Assessment of a Media Based Aquaponics System: A Way Towards Sustainability

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Abstract

This paper deals with the evaluation of developed deep bed media based aquaponics system. GIFT Tilapia and Foxtail Amaranth (Amaranthus gangeticus). Hence combined plant culture and fish culture unit has been made (ie,Aquaponics system). The GIFT (Genetically Improved Farm Tilapia) tilapia fingerlings of average weight 0.70 g were obtained from a fish farmer and Foxtail Amaranth (Amaranthus gangeticus) seeds were obtained from a local supplier, respectively. GIFT tilapia was cultured in culture tank and seeds were planted in plant bed respectively in aquaponics unit.Tilapia fishes are generally prolific breeder in nature. Fish were fed at the rate of 8% of its body weight with commercially available feed. The average weight of fish was recorded in aquaponics and glass tank fish culture units and was found to be 83.20 and 78.10 g respectively. After 160 days of culture,plant height observed in aquaponics system and normal culture system was found to be 18.10 and 20.20 cm, respectively. Mass balance approach was applied to fix the recirculation flow rate in aquaponics system and was maintained 0.43 lpm throughout the culture and the average biofiltration efficiency was found to be 23%.

Key words

Aquaponics system; GIFT tilapia; Foxtail Amaranth (Amaranthus gangeticus); recirculation flow rate

I. INTRODUCTION

Aquaculture practice generates lots of effluent and to treat or dispose of effluent is both expensive and environmentally harmful. Therefore, an aquaponics system will serve the purpose of producing food for a sustainable future without much degradation to the environment.It is an integrated multi-tropic system that combines elements of recirculating aquaculture and hydroponics where the water from fish tank that is enriched with nutrients is used for plant growth viz; raising fish, crayfish or prawns in tanks or ponds with hydroponics i.e. cultivating plants in water in a controlled environmental condition. An aquaponic system can benefit the aquaculture operation by improving the quality of recirculated water or by reducing costs associated with treating effluent from flow-through raceways (Rakocy *et al.*, 2006). Thus, the marriage of fish culture with plant culture in aquaponics system allows both operations to reduce inputs and makes the enterprise more profitable (Tyson *et al*., 2004). The aquaponics systems gained the popularity in the past few years (Love *et al.*, 2014). Aquaponics systems are nothing but recirculating aquaculture systems where water is continuously recycled through an interconnected series of fish tanks and waste treatment systems (Timmons and Ebeling, 2002). A toxic by-product of fish waste is ammonia and which needs to removed from fish culture water. Hence, to remove toxic nitrogenous compounds and improve water quality, biofilters were used. Francis *et al.* (2003) reported that sustainable agricultural production can be achieved similar to natural ecosystems like aquaponics system. Although preliminary research has shown that developed aquaponic system components are not yet fully realized in view of either cost effectiveness or technical capabilities

(Rakocy, 2012; Vermeulen and Kamstra, 2013). The linking of fish culture with plant culture allows both operations to reduce inputs and makes the enterprise more sustainable (Tyson *et al.*, 2008). The objective of this research was to develop aquaponics system and evaluate the performance of GIFT tilapia reared and Foxtail Amaranth (*Amaranthus gangeticus*) cultured in the developed aquaponics system.

Components

The main components involved in Aquaponics system installation are as follows:

- FRP (Fiber Reinforced Plastic) Tanks-2 Nos.
- PVC pipes-required length.
- Submersible pump.
- Nylon pot scrubber-500 Nos.

II. METHODOLOGY

The aquaponics system set-up was installed in College of Fisheries Engineering, Tamil Nadu Fisheries University Nagapattinam. A typical schematic diagram of aquaponics system is presented in Fig. 1. The installed set –up consists of:

A) Fish rearing tank

An FRP tank of inner dimensions 2.5 × 2 × 1.4 m^3 was used as a Fish culture unit. Under controlled conditions, Tilapia Fingerlings of size 0.70g was stocked in this tank under controlled conditions. Generally, PVC pipes of certain length is used for the water flow from fish culture unit to plant culture unit. Water from the fish rearing tank was pumped with the use of a submersible pump.

