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Aquaponic systems as excellent agricultural research instruments in Albania

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Abstract

Aquaponic systems are recirculating aquaculture systems (RAS) that incorporate the production of plants without soil. Recirculating systems are designed to raise large quantities of fish in relatively small volumes of water by treating the water to remove toxic waste products and then reusing the water many times. The accumulated metabolic by-products, like non-toxic nutrients and organic matter, need not be wasted if they are channeled into secondary crops that have economic value or in some way benefit the primary fish production system. We plan to use as secondary crops, terrestrial plants grown in conjunction with fish. This integrated system is referred to as an aquaponic system. The goal is to culture a vegetable that will generate the highest level of income per unit area per unit time. Culinary herbs are the best choice. We think that there may be also good potential for growing traditional medicinal plants in aquaponic systems, especially in Albania, which is one of the leading exporters of medicinal herbs in Europe. The aims and objectives of building an aquaponic system in the Agricultural University of Tirana are 1. to create an excellent scientific research environment inside the greenhouses, where the aquaponic systems can be equipped with all necessary monitoring instruments in order to evaluate the performance of several experiments that can be performed by PhD students under the assistance of technical staff members and 2. to establish a perfect scientific environment where new ideas may come out from the collaborations between PhD students, researchers and professors.

Keywords: traditional medicinal plants; recirculating aquaculture systems; hydroponic subsystems.

Introduction

In aquaponic systems plants grow rapidly with dissolved nutrients that are excreted directly by fish or generated from the microbial breakdown of fish wastes. In closed recirculating systems with very little daily water exchange, dissolved nutrients accumulate in concentrations similar to those in hydroponic nutrient solutions.

Dissolved nitrogen, in particular, can occur at very high levels in recirculating systems.

1. Fish excrete waste nitrogen, in the form of ammonia, directly into the water through their gills.
2. Bacteria convert ammonia to nitrite and then to nitrate.

Ammonia and nitrite are toxic to fish, but nitrate is relatively harmless and is the preferred form of nitrogen for growing higher plants such as fruiting vegetables.

Aquaponic systems offer several benefits [1]:

i. Dissolved waste nutrients are recovered by the plants, reducing discharge to the environment and extending water use (i.e., by removing dissolved nutrients through plant uptake, the water exchange rate can be reduced).
ii. Minimizing water exchange reduces the costs of operating aquaponic systems in arid climates and heated greenhouses where water or heated water is a significant expense.
iii. Having a secondary plant crop that receives most of its required nutrients at no cost improves a system's profit potential. The daily application of fish feed provides a steady supply of nutrients to plants and thereby eliminates the need to discharge and replace depleted nutrient solutions or adjust nutrient solutions as in hydroponics.
iv. The plants remove nutrients from the culture water and eliminate the need for separate and expensive biofilters.
v. Aquaponic systems require substantially less water quality monitoring than separate hydroponic or RAS.

vi. Savings are also realized by sharing operational and infrastructural costs such as pumps, reservoirs, heaters and alarm systems.

vii. In addition, the intensive, integrated production of fish and plants requires less land than ponds and gardens. Aquaponic systems do require a large capital investment, moderate energy inputs and skilled management.

viii. Niche markets may be required for profitability.

