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An Investigation on Tilapia Culture in Aquaponic System in Iran

Farhad Rajabipour[1], Nassrin Mashaii[1], Habib Sarsangi[1], Mohamad Mohammadi[1], and Abbas Matinfar[2]

1. National Research Center of Saline Water Aquatics, Iranian Fisheries Science Research Institute, Agricultural Research, Education and Extension Organization (AREEO), Bafq, Yazd, Iran

2. National Research Center of Saline Water Aquatics, Iranian Fisheries Science Research Institute, Agricultural Research, Education and Extension Organization (AREEO), Tehran, Iran

Abstract: Water shortage and deficit of agricultural soil are limiting agents for development of agronomy, especially in dry areas, such as Iran. Tilapia is an important commercial fish because of its fast growth, tolerance to environmental conditions and diseases, possibility of intensive culture, low costs of production and marketable flavor. Production of aquatic and agricultural crops in an aquaponic system would ask these expectations. Aquaponic system that includes combination of hydroponics and water recycling systems was examined for modulated culture of tilapia and agricultural crops at the present study. Tilapia fries with 6.2 g and 5.9 g mean weight and stocking density of 40 m^3 were respectively stocked in two 2.5 m^3 tanks at September 2013 for 9 months. Fish culture in the two tanks tended to 17.2 kg/m^3 and 19 kg/m^3 fish production with 658 g and 596 mean final weights, 98% and 100% survival and 1.4 and 1.6 food conversion rates. Plants were implanted using grow beds, floating rafts and nutrient film methods. Monthly production of mint, basil, lettuce, cucumber, tomato and pepper were 1.14, 0.5-0.8, 1.32, 2.7-4, 2.03-3.4 and 1.1 kg/m^2 crops, respectively.

Key words: aquaponics, tilapia, plant crops, Iran

1. Introduction

Food security is one of the main current concerns of nutrition planners and administrators. Restrictions of water supplies caused to production systems with low water needs and water usage turnover taken into consideration. On the other hand, the soil is of one of the national wealth that has important role in the agriculture economy. Soil erosion occurs following many traditional farming methods. On the other hand, the limitation of aquatic stocks in the natural water resources tended to development of aquaculture in many countries. So, aquaponics system would be an appropriate response to these limitations. The system includes the integration of hydroponics with aquaculture in a recycle system that farmed fish waste and metabolites exist by the nitration and absorption by the plants. The main benefit of aquaponic systems are: using of wastes as feed or fuel for production in biological systems, combining fish and plants production and increasing yield diversity of the farm, reduction of waste discharge to environment, simple and cost-effective system that is easy acceptance [1].

Tilapia culture has significantly developed in recent decades around the world. It is produced in more than 135 countries [2]. Tilapia culture in recycling systems is currently done. Production of tilapia in aquaponic system, especially in arid regions with water shortages and high rates of evaporation is eligible [1].

Studies about tilapia have started in Iran from November 2008. Some aspects of tilapia aquaculture in Iran are studied in National Research Center of Saline Water Aquatics, Bafq, Iran [3-6].

Corresponding author: Farhad Rajabipour, Research Expert, research areas/interests: aquaculture, tilapia. E-mail: Farhadrajabipour@yahoo.com.

In the present study, culture of nile tilapia, Oreochromis niloticus in an aquaponic greenhouse was examined. The production rate per unit volume, food conversion ratio and the amount of greenhouse production of some plants per unit area were obtained.

2. Materials and Methods

Tilapia fish and plants were cultured in an aquaponic system in National Research Center of Saline Water Aquatics, Bafq, Iran.

2.1 Production System

Aquaponic system was set up in 100 m^2 greenhouse space. Two round 2.5 m^3 polyethylene tanks were used for tilapia culture. Plant cultivation media contained 25 rectangular cube vessels (47×16×260 cm). PVC pipes in the upper part of the tank were used for Plant cultivation, too. Fresh water (salinity 0.1 ppt) was conducted from fish rearing tanks to plant culture vessels by a 105 watts pump (Grundfos 180, 1/4 hp). Plant containers with vents in bottom were deployed with a slight slope to direct the excess water to the fish tank as gravity. Water was replaced about 1% per day. 14 lit/min air stones were used to supply oxygen. In order to filtration of suspended particles, water of fish tanks reached into a 300-liter polyethylene tank containing media made of polyethylene mesh and polystyrene parts. Then, water was pumped to plant containers. A greenhouse heater was used in the workshop space in cold season. The method was based on Rakocy et al., 2004; Rakocy, 1997 [7, 8].