B) Plant culture tank

An FRP tank of inner dimensions 2.5 × 2 × 1.4 m^3 was used as a plant culture unit. 500 numbers of nylon pot scrubbers were placed in the plant culture unit and over it construction gravel was used and both were used as a plant bed. The free board was kept as 40 cm. 25 numbers of Foxtail Amaranth (*Amaranthus gangeticus*) seeds were spreaded on the entire plant culture bed and the system was run for continuous operation. The flow rate was fixed as 0.43 lpm throughout the culture period on the basis of mass balance approach.

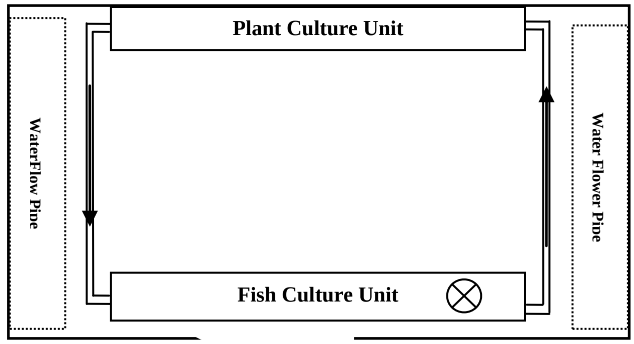

Fig. 1: Aquaponics system showing individual components

C) Feed

The major feed given to GIFT tilapia is rice bran and mahua oil cake in the ratio of 1:2.They were fed at the rate of 2, 3.5, 5, 6.5 and 8 percent of fish biomass consecutively for 30, 60, 90, 120 and 160 days respectively. Feeding was done thrice a day to enhance easy digestibility of feed by fish (Penry and Jumars, 1986).The percentage of proximate composition of the GIFT tilapia feed is shown in Table 1.

S. No.	Composition	Percentage
1.	Crude protein	40
2.	Crude fat	8
3.	Crude fibre	6
4.	Crude ash	16
5.	Moisture	11
6.	Nitrogen free extract	32

Table 1: Proximate composition of the feed

D) Bio-Filtration

The ammonia from the Fish faeces containing water is pumped into plant culture unit where nylon pot scrubbers were kept in which gravel is spreaded over it, which acts as a bio-filter.Here, Nitrification process takes place in which ammonia get converted into nitrite(NO_3) in presence of *Nitrosomonas* and *Nitrobacter* and then nitrite(NO_3) gets converted into nitrate(NO_2)

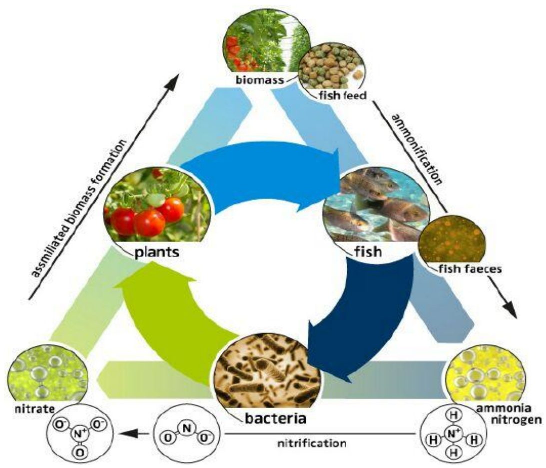

Fig.2.Nitrification process occurring inside biofilter.

III. RESULTS AND DISCUSSION

A) *Fish growth:*

The average initial weight of fishes was recorded as 0.70 g on 07 day interval basis. From Fig. 3 and 4 it can be inferred that the specific growth rate followed a reducing trend after 60 days of culture. This happened due to the faster growth at the initial stage.