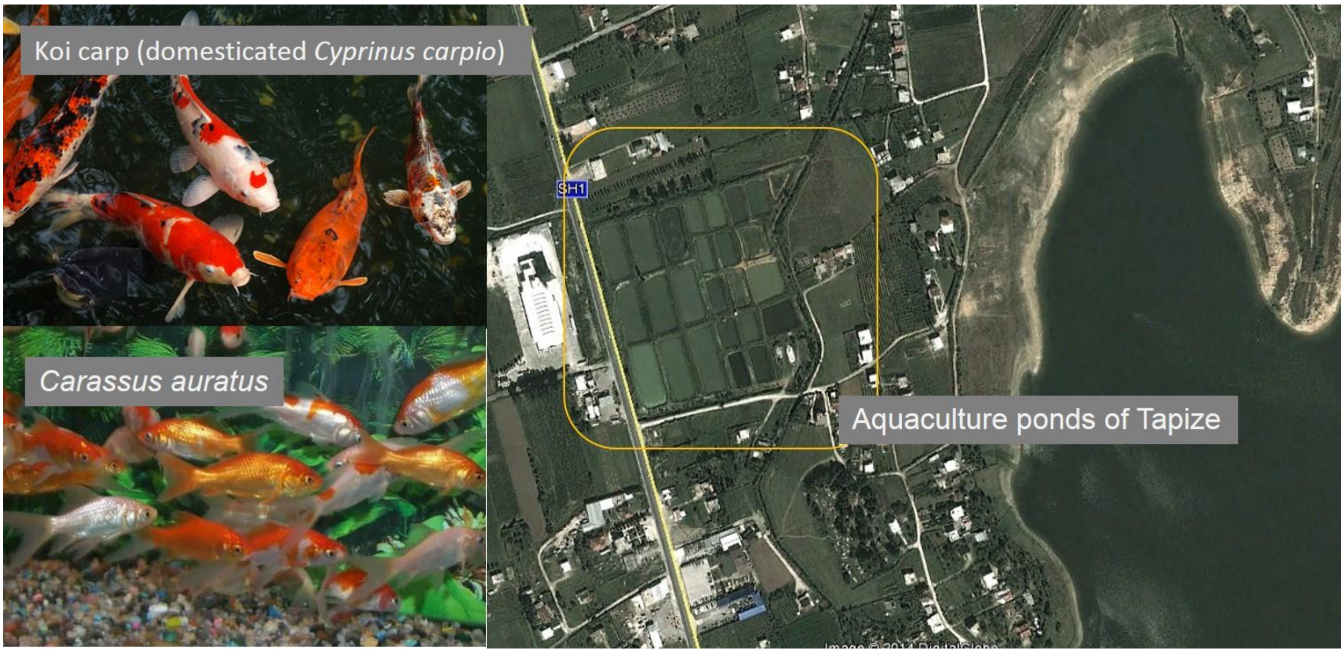

Figure 1. The ornamental fishes (left) and the mapview of aquaculture ponds of Tapize.

Fish production in RAS component

Tilapia is the fish species most commonly cultured in aquaponic systems. Although some aquaponic systems have used channel catfish, largemouth bass, crappies, rainbow trout, pacu, common carp, koi carp, goldfish (*Carassius auratus*), Asian sea bass (barramundi) and Murray cod, most commercial systems are used to raise tilapia. Most freshwater species, which can tolerate crowding, will do well in aquaponic systems (including ornamental fish) [1]. We think that the best alternatives could be using ornamental fishes like *C. auratus* and koi carp (Figure 1) as cultured species in our aquaponic systems, because the profits from these cultured species selling are immediate and secure. Furthermore we have some of these individuals in the aquaculture ponds of Tapize and in the laboratory of aquarology. Goldfish are popular pond fish, since they are small, inexpensive, colorful and very hardy. In an outdoor pond or water garden, they may even survive for brief periods if ice forms on the surface, as long as there is enough oxygen remaining in the water and the pond does not freeze solid. Common goldfish, London and Bristol shubunkins, jikin, wakin, comet and some hardier fantail goldfish can be kept in a pond all year round in temperate and subtropical climates [2]. Moor, veiltail, oranda and lionhead can be kept safely in outdoor ponds year-round only in more tropical climates and only in summer elsewhere [2]. Koi are domesticated common carp (*Cyprinus carpio*) that are selected or culled for color; they are not a different species, and will revert to the original coloration within a few generations if allowed to breed freely [3]. In general, goldfish tend to be smaller than koi, and have a greater variety of body shapes and fin and tail configurations. Koi varieties tend to have a common body shape, but have a greater variety of coloration and color patterns. They also have prominent barbels on the lip [3]. Some goldfish varieties, such as the common goldfish, comet goldfish, and shubunkin have body shapes and coloration that are similar to koi and can be difficult to tell apart from koi when immature [2]. Since goldfish and koi were developed from different species of carp, even though they can interbreed, their offspring are sterile. To recover the high capital cost and operating expenses of aquaponic systems and earn a profit, both the fishrearing and the hydroponic vegetable components must be operated continuously near maximum production capacity. The maximum biomass of fish a system can support without restricting fish growth is called the critical standing crop [1]. Operating a system near its critical standing crop uses space efficiently, maximizes production and reduces variation in the daily feed input to the system, an important factor in sizing the hydroponic component.

