Project Report

# AN EXPERIMENTAL STUDY ON THE SMALL SCALE AQUAPONICS

*Dissertation submitted to the University of Kerala in partial fulfillment of the requirements for the award of the degree of*

**Bachelor of Science**

in

**ZOOLOGY**


**Submitted by**

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DEPARTMENT OF ZOOLOGY
TKM COLLEGE OF ARTS AND SCIENCE
KOLLAM-5



March - 2018

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# CERTIFICATE

This is to certify that the dissertation entitled **An Experimental Study on the Small scale Aquaponics** is an authentic record of the work done by ........................................................ with Reg. No: .............................. under my supervision as partial fulfillment of the requirements for the Degree of *Bachelor of Science* in Zoology and this report has not been submitted earlier for the award of any degree or diploma or any other similar titles anywhere.

12/04/18

Dr. Sirajudheen T.K.
(*Supervisor*)
Asst. Professor
Dept. of Zoology

Certified bona fide:

18/4/18

Head of the Department

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**Asst. Professor**
**Dept. of Zoology**
**TKM College of Arts & Science**
**Kollam, Kerala - 691 005.**

**EXAMINERS:**

1.

2.

# DECLARATION

I do hereby declare that this dissertation entitled **An Experimental Study on the Small scale Aquaponics** is a bona fide report of the project work carried out by me, under the supervision and guidance of Dr. Sirajudheen T.K., Asst. Professor, Department of Zoology, TKM College of Arts and Science, Kollam as partial fulfillment of the requirements for the award of the Degree of Bachelor of Science in Zoology.

Student

Karicode

04.04.2018

# ACKNOWLEDGEMENT

*I have got many people to thank for their encouragement and support to accomplish the objectives of my work.*

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***Student***

## CONTENTS

*DEDICATED TO MY PARENTS AND TEACHERS….*

Aquaponics, a combination of fish farming and soilless plant farming, is growing in popularity and gaining attention as an important and potentially more sustainable method of food production. This is mutually beneficial integration of hydroponics (*e.g.*, soilless systems for crop production) and aquaculture (*e.g.*, aquatic animal farming) to simultaneously produce plant and animal products. In an aquaponic system, aquatic animals excrete waste, bacteria convert the waste into nutrients, and plants remove the nutrients and improve water quality for the aquatic animals. Aquaponics applies methods developed by the hydroponics industry in which chemical salts dissolved in water are the source of nutrients for plants (Gericke, 1940). A major challenge for recirculating aquaculture was the accumulation of nitrogen compounds, a potentially toxic by-product of fish waste. Investigators experimented with soilless plant systems as a means of treating fish waste and removing nitrogen compounds (Naegel, 1977; Sutton and Lewis, 1982), which marked the beginnings of contemporary aquaponics.

To add value to the soils' nutrient stock, agricultural trends have been to add increasing amounts of fertilizer, which, along with herbicides and pesticides, has contributed to significant and alarming environmental problems. Hydroponic methods have been the subject of much research during the last century as more focus has been put on our agricultural methods. As a result, many advances have been made in the field and current hydroponic methods take many forms. Aquaponics is touted as a form of sustainable agriculture because it mimics natural systems, is water efficient, and has fewer environmental impacts than some forms of aquaculture (Blidariu and Grozea, 2011).

Aquaponics is a recent technology emerging attention around the world because of its efficient use of resources. It provides a simple and practical solution to the food security issues and has the potential to increase the health and stability of families by feeding them and helping them become financially secure. Recirculation systems in aquaponics are planned to raise large quantities of fish in relatively small volumes of water by treating the water to remove toxic waste products and then reusing it. In the process of reusing the water many times, non-toxic nutrients and organic matter accumulate. These metabolic by-products need not be wasted if they are channelled into secondary crops that have economic value or in some way benefit the primary fish production system. Systems that grow additional crops by utilizing by-products from the production of the primary species are referred to as integrated systems. If the secondary crops are aquatic or terrestrial plants grown in conjunction with fish, this integrated system is referred to as an aquaponics system.

