Working Together

BY GRETCHEN SHERRILL

Photos courtesy of Dr. James Rakocy, University of the Virgin Islands

Heads of lettuce grown in a raft hydroponic system wait for harvest at the University of the Virgin Islands on St. Croix. The lettuce is fed from water from the system's aquaculture tanks, which is then recirculated back to the fish.

The tiny, tranquil Caribbean island of St Croix, part of the U.S. Virgin Islands, may seem an unlikely place to find the world's most established aquaponics program. But almost three decades of research have yielded a nearly flawless production system and a wealth of experience to share.

Dr. James Rakocy, director of the University of the Virgin Islands Agricultural Experiment Station, believes the effectiveness of the aquaponics system illustrates the best of both hydroponics and aquaculture but is simpler to operate than either.

"I like to call raft aquaponics the lazy man's hydroponics," said Rakocy with a laugh.

Of course sloth has not been part of the research process for the UVI aquaponics team, which through trial and error developed a system that conserves both water and land resources. Now the team is sharing its successes with others. Academics, entrepreneurs and enthusiasts from across the globe are making the trek to the St Croix campus of UVI to learn firsthand about this long-running and remarkably efficient program.

History and System Overview

The globally recognized program began in earnest 27 years ago when Rakocy, then conducting aquaponics research with aquatic plants at Auburn University in Alabama, joined UVI charged with developing aquaponic systems appropriate for the U.S. Virgin Islands.

Like many island paradises in the Caribbean, St Croix has no lakes or rivers. It dependends on stored rainwater for its freshwater needs. The island also has limited agricultural land. In addition to the need to create a system viable for an area with restricted land and water, Rakocy wanted to be able to recycle nutrients, since discharge of potential pollutants is also a sensitive issue for island ecosystems.

Specific needs and burgeoning research sparked university interest, but the territory had no aquaculture industry. Lacking an established industry in search of immediate answers to commercial questions, Rakocy enjoyed, "a luxury of a long, long period of time to develop these systems."

The system began as three and one-half oil barrels, two dedicated to production, on the back porch of Building E, the Agricultural Experiment Station headquarters. Yet in a little more than four months this small set up generated more than 100 pounds of food: 30 pounds of fish, 8 pounds of lettuce and 64 pounds of tomatoes.

"The basic design that we hit on then is the design that we've followed ever since," said Rakocy.

Following this early success, the team experimented with adjustments in size and ratio of fish to plants. Early problems such as nutrient accumulation, clogging from incorrect pipe size and poor drainage were corrected during these trials. The implementation of raft hydroponics resulted from problems with gravel which accumulated solids, clogged and became a source of ammonia. In addition, gravel requires construction of heavy support structures to hold the extra weight. The raft system, comprised of floating sheets of polystyrene set with net pots, solved the gravel problems and combined the biofiltration and hydroponic requirements.

During this research and development period, Rakocy devoted his time to field work construction, "digging holes and trenches." Building an aquaponics system requires construction skills and the work may be off-putting to some. As Rakocy admits, the building the system is "much more advanced than installing a home aquarium or backyard garden."

Following several scale-ups and a half dozen more iterations to work out the remaining structural and organizational kinks, the team developed the current commercial-size system that Rakocy says leaves little room for improvement.

The system they've hit on consists of four aquaculture tanks in which tilapia are raised. Tilapia are fast growing, can tolerate a wide variety of environmental conditions and have firm white meat. The water from the aquaculture tank then feeds through sump, clarifier and degassing tanks that remove most of the solids from the fish waste. The water is then pumped into six hydroponic tanks that are fed by effluent lines. The crops growing hydroponically take nutrients from the water, cleaning it for the fish. The water then passes back through the system to the fish. Fish production is staggered with a harvest every six weeks.