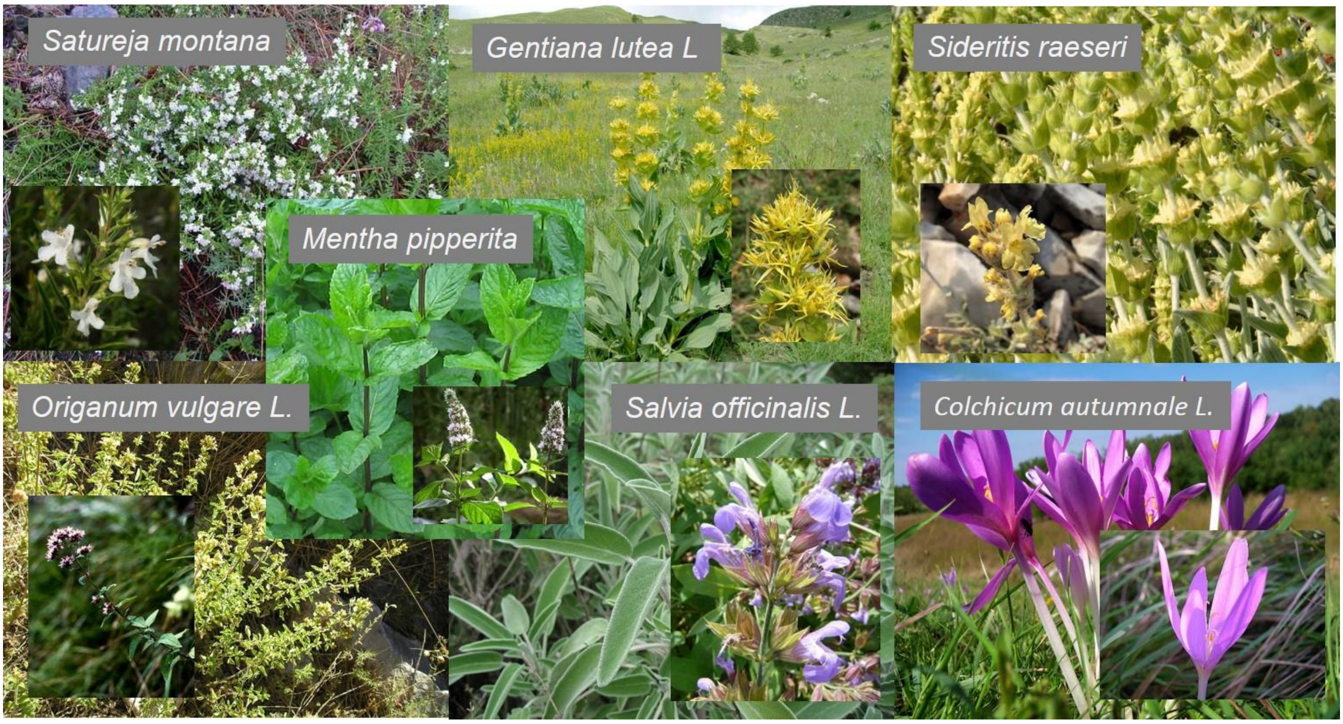

Figure 2. Representative native aromatic plants in the actual territory of Albania.