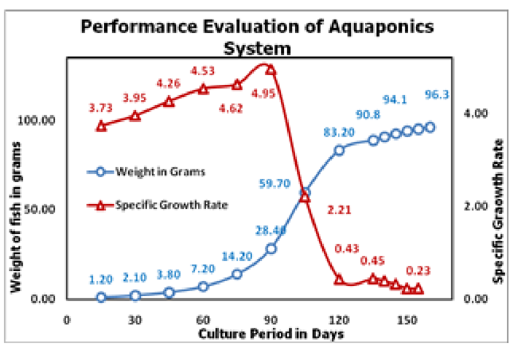

Fig. 3 Specific growth rate and Weight of Gift in Aquaponics system

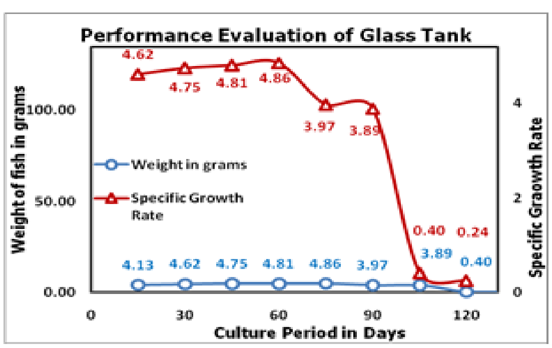

Fig.4 Specific growth rate and Weight of Gift in Glass Tank System

The length of fish was continuously increasing throughout the culture in aquaponics and normal culture (glass tank) unit (Fig. 5). The growth of fish in this manner indicated that the fish were adequately fed and well nourished.

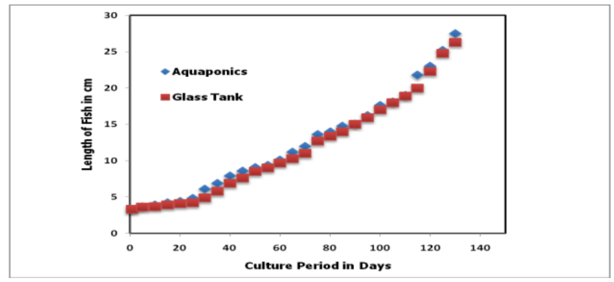

Fig. 5- Length of fish observed in aquaponics and glass tank culture system

B) *Plant Growth:*

The Foxtail Amaranth (*Amaranthus gangeticus*) seeds were spreaded over the plant bed and growth of plant was observed at every seven day interval. At the end of 60 days plants were harvested.

Table 2: Plant height with duration

Date	Aquaponics System Height(cm)	Normal Culture System Height(cm)
10.2.17	0	0
17.2.17	3.3	3.8
24.2.17	4.5	5.0
03.3.17	6.1	7.0
10.3.17	8.7	9.2
17.3.17	11.0	11.7
24.3.17	12.8	13.4
31.3.17	14.3	15.0
01.4.17	16.2	16.9
08.4.17	18.1	20.2

The average height of the plants in aquaponics unit and normal culture system was measured as 18.1 and 20.2 cm respectively. The average height increase in every seven days in both aquaponics and normal culture system is found to be 1.85 and 2.05 respectively.

Though the average height of plant cultured in normal culture system on the ground was quiet higher than the plant grown in aquaponics system but it required additional space and water. Therefore, it can be inferred that plants adequately utilized the nutrients available in recirculated fish culture water and well nourished.