The Food and Agriculture Organization of the United Nations has emphasized aquaponics as a future sustainable food production practice and has recently released guidelines on small scale aquaponics production systems (Somerville *et al.*, 2014). Many companies, aquaponics suppliers and start-up businesses are running successful commercial aquaponics production around the world. For example aquaponics products produced in the USA can be certified organic according to the rules laid out in federal law by the National Organic Program of the United States Department of Agriculture since 2008 (United States Department of Agriculture, 2018), which provides a good starting point for pricing aquaponics products higher and offers a better competitive advantage on the market.

All available studies about aquaponics have focused mainly on surveying aquaponics producers (Love *et al., 2015)* or analysing specific case studies of aquaponics production, mostly in the USA or specific Canadian provinces such as Alberta (Savidov, 2004), or states such as Puerto Rico (Bunyaviroch, 2013) and Hawaii (Tokunaga *et al.*, 2015), Malaysia (Tamin *et al* 2015), Romania (Zugravu *et al.*, 2016) and Berlin (Specht *et al.*, 2016). Since the technology itself is in its infant stage in India, no published data were available on studies on the aquaponics in the country.

## Objectives of the Study

- To develop an aquaponics system on an experimental basis
- To describe the operating conditions in a small scale aquaponics system
- To monitor the growth and production of fish and vegetables in the aquaponics system.
- To create an awareness regarding the utilisation of fish waste as a nitrogenous fertilizer for plant growth by using aquaponics systems.

## *Principle behind Aquaponics*

Aquaponics systems are recirculating aquaculture systems that incorporate the production of plants without soil. It works on the principle of recirculation systems. Basically it was 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 it. In the process of reusing the water many times, non-toxic nutrients and organic matter accumulates. In a fish tank, more than 50% of the waste produced by fish is in the form of ammonia and is secreted through the gills and in the urine. The remainder of the waste is excreted as faecal matter. The fish waste undergoes a process called mineralization which occurs when Heterotrophic bacteria consumes fish waste, decaying plant matter and uneaten food. During mineralization fish waste, decaying plant matter and uneaten food are converted to ammonia and other compounds. Excess quantities of this ammonia are toxic to fish.

Nitrifying bacteria, which naturally live in the soil, water and air convert ammonia first to nitrite (managed by *Nitrosomonas* bacteria) and then to nitrate (*Nitrobacter*) which the plants consume. Nitrifying bacteria will thrive in the gravel beds and in the water in the system. The plants readily take up the nitrites and nitrates in the water and, in consuming it, help to keep the water clean and safe for the fish. Plants need nutrients in the proper amounts, oxygen, $CO_2$, water and light. They can come from natural or artificial means. Aquaponics takes advantage of a natural process in a controlled environment and fulfils these requirements (Fig. 2.1).

**Fig. 2.1: Aquaponics Cycle**

## ***Aquaponics system design***

A small scale aquaponics system was set up in laboratory of Zoology Department. The system was operated with fish and vegetable plants and weekly data for the study were recorded for two months (November and December 2017). The design and specifications of the system are presented in Fig.2.2.