Plant production in hydroponic component

Many types of vegetables have been grown in aquaponic systems. However, the goal is to culture a vegetable that will generate the highest level of income per unit area per unit time. With this criterion, culinary herbs are the best choice. They grow very rapidly and command high market prices. The income from herbs such as basil, cilantro, chives, parsley, portulaca and mint is much higher than that from fruiting crops such as tomatoes, cucumbers, eggplant and okra [1]. Traditional medicinal plants and plants used for the extraction of modern pharmaceuticals have not been cultivated in aquaponic systems, but there may be potential for growing some of these plants. In the actual territory of Albania there are present many culinary herbs and medicinal plants (Figure 2) like winter savory (*Satureja montana*), mountain tea (*Sideritis raeseri*), great yellow gentian (*Gentiana lutea L.*), autumn crocus (*Colchicum autumnale L.*), european oregano (*Origanum vulgare L.*), sage (*Salvia officinalis L.*) [4] and many others. Some of them have been cultivated in large areas of land and they are winter savory, european oregano, sage and peppermint (*Mentha piperita*). We think that it could be a good alternative to try cultivating these plants in the hydroponic component of aquaponic systems for many reasons which are reported below and in the next section. Pesticides should not be used to control insects on aquaponic plant crops. Even pesticides that are registered would pose a threat to fish and would not be permitted in a fish culture system [1]. Similarly, therapeutants for treating fish parasites and diseases should not be used because vegetables may absorb and concentrate them. The common practice of adding salt to treat fish diseases or reduce nitrite toxicity is detrimental to plant crops. Nonchemical methods of integrated pest management must be used. These include biological control (resistant cultivars, predators, pathogens and antagonistic organisms), physical barriers, traps, and manipulation of the physical environment [1]. There are more opportunities to use biological control methods in enclosed greenhouse environments than in exterior installations. Parasitic wasps and ladybugs can be used to control white flies and aphids. The prohibition on the use of pesticides makes crop production in aquaponic systems more difficult. However, this restriction ensures that crops from aquaponic systems will be raised in an environmentally sound manner and be free of pesticide residues. A major advantage of aquaponic systems is that crops are less susceptible to attack from soilborne diseases. Plants grown in aquaponic systems may be more resistant to diseases that affect plants grown in standard hydroponics [1]. This esistance may be due to the presence of some organic matter in the culture water that creates a stable growing environment with a wide diversity of microorganisms, some of which may be antagonistic to plant root pathogens

Figure 3. The greenhouses of Agricultural University of Tirana.

Aims and motivations

In our country there are present about 3260 plant species. Over 300 of them are considered as medicinal and culinary herbs [5]. Until 1990, Albania has been one of the biggest exporters of medicinal plants in Europe. The export incomes of secondary forest products were 30 million American dollars a year. Medicinal plants incomes were positioned at the top and over 100 people were working to collect these plants. Even in recent years, specific weight of medicinal plants occupies the leading place in the exports of agricultural products. Albania and the Albanian regions of Montenegro provide about 80 % of common sage world production [6].

The leading Albanian aromatic plants importers are France, United States of America, Italy and Germany. In 2002, about 2000 tons of sage, 200 tons of European oregano and 400 tons of winter savory were exported outside Albania [6]. Thus, they productivity represents an excellent economic activity for our country and for this reason it is obligatory for everyone to optimize their productivity and create possibly less negative impact to the environment. About 90% of the exported plants have been collected and continue to be collected from the wild and without any possible control. Consequently, many of the previously mentioned plant species are going to be quality degraded over time and some are going toward extinction [7]. Eventually, all these facts convinced us to use innovative production systems like aquaponic systems in order to protect from the degradation in the greenhouses like those that are property of Agricultural University of Tirana (Figure 3). Another reason could be to ad values to the cultivated plants and sell them as bio herbs (free of pesticide residues) to the national and international markets. Other aims and objectives of building an aquaponic system in the Agricultural University of Tirana are 1. to create an excellent scientific research environment inside the greenhouses, where the aquaponic systems can be equipped with all necessary monitoring instruments in order to evaluate the performance of several experiments that can be performed by PhD students under the assistance of technical staff members and 2. to establish a perfect scientific environment where new ideas may come out from the collaborations between PhD students, researchers and professors.

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