The minimum and maximum of air temperature range were 15-21°C and 24-35°C, respectively, during the study period September 2013 till May 2014. Lowest values of air temperature were recorded in January. The water temperature range was 26-24°C. PH was maintained at 7.22-7.65. Average of dissolved oxygen, ammonium, nitrite, nitrate and alkalinity were 7.24±0.52, 0.35±0.2, 0.26±0.2, 6.31±0.8 and 112.5±23.76 mg/lit, respectively.

2.2 Fish Culture

Sex reversed nile tilapia fries from hatchery at the National Research Center of Saline Water Aquatics (Bafq, Centre of Iran) were stocked 40/m^3 in September 2013. Fish culture continued till May 2014.

Cultured fish were fed adlibitum using 35% crude protein plates 3 times a day and food intake was recorded. Total length and body weight of fish were measured at the beginning and the end of culture period. Weight gain and feed conversion ratio were calculated [9].

2.3 Plants Cultivation

Plants were cultivated in three cultivation substrates including the plant growth media, floating laminates and nutrient film [10]. Plant growth media consisting of a mixture of 80% coco peat and 20% perlite, floating laminates of 3cm thick polystyrene and nutrient film including a thin layer of water of the fish tanks containing nutrients flowing to 110 mm diameter PVC pipes. Circular pores were created in the body of the pipes in order to establish disposable cups for the cultivation of plants.

Basil, mint, lettuce, kohlrabi, cucumber, tomato, green pepper, bell peppers, pumpkin, eggplant, okra, watermelon and rice were cultivated. Cultivation of plants continued till May 2014. No fertilization or spraying took place during the study period [7, 8, 10].

Cultivation density of plants per m^2 for lettuce, cucumbers, tomatoes, green peppers, pumpkin, eggplant, okra and watermelon were 10, 10, 7, 4, 1, 10, 4 and 4, respectively. Basil, mint and rice were cultivated as dense. Plants were harvested and weighed after handling.

3. Results

The average weight of stocked tilapia in two tanks at the beginning of the breeding period were 8/5±2/6 g and 6/4±9/5 g, respectively. At the end of the 9 months culture period, mean body weight of fish were 658.03±252.08 g and 596.15±170.11 g, survival 98%

and 100%, FCR 1.4 and 1.6 and the yield 17.2/m^3 and 18.96/m^3, respectively.

Cultivation of basil, mint, lettuce, tomatoes, cucumbers, green peppers and eggplant tended to yield production (Table 1). Despite considerable growth and abundant flowering of pumpkin bushes, a few pumpkins with 1836 g total weight were harvested. Pumpkin flowers or its 50-100 g fruits abundantly fell. Cultivation of kohlarbi on floating laminate tended to yield but it was not successful on coco peat bed. Okra bushes flowered on different media but okra crop only obtained on the nutrient film bed. Watermelon bushed flowered only on floating laminate. Rice seedlings grown about 10 cm on all three cultivation substrates but were gradually turned yellow and withered. Bell peppers produced only on floating plates.

Success of crop production of cultivated plants on different beds is shown in Table 2.

Table 1 Results of plant cultivation in aquaponic system.

		Basil	Mint	Lettuce	Tomato	Cucumber	Green pepper	Eggplant
density (N/m^2)		Dense	Dense	10	7	10	4	10
cultivation-harvest interval (days)		35	35	40	74	50	55	120
harvest period (months)		5	4.5	3.5	3.5	4	5	2
	15-Nov			412				
	30-Nov			200		4350		
	15-Dec	450	400	200		9700	300	
	30-Dec	490	450	4150		3210	210	
	15-Jan	595	520	4160		5800	220	
Harvest (g)	30-Jan	565	590	460	1670	2050	260	
	15-Feb	580	109	2000	510	2110	300	
	30-Feb	590	695		3200	10670	260	
	15-Mar	600	2200		1150	1930	230	55
	30-Mar	582	4300		3400		390	950
	15-Apr	490	960		9100		275	
	30-Apr	100			13830		315	1005
	Total	5024	10224	11582	32860	39820	2760	2010
yeild (g/m^2)		4019	5112	4633	11949	15928	5520	2010

Table 2 Cultivation of plans on different substrates in aquaponic system led to crop production (●) or not (-).

Cultivation substrate	Basil	Mint	Lettuce	kohlrabi	Tomato	Cucumber	Green pepper	Bell pepper	Eggplant	okra	pumpkin	watermelon	rice
growth media	-	-	●	-	●	●	●	-	-	-	●	-	-
floating laminates	●	●	-	●	●	-	●	●	●	-	-	-	-
nutrient film	●	●	-	-	-	-	-	-	●	●	-	-	-

4. Discussion

Aquaculture is one of the most important and economical methods of protein production to meet the nutritional needs of human communities. Tilapia is long cultured in different systems far from the sea like earthen ponds, concrete tanks and canals. However, limited water reserves and agriculture soil, increase of land prices, climate changes and environmental considerations lead to the use of water recycling systems for aquaculture and tilapia production [1]. Tilapia farming in circulation systems has developed around the world, especially in areas with fresh water shortage and the difficult weather conditions [11].