C) Water quality data

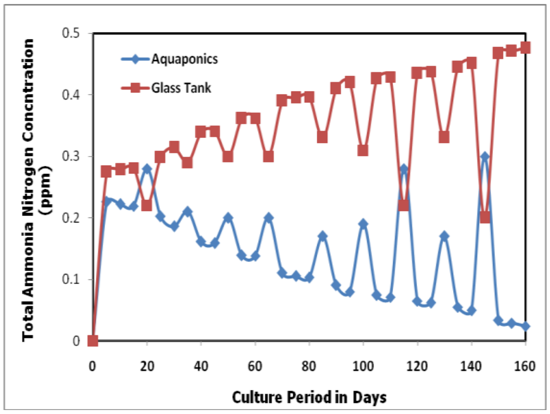

Fig. 6- Comparison of TAN concentration (mg/L) of fish culture water in aquaponics system and glass tank

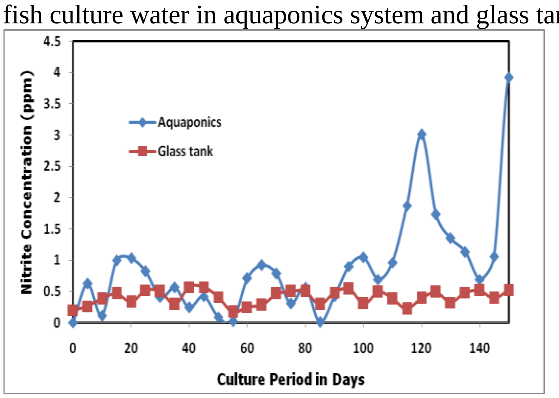

Fig. 7- Comparison of Nitrite concentration (mg/L) of fish culture water in aquaponics system and glass tank

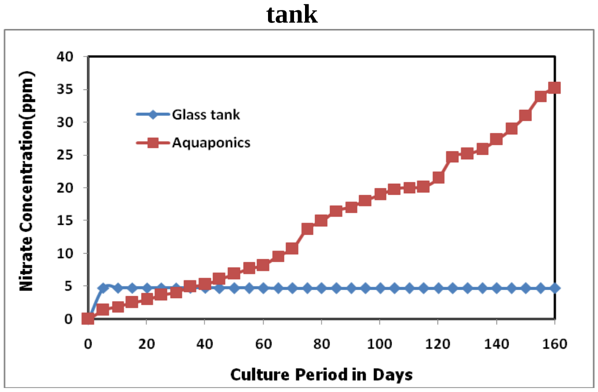

Fig. 8- Nitrate concentration (mg/L) of fish culture water in aquaponics system

1) TAN, nitrite-N and nitrate-N concentration:

TAN and nitrite-N and nitrate-N concentrations of water in fish rearing tank and glass tank were measured on a weekly basis and the plot of observed values in aquaponics system and glass tank is shown in Fig.6, 7 and 8 respectively.

It can be seen from Fig.6 that the TAN concentration fluctuated throughout the culture period and follows the same trend both in aquaponics and glass tank system respectively. Thus, before the TAN concentration becomes lethal necessary water exchange was performed. It can be clearly observed from Fig.7 that nitrite-N concentration does not increase beyond 5 mg/L in glass tank culture. This happened due to a regular water exchange. However, the NO_3-N concentration was drastically increased in aquaponics fish culture tank due to very limited water exchange as shown in Fig. 8. There was no harm recorded to fish and plant growth due to NO_3-N Concentration.

2) DO concentration and pH

The DO concentration was monitored every day and maintained between 6-8 mg/L in aquaponics and normal glass tank culture system. The water pH was recorded within its ideal range (7-8.5) in glass tank and aquaponics culture system.

3) Biofiltration efficienct

The biofiltration efficiency was calculated by considering TAN concentration in water in aquaponics fish rearing tank and TAN concentration in water out form the plant culture tank. The average biofiltration efficiency of the developed system was found to be 23%.

IV. CONCLUSIONS

The following conclusions are drawn from the study:

- The developed desktop based aquaponics system in the study is applicable to any fish species and leafy plant variety.
- Unlike in usual aquaculture system where daily partial exchange of water in fish culture tank is performed, the system is developed to overcome the difficulty of daily water exchange and thereby saving pumping and labour costs.
- It will be an emerging trend in Aquaculture side in upcoming Decades.

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