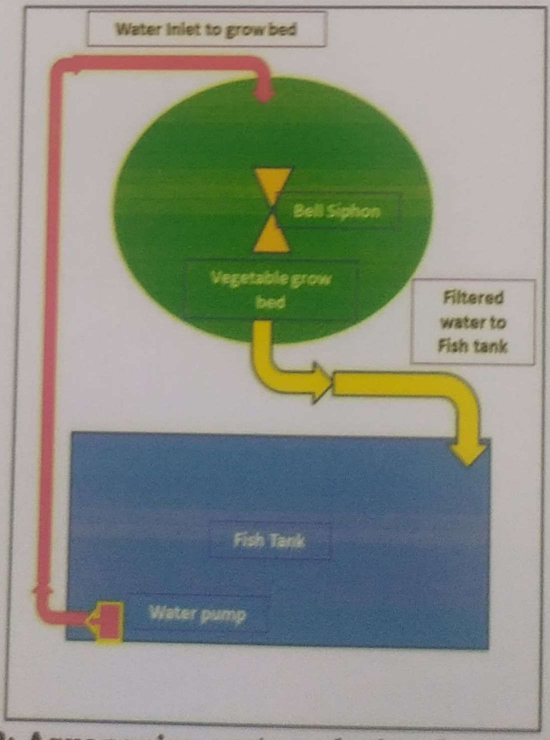


**Fig. 2.2: Aquaponics system design for the study**

Glass tank with dimensions 75cm X 29cm X 38cm (Length X Width X Height) (Fig. 2.3a) was used for stocking fish. A circular plastic tray with 54 cm diameter and 15 cm height (Fig. 2.3b) was used as grow bed for vegetables. Rock gravels of 1-2 cm thicknesses (Fig. 2.3c) used as medium for planting. Mechanical components included a water pump, a bell siphon and associated equipment such as hoses. A normal type of submersible aquarium pump (Fig. 2.3d) is used for pumping water from fish tank to the vegetable grow bed.

**Fig. 2.3a: Fish tank used in Aquaponics system**

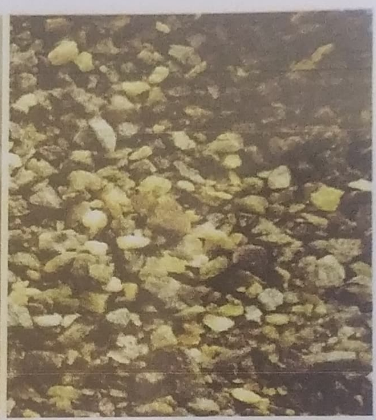

**Fig. 2.3c: Grow bed media**

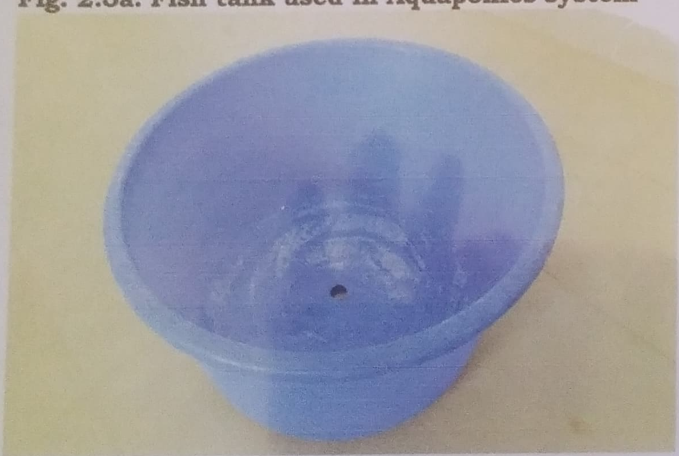

**Fig. 2.3b: Tray used for grow bed in the study**

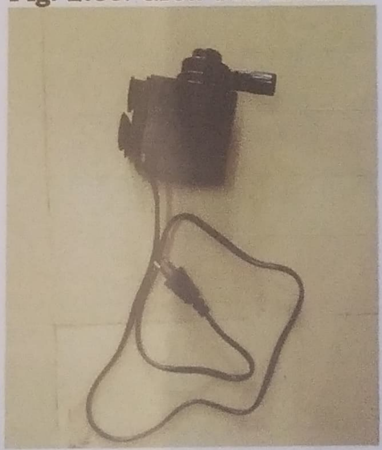

**Fig. 2.3d: Water pump used**

PVC pipes of varying diameters were used for making Bell siphon (Fig. 2.4). A garden hose was used to lead water pumped from fish tank to grow bed and the filtered water from bell siphon was drained to fish tank through PVC pipes. The whole system was set up in a vertical position on a wooden stand with grow bed on upper portion and fish tank in the lower portion (Fig. 2.5a,b) in order to facilitate water flow in between the grow bed and fish tank..

