BOHR

BOHR International Journal of Civil Engineering
and Environmental Science
2023, Vol. 1, No. 1, pp. 32–40
DOI: 10.54646/bijcees.2023.04
www.bohrpub.com

EXPERIMENTAL RESEARCH

Comparative analysis between traditional aquaponics and reconstructed aquaponics systems in propagating tomatoes (*Solanum lycopersicum*)

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Received: 18 February 2023; **Accepted:** 21 March 2023; **Published:** 20 April 2023

The aquaponic system of planting is a method that does not require soil usage. It is a method that only needs water, fish, lava rocks (a substitute for soil), and plants. Aquaponic systems are sustainable and environmentally friendly. Its use not only helps to plant in small spaces but also helps reduce artificial chemical use and minimizes excess water use, as aquaponics consumes 90% less water than soil-based gardening. The study applied a descriptive and experimental design to assess and compare conventional and reconstructed aquaponic methods for reproducing tomatoes. The researchers created an observation checklist to determine the significant factors of the study. The study aims to determine the significant difference between traditional aquaponics and reconstructed aquaponics systems propagating tomatoes in terms of height, weight, girth, and number of fruits. The reconstructed aquaponics system's higher growth yield results in a much more nourished crop than the traditional aquaponics system. It is superior in its number of fruits, height, weight, and girth measurement. Moreover, the reconstructed aquaponics system is proven to eliminate all the hindrances present in the traditional aquaponics system, which are overcrowding of fish, algae growth, pest problems, contaminated water, and dead fish.

Keywords: aquaponics, reconstructed aquaponic system, comparative analysis, traditional aquaponic systems, STEM SHS Philippines

Introduction

Planting is a type of labor practiced for centuries. Aside from flowers and trees, vegetables, rice, and fruits help alleviate food insecurity. It aids in alleviating hunger and the preservation and in the attractiveness of the environment. However, there are times when tree and plant death is unavoidable, sometimes due to drought or a lack of personal care.

Another reason for the decrease in crops is the expanding construction of buildings in the country. Due to its expansion, the space wherein plants, fruits, and vegetables can grow became limited, prompting the development of the aquaponic system.

The aquaponic system is a method that does not require soil usage. It is a method that only needs water, fish, lava rocks (substitute for soil), and plants. Aquaponic systems are sustainable and environmentally friendly. Its use not only helps plants in small spaces, but it also helps reduce artificial chemical use and minimizes excess water use, as aquaponics consumes 90% less water than soil-based gardening.

When compared to planting in the ground or on a traditional plantation, aquaponics is also more effective because the plant grows faster. With the help of water and fish, aquaponic plants supply more efficient nutrients to their roots.

The research study tried a new combination of plants and fish. In aquaponics, the possible combinations between plants and marine animals are endless. Furthermore, the research study revealed the significance of aquaponics because it will assist farmers in having a more nourished crop faster than the traditional method.

The research study provided a more convenient aquaponics system than usual. A comparison between the traditional aquaponics system and the reconstructed aquaponics system was employed. The reconstructed aquaponics system, for example, used a smaller diameter pipe rather than a massive tube because a massive tube impedes water distribution into the grow or plant bed.

The reconstructed aquaponics system employed DC valves in its electrical construction so that problems would not be evident while using the solenoid valves, just like other individuals. Finally, the rebuilt aquaponics system installed pressure gauges at the entrance and exit of both filters to ensure that the water is not contaminated in any way.

Aquaponics is the future of agriculture because crop production is 10 times higher than on a traditional plantation; it also reduces water consumption and minimizes energy consumption. Additionally, crops produced in aquaponics are resilient to floods and droughts.

Research elaborations

Food security is one of the world's problems, which refers to a lack of food that causes individuals to go famished. The people's poverty and unemployment are some of the reasons for this. As a result, most people grow healthy crops such as tomatoes, Chinese cabbage, eggplant, and other harvestable foods to have something to eat.

Planting became difficult, especially in cities, due to progressive changes, such as the development of enormous buildings. The planting area is reducing, and the soil is getting increasingly cement-like. As a result, researchers decided to use and develop aquaponics, which the ancient Aztecs called "chinampas."