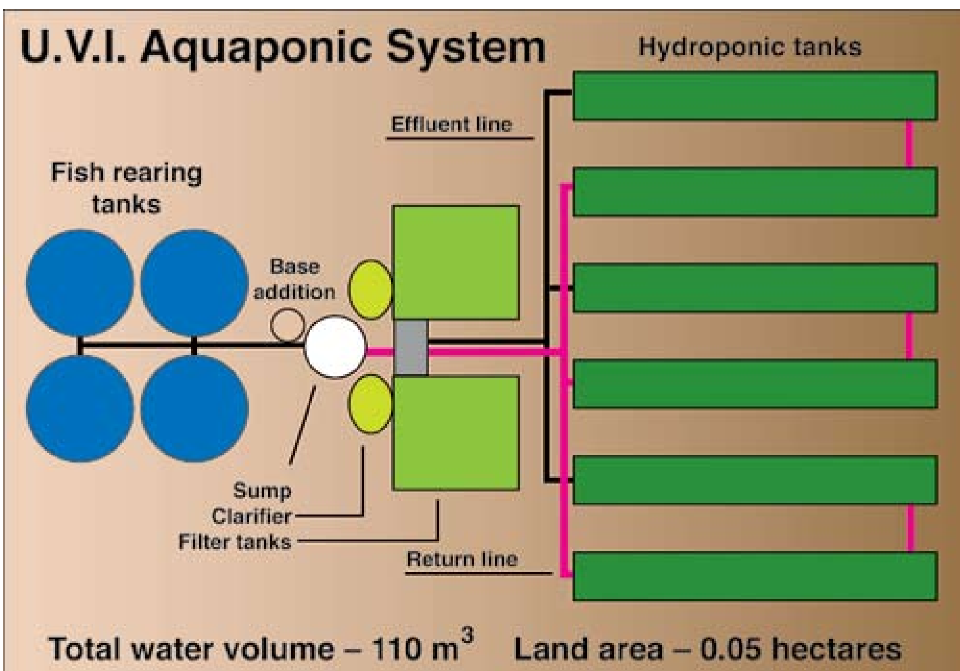
The UVI system employs additional tilapia fingerlings to keep the clarifier sides and drain lines clean – a job that would otherwise have to be done manually.

The ratio of fish to plant production has been calculated to balance nutrient generation from fish with nutrient removal by plants. The ratio is expressed as the weight of feed given to fish on a daily basis relative to the plant growing area. The optimum ratio is 60-100 grams per square meter of plant growing area per day. By applying this ratio and attending to minor general maintenance the system can operate uninterrupted for years, another key to success. A new aquaponics system requires an establishment time of 6 weeks for essential bacteria and 18 weeks until all four fish rearing tanks are stocked.

Due to the required establishment time, Rakocy warns, "Once you start it, you never want to stop the system."

Rakocy refers to the UVI aquaponic system not as high tech but as "appropriate technology." He considers the system reliable, robust and simple to operate, especially in comparison to hydroponics and aquaculture systems.

Dr. Rakocy with a fish from the aquaponics system he helped design and build.



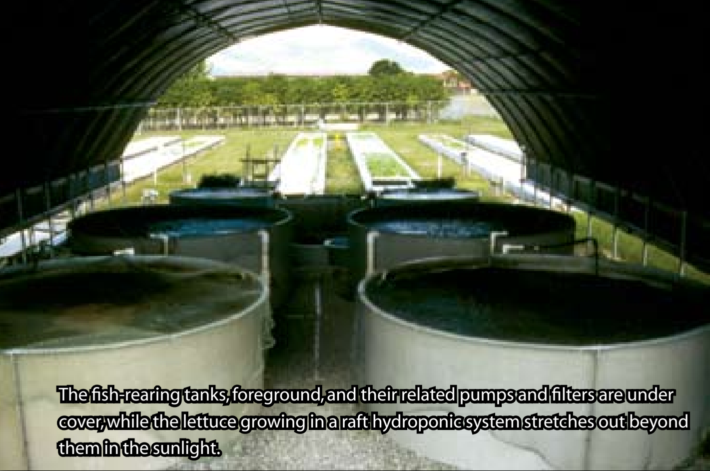
System Advantages

Aquaponic systems retain water for long periods of time, require less monitoring, and provide free nutrients.

Rakocy believes UVI's aquaponic system encounters fewer pest and disease problems than traditional hydroponic systems due to the amount of organic material in the water. In contrast to the sought after sterile environment of hydroponics, the UVI aquaponics system thrives on a diversity of bacteria – bacteria that can be antagonistic to pathogens and bacteria that boost plants' immune systems. In fact, the UVI aquaponics system has operated for several years without changing the water.

"We like to go dirty," chuckles Rakocy.

Other than pH tests, the UVI aquaponic system's water is tested only once per year when experiments are not being conducted. Water pH must be monitored daily and base added to maintain a neutral 7.0. The base added to maintain pH serves a dual purpose as a nutrient supplement.



The fish-rearing tanks, foreground, and their related pumps and filters are under cover, while the lettuce growing in a raft hydroponic system stretches out beyond them in the sunlight.

Aquaponics short course brings the world to St. Croix

Each summer since 1999 the University of the Virgin Islands aquaponics short course draws people from all around the world to the island of St. Croix for an intensive one-week session on aquaponics.