**Fig. 2.4: Parts and setup of Bell Siphon used in Aquaponics system**

**Fig. 2.5a: Wooden stand used as supporting platform**


**Fig. 2.5b: Fully setup Aquaponics system.**

## *Fish and Plants used for the study*

Fish tank was stocked with 20 number of Tilapia (*Oreochromis sps*) (Fig. 2.6). Seeds of Tilapia having an average length of about 2.5 cm were collected from local dealers were used. Easy growing and popular vegetable plants such as Pea (*Pisum sativum*), Tomato (*Solanum lycopersicum*) and Eggplant (*Solanum melongena*) were used for the study (Fig. 2.7). Home grown saplings of each plants were planted in the grow bed.

**Fig. 2.6: Tilapia**

**Fig. 2.7: Vegetable Plants- Tomato, Pea and Eggplant**

## *Fish and Plant production*

A continuous water circulation was maintained in between the fish tank and vegetable plants grow bed using the water pump. The fish were fed with pelleted fish feeds available in the market. It was a slow sinking feed with about 35% protein content. Fish were fed by hand once a day in quantities based on the number of fish in the system and their body weight (Fig. 2.8a). Length and weight of a sample of five to ten fish from tank were measured on a weekly basis, and these measurements were used as average measurements for analysis. Samples were obtained by dipping the net into each tank five times and measuring the fish caught. Length of the fishes was measured using a scale calibrated up to millimetre level (Fig. 2.8b) and weight was recorded using an electronic balance with lowest division as milligrams.

Length of all the three varieties of vegetable plants grown in the grow bed of aquaponics system were also measured (Fig. 2.8c) on weekly basis for two months. Other parameters such as budding, flowering, fruiting, infections, damages, mortality, etc was also monitored and recorded regularly for both the plants and fishes for a period of two months starting from November to December, 2017.