Recycling aquaculture systems are the most appropriate way to optimal utilization of water because of reuse water flow and minimum waste discharge. Sterilization, aeration and discharge of solid wastes and metabolites are predicted in these systems to maintain water quality for fish culture. Solids removal tanks, filters, mechanical or biological removal of nitrogen compounds, ultraviolet light disinfection and aeration compressor are prepared in the recycling systems [11, 12]. It should be noted that circulation systems are technically complex and expensive, so, cost-benefit analysis for employing these systems is necessary, especially in developing countries [1].

The trend toward the use of integrated aquaponic systems is increased due to the simplicity, lower prices and diversity of products of the farm compared to non-integrated recirculation aquaculture systems. Aquaponic is a relevant candidate system for arid and arable zones [13-15].

The necessity for proper use of water, land and agricultural soil constraints caused to using hydroponics system. However, aquaponic systems have advantages to hydroponics: the system does not use nitrogen fertilizer, water is absolutely turned over, there is no waste water and water pollution therefore no risk of fish diseases through the entry of water resources, nutrient density is about 10 times less than the hydroponic system [16].

Tilapia is very good choice for culture in the aquaponic systems because of high resistance to disease and water agents and intensive culture. Various studies about tilapia production in aquaponics have been tended to favorable results [1].

In a study about integrated culture of tilapia-basil culture in aquaponic system, 61.5 kg/m^3 and 70.7 kg/m^3 nile and red tilapia, with average weight of 813.8g and 512.5 g, survival rate 98.3% and 89.9%, feed conversion ratio 1.7-1.8 and 7.7-25 kg/m^3/year basil has been produced during two years [7]. Annual production of 133 kg/m^3 and 153 kg/m^3 black and red tilapia with more than 80 percent survival in aquaponics under high water recycle, aeration and high-density stocking [15] have also been reported. A commercial scale of aquaponic system in 0.05 acre area led to annual production of 4370 kg tilapia and 2.06 kg/m^2 lettuce [15]. The use of higher storage densities of tilapia in aquaponics along with changes in water flow and aeration system causes significant increase in fish production up to70 kg/m^3 [7].

In the present study, tilapia culture in aquaponic system led to the production of 17.2-18.96 kg/m^3 fish with survival rate 98%-100% and feed conversion ratio 1.4-1.6 during the 9 months.

A great variety of plants are grown in aquaponics. Generally, all species that will thrive in hydroponic systems will thrive in an aquaponic system. However, leafy vegetables such as basil and mint considered the most economical because of more rapid growth than fruiting plants and lesser risk of pests. Besides, a large portion of leafy plant biomass might be harvested. Lettuce is also a suitable and could be produced in a short time of about 4-3 weeks. Flowers have also been successfully grown in aquaponics. Production of medicinal herbs in this system is possible but not yet fully experienced. Any plant production should be commensurate with costs, local markets and demand [10].

In the present study, cultivation of basil, mint, lettuce, cucumbers, tomatoes and peppers led to favorable crops (Table 3).

Water consumption in aquaponic method is much less than other methods of cultivation and aquaculture. Also, agricultural production in the aquaponic system might be performed without need to soil. Environmental considerations and reduction of production costs are the specific traits of aquaponic system. Integrated production of agricultural products and fish play an important role in the agricultural economy.

This study showed appropriate integrated production of tilapia and vegetable crops. More studies needed specially on increasing the production of fish/plant per unit volume and area, cultivation of native medicinal plants, and determination of optimal environmental factors in the system in Iran.

Table 3 Results of crop production (kg/m^2) in aquaponic system compare to results of other researchers.

Tomato	Cucumber	Eggplant	Lettuce	Basil	Mint	Reference
17	21		5	8		[17]
4 months	3 months		1 month	1 month		
				1.95		[7]
				(open land:0.7)		
				1 month		
				7.7-25kg/m^3		[7]
				yearly		
30.1	62	11.5	7-30.5			[18]
yearly	yearly	yearly	yearly			
	2.5		2.37-2.41	4.1-4.4		[16]
	3 months		1 month	1 month		
3.4	4	2	1.32	0.8	1.14	Present study
1 month	1 month	1 month	1 month	1 month	1 month	

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