This year from June 15 through 21 aquaponics enthusiasts will receive hands-on training, detailed procedures manuals and advice on daily operations.

The UVI team has trained 271 students from four U.S. territories, 35 states, 35 countries and all seven continents.

No more than 64 students are accepted into the course each year, the number capped to allow for small groups during hands-on sessions.

"They shared everything they did wrong. Instead of burying mistakes they freely shared them and probably saved me $30,000 in failed experiments," said Tim Mann of Hawaii, who participated in 2007.

Enrollment in the 2008 program is open. The course costs $920 for early registration (by May 16) and $1,020 for late registrations. Information on the course and online registration can be obtained at the program's Web site: http://rps.uvi.edu/AES/Aquaculture/UVIShortCourse.html.

Unlike traditional hydroponic solutions that require a complete nutrient mix, the UVI system's tilapia provide adequate amounts of 10 of the 13 nutrients essential to plants. Only potassium, calcium and iron must be supplemented. And to maintain the proper pH level the operators add either calcium hydroxide or potassium hydroxide, which provide the missing potassium and calcium nutrients. Iron is added separately.

Normal recirculating aquaculture systems discharge an estimated five to ten percent of system water daily due to excess nitrate accumulation. UVI's system uses nitrates and other nutrients for plant growth, so it discharges less than one percent of system water daily, alleviating the potential for pollution related to water discharge.

The UVI system not only recovers nutrients lost as waste in traditional aquaculture systems but also produces the valuable by-product of plants, which typically generate more income than the fish. In contrast to aquaculture, the plants serve as the biofilter, eliminating that maintenance expense.

"Aquaponics is the only system in the world that has a biofilter that makes money," Rakocy said.

On one-eighth of an acre of land the UVI aquaponic system produces an estimated 25,000 pounds of food per year. One acre would have the potential yield of 200,000 pounds of food per year.

In contrast to dirt-grown field crops, plants grown in aquaponic systems tend to grow more rapidly, have ample water and nutrients, and enjoy a weed-free environment, Rakocy said. In experiments comparing the two, the UVI aquaponics system yielded three times more basil and seventeen times more okra than field crops.

However, vegetable production is never foolproof: insect damage and disease occur. Aquaponic growers can't use the pesticides and insecticides that traditional agriculture employs. In aquaponic systems of interdependent fish and plants, treatment of one might harm the other. Aquaponics depends on biologic control methods and is therefore guaranteed to be pesticide free.

UVI's aquaponics team members Charlie Schultz, a research analyst, and Jason Danaher say aquaponics might be the answer to growers seeking to market organic produce. Research specialist Danaher cites growing aquaculture industry interest in developing methods to certify products organic and sell them as such. Schultz believes aquaponics offers a solution to the need for an organic-based fertilizer for hydroponics production and an antidote to the rising expense of utilizing petroleum-based products.

"Our system has the potential to be a very big leader, if interest in certifying it to be organic could be worked out," Schultz said, "and the produce tastes so delicious and that's a fact."

Of course not all plants grow well in the UVI aquaponics system. The raft system does not accommodate root crops, and certain crops, such as spinach, prefer a cooler, less tropical climate than that of St Croix. Even among the current crop of cantaloupe, the vine variety thrived while the bush variety did not. Research specialist Donald Bailey sees this disappointing bush crop as a valuable lesson.

"We teach with examples and with this varietal difference, we can inform farmers and save them production dollars," explains Bailey.

In fact, a goal for the research team is to increase profits for farmers. These findings will be shared as part of the UVI aquaponics short course, developed and administered by Rakocy and his staff. The short course has more than doubled in attendance and gained global attention in just a few years.

Aquaponics' Future

New technologies take time to be accepted and implemented. However, global water shortages have created a more urgent interest in aquaponics, one of the most water-efficient systems in the world, Rakocy said.

UVI's success and lengthy track record of research has generated interest and led to the implementation of similar systems in several locations in the U.S. and abroad – including the New Jersey EcoComplex at Rutgers University and the Crop Diversification Center South in Alberta, Canada. The Canadian system has produced more than 60 types of vegetables.

Raocy cites planned multimillion-dollar commercial projects in Australia and the U.S. as evidence of recent investment growth in the aquaponics industry.

When thinking back to beginning of his career in the late 1970s, Rakocy said that he and other aquaponic proponents were considered "on the lunatic fringe."

With the completion of the UVI commercial-scale aquaponic system and the implementation of the short course, Rakocy has connected with a growing mainstream commercial and academic interest in aquaponics. An interest he finds as an amazing and personally gratifying acceptance of a life's work.