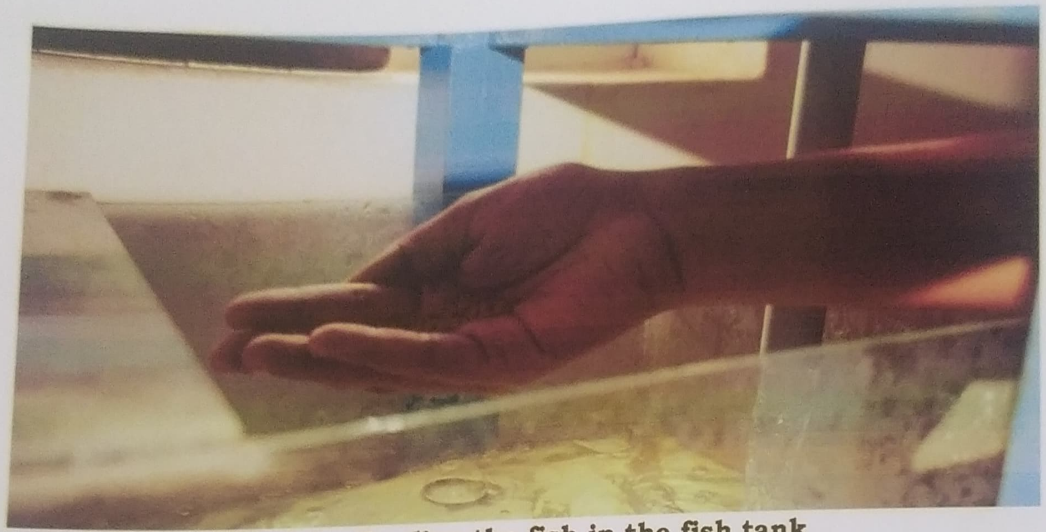

**Fig. 2.8a: Feeding the fish in the fish tank**

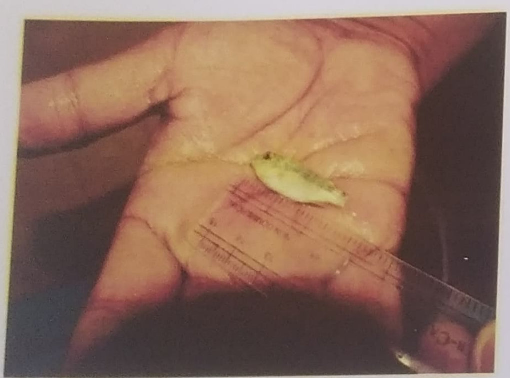

**Fig. 2.8b: Measuring fish growth**

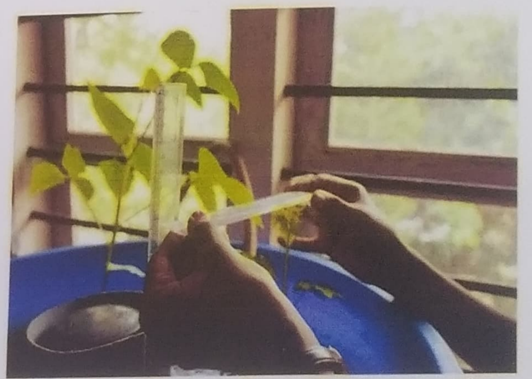

**Fig. 2.8c: Measuring plant growth**

The experimental study conducted for a period of two months to find out the growth performance of vegetable plants and fish in a small scale aquaponics system revealed the following results.

## Fish Growth

All the twenty fishes kept in the tank showed an increasing trend in terms of body length and weight. The average initial length and weight were 2.5 cm and 0.8 gm respectively, which was increased exponentially to 4.2 cm and 2 gms by one week time. Then both the length and weight showed a steady increase in subsequent weeks and the final length and weight recorded was 9.5 cm and 7.2 gms respectively (Fig. 3.1).