Aquaponics combines aquaculture (growing fish) and hydroponics (growing plants on alternatives to or substitutes for soil). It utilizes natural bacteria cycles because it is a system in which fish feces serve as a source of plant nutrients. In return, the plants purify the water for the fish. The study aims to determine the difference between the traditional aquaponic system and the researchers' reconstructed aquaponic system regarding plant specimens' height, weight, number of fruits, and girth measurement.

The study applied a descriptive and experimental research design to assess and compare conventional and reconstructed aquaponic methods for reproducing tomatoes. The researchers created an observation checklist to determine the significant factors of the study. The reconstructed aquaponics system's higher growth yield results in a much more nourished crop than the traditional aquaponics system.

It is superior in its number of fruits, height, weight, and girth measurement. Moreover, the reconstructed aquaponics system is proven to eliminate all the hindrances present in the traditional aquaponics system, which are overcrowding of fish, algae growth, pest problems, contaminated water, and dead fish.

Aquaponics revolutionized the recirculation of the environment by cultivating plants and marine animals. It is an environmentally friendly way of naturally growing food without chemical fertilizers. The combination of aquaculture and hydroponics can be conducted by individuals and farmers almost waste-free because there is a significant reduction in its impacts on the environment, especially in soil. Moreover, aquaponics minimizes farmers' water consumption more than traditional plantations because water is recycled repeatedly through the aquaponics system.

The researchers used a quantitative method to determine the effects, impact, and significant difference between the reconstructed and traditional aquaponics systems in propagating tomatoes. The research study applied a descriptive experimental research design to assess and compare conventional and reconstructed aquaponic methods for reproducing tomatoes.

The researchers created an observation checklist to determine all the research study's significant factors. The experimentation, or experimental method, was used by the researchers to determine data using a scientific approach with two variables. The first variable is the independent variable that the experimenter manipulates. The second is the dependent variable that experimenters measure.

The researchers used a quantitative method to determine the effects, impact, and significant difference between the reconstructed and traditional aquaponics systems in propagating tomatoes. The research study applied a descriptive experimental research design to assess and compare conventional and reconstructed aquaponic methods for reproducing tomatoes. The researchers created an observation checklist to determine all the research study's significant factors.

The experimentation, or experimental method, was used by the researchers to determine data using a scientific approach with two variables. The first variable is the independent variable that the experimenter manipulates. The second is the dependent variable that experimenters measure. Traditional farming has been one of the things that are still being practiced in the Philippines. The traditional farming method involves the use of indigenous knowledge, land use, tools, resources, and fertilizers. This method was practiced in Tagaytay City. But due to the eruption of Taal Volcano in 2020 not only affected thousands of people residing near the area but also numerous crops and farms.

The Department of Agriculture stated that 15,000 hectares of agricultural land were damaged or affected, resulting in a loss of P3 billion in agriculture. Mendiola stated that leafy vegetables were the most damaged and affected in outdoor fields, and the best way to recover is to plant them all over again. But small farmers are unable to do it because of insolvency.

So, as Ref. (1) stated, growing edible plants should improve to combat or protect them from disasters so that they can sustain the world's growing population. Also, it should cover the fast-growing demand with minimal cost and consumption of natural resources.

According to Ref. (2), soilless cultivation was seen as a viable solution to the limited land areas and suitable to provide better opportunities for a sustainable food supply. Soil-less cultivation has become one of the fastest growing and second-generation crop production systems in the agricultural industry.

With the use of this method, it is possible to achieve the potential reuse of treated wastewater for food crop production, the governance of national water and land footprints, a significant reduction in the excessive application of agrochemicals, and the potential improvement of food crop quality and environmental sustainability (2).

The purpose of an aquaponic system is to enhance productivity while reducing nutrient inputs and water use. Because water is regularly recycled throughout the system and does not need to be refilled with new, clean water, plants operate as filters for the water, reducing the total consumption of water throughout the growing season.

Fish waste from the rearing tank provides adequate amounts of essential ammonia, nitrate, nitrite, phosphorus, potassium, and micronutrients, as well as some secondary nutrients for the healthy growth of hydroponic plants, so aquaponics does not require the addition of synthetic, chemical fertilizer.

