New Aquaponics Research in Italy

By Edoardo Pantanella

The discussion of climate change is pushing production systems toward more environmental-friendly management. On this point system integration and reduction of not renewable inputs are seen as good strategies to abate environmental impact and achieve cost effective productions.

At the University of Tuscia, Italy, I am participating in a PhD program, that has been established with the aim to improve quality of products with minimal use of inputs. For this research the lion's share is played by aquaponics that is mainly developed under two different methods: a) the UVI floating system adapted to greenhouse conditions and b) a "low-tech" pond aquaponic system.

In our vision, the aquaponics expansion to large scale commercial systems is possible providing that productions achieve the same standards and quality of hydroponics. Long term sustainability is not only the result of reduced ecological footprint and costs, but also the production of food that meets market demands for higher nutritional value, quality and safety.

On the other hand the development of low-tech systems have the big potential to help solve either management or pollution issues for pond systems (the world most diffused aquaculture system) as well as food security problems wherever land, credit or technology are not easily accessible, such as in developing countries.

RAS aquaponics

Aquaponics in RAS (Recirculating Aquaculture System) is well suitable for industrial production. However lack of extensive scientific literature about the characteristics and the differences in quality between aquaponics and hydroponics prevents a full acknowledgement of its potential by big companies or retailers. The research, which has been carried out this year at the University's Experimental Farm in six independent systems (3 replicates x 2 treatments), assessed lettuce growth, quality and food safety issues at different fish stocking densities/diets against standard hydroponics. The fish species under study was Nile tilapia (*Oreochromis niloticus*) from Nam Sai farms, Thailand and from Vulcittica, Italy.

Although some of the data is still under analysis, results for the first round of experiments showed that production from aquaponic systems was not different to hydroponics whenever nitrogen concentration was higher than 20-25 ppm, though some differences in color could be noticed at this nitrogen concentration.

Experience from ongoing experiments, however, showed that plant performance is specific for each cultivar and the same aquaponic nutrient pool may not be totally applicable to other plant varieties for optimal growth due to different nutritional needs.

On the fish side FCR of 0.95-1.25 found in Thai tilapia suggested that the use of fish strains adapted

at an early stage to RAS conditions and optimal management can sensitively increase productivity.

On the food safety level, the first criticism that people can put against aquaponics is the bacterial contamination of water. If it may be a minor concern for backyard production (indeed soil in organic agriculture is fertilized with cattle manure), but at an industrial level it is a key issue that limits the aquaponics access to the production of fresh vegetables.

The aquaponic system at the University of Tuscia. The system has six independent 1.5 m^2 floating systems each connected to a 250L fish tank, a clarifier and a two-layer net filter. Three 0.5 m^2 hydroponic tanks are also used as controls. Growth and colour of lettuce is almost similar in all the treatments.

According to World Health Organization (WHO) and national laws there are limits for coliform and E. coli in irrigation water that need to be followed. However, depending on the location such limits differ. In the case of coliform values range from the WHO's 1000 CFU/100 ml to the 200 CFU/100 ml for the EU countries, up to 2.2 CFU/100 ml for California state.

Trials carried out in November and December, 2009 at the University Experimental Farm using zero, one or two 25W UV lamps showed that sterilization process indeed has an influence to the bacterial load of the whole aquaponic system.

However to be effective sterilization should be carefully dimensioned to water particulate matter, flow rate, UV power and sterilization time. In these trials, zero coliform counts were steadily achieved with 2 UV lamps in sequence under a sterilization time of 10 sec.

Pond Aquaponics

Most of inland aquaculture is carried out in ponds where constant fertilization occurs to sustain phytoplankton and zooplankton growth. Fertilization can be achieved through supplement of chemical fertilizers, manure or compost whenever nutrient released from fish are insufficient to support algal bloom. On the other side use of water from fish very tolerant to bad water quality (*Clarias* sp.) allows plants to grow on a very rich pool of nutrients, which supply a bioremediation effect to effluent water.

Growth trials with rice ash pots on a catfish farm with high nitrogen loads. Plant strip nutrients directly from pond water (subirrgation) with no use of any mechanical tools.

Our research implied the use of alternative strategies in pond fertilization that let plants grow by taking up nutrients both from water and from growing media (compost), a concept that substantially diverges from the belief that hydroponic substrates have almost no incidence on the overall pool of nutrients.

The study of the Bangladeshi Dhats, rafts made with floating water weeds however confirmed that a degree of nutrients is available for plant growth through decay. Such indigenous floating systems were widely used all over the world under the name of Chinampas in Mexico, Kaing in Burma, Tonle Sap in Cambodia, and were said to be very productive.

For the trials, different blends of substrates were used in floating containers: straw/chicken manure or 3-week composted water weeds wherever poor nutrients in water suggested a supplemental support of minerals; rice husk ash as a very light porous substrate in nitrogen rich water such as in catfish ponds. Contrary to RAS aquaponics no use of supplemental pumping or aeration was needed for such pond systems.

Growth comparison for romaine lettuce on pond aquaponics.

***A** on raft made with water hyacinth;*
***B** on ash pots in a catfish farm;*
***C** on ash with zero nutrients (control);*
***D** on soil with full use of fertilizer. Lettuce growing on catfish water with high nitrogen content outperforms high-input soil production.*

Comparison against hydroponics (floating system) and high input soil-based agriculture showed that productivity in pond systems was similar if not higher than soil (+50%), though results were not still comparable to hydroponics. Interestingly very good yields with porous growing media can be achieved despite the very low water oxygen content (<1 mg/L) and high ammonia/nitrate ratio, which is a typical condition in catfish ponds in SE Asia.

What also arises from the use of organic media is the higher tolerance to salinity, a fact widely confirmed by scientific literature, that helps plants to cope with low quality water.

Financial analysis outlined a good suitability of these systems in developing countries due to the low tech nature, low capital but higher labor costs (50-70% of the total expenses), which eventually affects the return on investments with higher NPV than traditional systems and a payback period shorter than 1 year.

Future work

Since food safety has always be seen as a key issue by our team we would like to optimize the system to HACCP standards and address some pending issues in sterilization and/or in the development of optimal conditions for beneficial organisms growth at root level to protect plants from waterborne diseases. The main goal is to scale up operation and support the development of aquaponics at an industrial level.

Research for the next year aims to address all the underlying quality and production issues and to optimize fish/plant nutritional balances with aquaculture species more suitable to temperate climates or with higher return.

For the early 2010 a second campaign on pond aquaponics will be carried out in Thailand to optimize growth and address nutritional issues with the goal to scale up operation to commercial level.

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