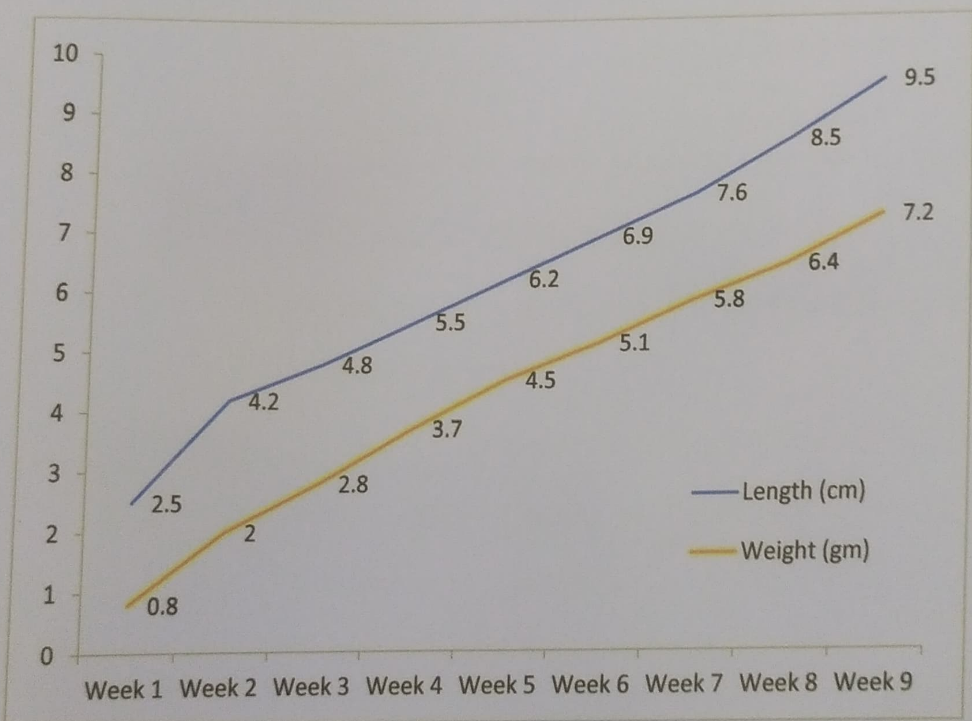


**Fig. 3.1: Growth performance of Fish, Tilapia in aquaponics system**

## Growth performance of Vegetable plants

All the three vegetable plants in the grow bed showed an increasing trend in terms of stem length. The initial stem length of Tomato was 9 cm, which was increased steadily to 190 cms by nine week time. The initial stem length of

Pea plant was 23.5 cm, which was increased steadily to 480 cms by nine week time. The initial stem length of Eggplant was 8.5 cm, which was increased steadily to 44 cms by nine week time. The growth performance of various vegetable plants in the aquaponics grow bed is shown in Fig. 3.2.

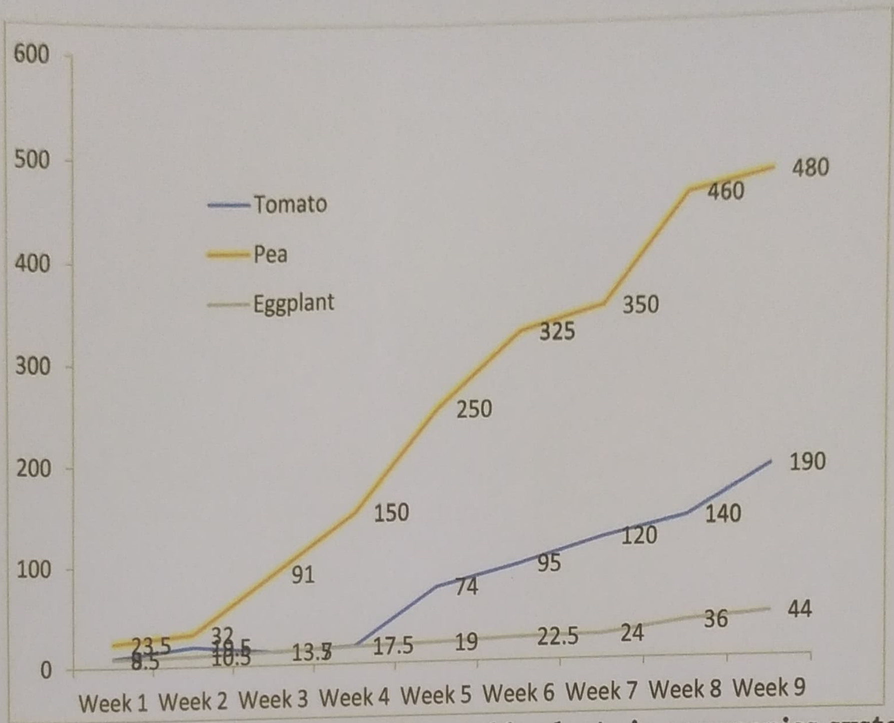


**Fig. 3.2: Growth performance of Vegetable plants in aquaponics system**

***<u>Other parameters noticed during the study period</u>***

- ✓ Flowers were found in pea plants during 5th week onwards and it became fruits by 6th week (Fig. 3.3).
- ✓ Although the tomato plants were flowered during 6th week of the study no tomato fruits were formed. It might be attributed to the lack of nutrients such as magnesium in water.
- ✓ No flowers and fruits were found in Eggplant plants.
- ✓ No infections or pests were found on plants throughout the study period.
- ✓ All the fishes lived healthy (Fig. 3.4, 5) except a few mortalities due to mechanical damages from water pump.

