DEVELOPMENT OF AN AQUAPONIC SYSTEM FOR THE INTENSIVE PRODUCTION OF TILAPIA AND HYDROPONIC VEGETABLES

by:
J.E. Rakocy, D.S. Bailey, K.A. Shultz, W.M. Cole

University of the Virgin Islands Agricultural Experiment Station.
RR 2, Box 10,000
Kingshill
U.S. Virgin Islands 00805

Editor's Note:
This paper was presented at the Conference on Island and Tropical Aquaculture held in Martinique this spring. It is reprinted with permission from Dr. Rakocy
AES Director, UVI

Introduction

Aquaponics is the combined production of fish and hydroponic vegetables in closed recirculating systems. The Interaction of fish and vegetables creates an ideal growing environment that is more productive than conventional methods. Aquaponic systems are very economical because several key costs, such as nutrients, land and water are substantially reduced and component operating and infrastructural costs are shared. Lower resource requirements extend the geographic range of production to areas that rely heavily on food imports such as Caribbean islands.

Research and development

Aquaponics research has been conducted at the University of the Virgin Islands for more than 16 years in response to the difficulty of growing freshwater fish and vegetables on semiarid islands. Replicated experimental systems have been used to discover the principles of aquaponics for successful commercial application.

Foremost among the principles earned are these: Raft hydroponics is the most suitable technique for culturing vegetables in conjunction with fish in outdoor systems in the tropics. Very large plant growing areas are required relative to the fish culture component. Fish waste provides most of the nutrients required by the plants, but some supplementation with Ca, K, and Fe is required.

The key design criterion is the ratio of daily fish feed input to the plant growing area. The optimum ratio for leaf lettuce is 57 g/m^2/d. At this ratio, the hydroponic component provides adequate biofiltration. In fact, the waste treatment capacity of raft hydroponics is equivalent to a fish feeding rate of 180 g/m^2 of lettuce growing area/d. Therefore, a separate biofilter is not required and water quality is very stable. Solids removal is a critical management practice. Solids will accumulate on the plant roots, create anaerobic zones and block the flow of water and nutrients to the plants.

But solids also have a beneficial role of providing nutrients to the plants through mineralization and promoting the growth of microorganisms that are antagonistic to plant root pathogens. Therefore, a delicate balance must be reached between too much accumulation of suspended

(Continued on page 13)

(Continued from page 12)
solids and too little.

Commercial-scale production trial

An outdoor, commercial-scale unit for the integral production of red tilapia and hydroponic leaf lettuce has been in continuous operation on St. Croix, U.S.V.I., since January 1995.

The production unit consists of four circular fish rearing tanks (4.5 m^3 each) and six hydroponic tanks (l 1.5 m^3). The hydroponic tanks are 29.6 m long by 1.3 m wide by 0.4 m deep and have a total combined surface area of 214 m^2 for plant production. The solid removal subsystem consists of two 1.8-m^2 cylindro-conical clarifiers and four rectangular filter tanks (0.7 m^3 each) containing orchard netting. A 1/5-hp variable speed in-line pump produced a maximum flow of 170 l/min and an average retention time of 1.7 h in the rearing tanks. In the 23rd month a 1/2-hp in-line pump was installed to move water at an average rate of 378 l/min from a 0.6-m^3 sump to the rearing tanks (mean retention time, 0.8 h) from which effluent flows by gravity through the solids -removal and hydroponic subsystems and returns to the sump. The fish rearing tanks are aerated with diffused air delivery stones. A 1/20-hp vertical lift pump is used to supply additional aeration to the fish rearing tank in the last 12 weeks of the production cycle.

Production of red tilapia is staggered so that one tank of fish is harvested every 6 weeks. Initial stocking rates of 222 mixed-sex fingerlings/m^3 were reduced to 178 male fingerlings/m^3. The fish are fed for 24 weeks with a nutritionally complete, floating ration (32% protein) delivered initially by demand feeders and currently by belt feeders.

Production has been relatively stable for the last seven harvests (out of 15 total harvests), during which time total production has averaged 345 kg per harvest. This is equivalent to annual total production of 170 kg/m^3 of rearing tank space. The final standing crop has averaged 78.5 kg/m^3. Male fish have attained an average size of 520 g. and a mean growth rate of 2.9g/day. The feed conversion ratio has averaged 1.76 and survival has ranged from 78.6 to 97%. Mortality has resulted from bird predation, disease, hurricane damage and power failure.

Lettuce plants are grown in net pots supported by floating polystyrene sheets. Production is staggered so that one forth of the lettuce is harvested every week.

Three week old transplants grow to marketable size (250-650 g) in 4 weeks. Five varieties (Sierra, Montello, Nevada, Jericho, and Paris Island) have been used.

In 90 harvests, marketable production has averaged 26 cases per harvest and ranged from 13 - 38 cases (24-30 heads/case). Losses have occurred due to caterpillar damage, wind damage, tip burn, root disease and root damage, caused mainly by zooplankton (ostracod) blooms. Two hurricanes interrupted production for 9 weeks.

The hydroponic component has maintained good water quality through direct ammonia uptake and nitrification on the tank surface. Total ammonia-nitrogen and nitrite-nitrogen values have averaged 1.3 and 0.6 mg/l, respectively. Total water consumption has been 1093 m^3 (91.6 m^3 system volume plus 1001 m^3 makeup water, which was 1.6% system volume/d).

AJ