquaponics (H173). New Mexico State University Cooperative Extension Service. College of Agricultural, Consumer and Environmental Sciences. https://pubs.nmsu.edu/_h/H173/index.html
8. Sallenave, R. (2016). Important Water Quality Parameters in Aquaponics Systems (Circular 680). New Mexico State University Cooperative Extension Service. College of Agricultural, Consumer and Environmental Sciences. https://pubs.nmsu.edu/_circulars/CR680/
9. Somerville, C., Cohen, M., Pantanella, E., Stankus, A., & Lovatelli, A. (2014). Small Scale Aquaponic Food Production (589). Food and Agriculture Organization of the United Nations. https://www.fao.org/in-action/globefish/publications/details-publication/en/c/338354/
10. Thorarinsdottir, R. (2015). Aquaponics Guidelines. University of Iceland. DOI:10.13140/RG.2.1.4975.6880

Online aquaponics resources, and community forums

1. The Aquaponics Association https://aquaponicsassociation.org/
2. National Aquaculture Association https://www.nationalaquaculture.org/
3. U.S. Aquaculture Society https://www.usaquaculture.org/

Online informational videos/webinars

1. Hager, J. V and Dusci, J. 2020. IBC Aquaponics: a step-by-step guide. https://www.youtube.com/watch?v=BwbvOMoU9oE
2. Shultz, C. Overview of Replicated Aquaponic Systems at Kentucky State University. Available: https://www.youtube.com/watch?v=gTg3eQZaR5E

Workshops/short courses and academic degrees

1. University of Arizona Annual Greenhouse Crop Production & Engineering Design Aquaponics short course. https://ceac.arizona.edu/events/cea-short-course
2. Santa Fe Community College, School of Controlled Environment Agriculture https://www.sfcc.edu/programs/%20controlled-environment-agriculture/
3. Cornell University short course on recirculating aquaculture. http://fish.bee.cornell.edu/short-course-info/
4. NMSU Cooperative Extension Service https://bernalilloextension.nmsu.edu/farmranch/aquaponics.html
5. The Aquaponic Source https://www.theaquaponicsource.com/online-aquaponic-farm-courses/
6. University of the Virgin Islands Aquaponics Program. https://www.uvi.edu/academics/school-of-agriculture/programs/aquaponics/index.html

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Revised August 2024 **Las Cruces, NM**