**Fig. 3.3: Fruit on Pea plant**

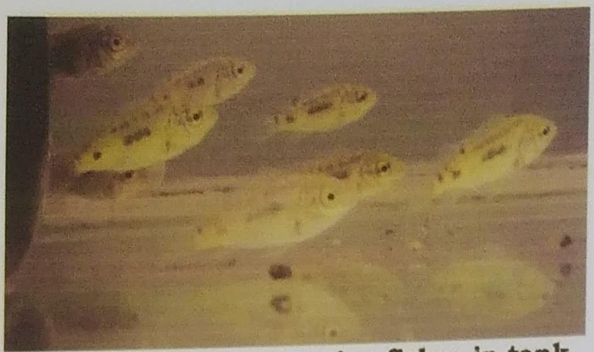

**Fig. 3.4: Actively swimming fishes in tank.**

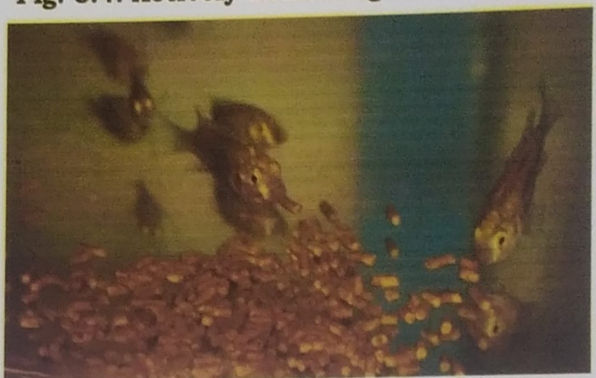

**Fig. 3.5: Fishes taking feed in tank.**

***Discussion***

The great challenge nowadays is and will be in the coming decades meeting the increasing need for food production and distribution in big cities in a sustainable way (Orsini *et al* 2013). Many billion people in the world today are currently undernourished due to many factors such as conflict, poverty, poor agricultural infrastructure and over-exploitation of the environment. Aquaculture and agriculture are the major solutions for maintaining food security worldwide. But extensive land and water farming have caused problems such as waste disposal and other environmental concerns. Aquaponics is a technology which provides a solution to the need for sustainable ways of filtering or disposing of nutrient-rich fish waste in aquaculture and the need for nutrient-rich water to act as a fertilizer with all of the nutrients and minerals needed for plants grown through hydroponics (Nelson, 2008). Crops are grow in a concentrated manner without compromising the health of the system and while greatly reducing the required input of water resources (Nelson, 2008) and increasing the value gained from the continuously cleaned and recycled water (Considine, 2007). Aquaponic systems combine the two forms of agricultural production mentioned above, recirculating aquaculture and hydroponics. Accordingly, the waste of one biological system becomes nutrients for another biological system (Diver, 2006).

There is growing interest in locally produced food that is sold directly to consumers. Aquaponics, due to its recycling character, is one of the most promising types of sustainable urban farming (Specht *et al.*, 2014). This particular system is extremely sustainable, since it operates without fertilizers and is clearly linked to ecologically friendly practices (Orsini *et al* 2013).

The narrow focus on tilapia by aquaponic researchers means that production methods have not been optimized for many other aquatic livestock. There were a wide variety of fish and crustaceans reportedly grown by respondents, and additional research is warranted on production of these species. Aquaponics enthusiasts are often driven by the idea of aquaponics being sustainable food production, minimizing waste and making the most of water, energy and nutrient resources. Limited information, however, exists about general consumers' acceptance of aquaponics products. This innovative technology of producing organic fish and vegetables need more popularity in order to exploit its maximum potentials in our country.

Aquaponics is believed to have future potential as a sustainable integrated food production method. However, development is still in its early stage and although many new aquaponics companies are starting up in developed countries such as USA, only a few are currently practicing in India. This study was an experimental work to analyse the growth of fish and vegetables in a small scale aquaponics system. The results showed a steady growth of fish as well as vegetable plants in the aquaponics system. It is proved that such a soilless and integrated culture practice is suitable for conditions in Kerala. So it is recommended to conduct more studies in order to commercialise aquaponics system in our area.

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