In the combined system of aquaculture and hydroponics, two products are produced simultaneously and equally when the aquaponics system is optimally balanced. Another significant advantage is the produced synergetic effects, which significantly increased crop production in plants such as leafy crops such as lettuce over traditional plantation (3), decreased energy use (4), and had a lower environmental impact compared to other types of system production (5).

In aquaponics, resources can be allocated by the combination of plants and fish. One of the major environmental problems in terms of fish production consists of fish feeding and wastewater. It is largely independent of location. The most significant environmental products of an aquaponics system are often fossil fuels in the form of heating or transportation. Hence, it all depends on the cradle and distance of the consumer (6). The aquaponics system is designed as a DAPS four-loop system (7).

The first option in an aquaponics system is to avoid allocation by making use of a subdivision to expand the systems investigated (8). In conclusion, in this DAPS four-loop paper system, expansion was used. System expansion is frequently used in complex systems with co-products like aquaponics systems, as is the case in modern greenhouse horticulture and aquaculture (9).

In aquaponics systems, consequential life cycle assessment (CLCA) is increasingly used as a favorite method (10). Background data were included in most capital goods. However, infrastructural processes were excluded from the background data. The functional units consisted of 0.5 kg of packed tomatoes and 1 bag of sliced lettuce (150 g), which was commonly known as the gate. In conclusion, the cradle-to-gate principle was not used in the complete life cycle, including waste management, when it was conducted.

The aquaponics system is quite complex because it deals with three different concepts at once: fish, plants, and microorganisms. Failure to manage the aquaponics system's unique water quality parameter, particularly pH stabilization, may have a negative impact on the entire system, resulting in the mass killing of fish, plants, and beneficial microbes.

In simpler terms, the pH requirement for most of the plant species ranges from 6 to 6.5 to enhance the nutrient uptake of the crops. However, marine animals, specifically fish, need a pH range of 7–9 to show the best growth performance (11). The nitrifying bacteria require a high pH level (> 7).

In general, three types of bacteria play a critical role in the aquaponics system's nitrification process, and their optimal pH levels range from 7.5 (12), 7.0–7.5 (13), and 8.0–8.3 [K] for Nitrobacter, Nitrosomonas, and Nitrospira, respectively. In conclusion, the ideal pH range applicable for this whole aquaponics system is 6.0–8.0.

Urban farming is one of the most important solutions to global food insecurity, yet it is limited by several factors. Due to the scarcity inside urban areas, adoption of this strategy is difficult. In order to address this problem, hydroponic farming is an excellent technique for preserving both water and space. Because there are more growth mediums in hydroponics, it is more difficult. Plant development can be influenced by a variety of circumstances.

Urban hydroponic farming requires systematic monitoring of parameters, which can be addressed by building a hydroponic tower prototype with an automated monitoring system. The parameters include plant length, leaf height, fresh weight, water temperature, ambient temperature, relative humidity, pH level, water level, and total dissolved solids.

Related to aquaponics, hydroponics is the other way to address food security, especially in the Philippines. Hydroponic indoor farming can sustain a level of food security in the community. Lettuce is one of the vegetables that can be grown hydroponically, or simply in water. Considering the time, lettuce became more productive and green in just 27 days, owing to the long, healthy roots. The hydroponic tower was a success in terms of plant growth and time required to grow the plants in a span of 27 days.

The hydroponic tower gives enough space for plant growth and the allocation of water because the water valves are oriented upward and downward, which indicates the only motion available for the water is in the direction, which is up for one valve and down for the other valve.

Data gathering procedure

The research study executed the experiment by first drilling the drum cap, which will serve as the holder of the bendable polyvinyl chloride (PVC) pipe at the bottom of the aquaponics system. Second, use a saw to cut off the lid and make a hole for holding the bendable PVC. Third, place the drum cap and bendable PVC pipe until it reaches the bottom of the drum (the cap should fit the drum until it comes to the bottom surface). Fourth, cut a hole in the Styrofoam (the Styrofoam will serve as the grow bed in the aquaponics system) to fit the bendable PVC pipe. Fifth is the placement of the air pump in the traditional and reconstructed aquaponics systems—lastly, the addition of fish.

The materials used in the traditional aquaponics system consist of the drum, grow bed, grow medium, water pump, air pump, bendable PVC pipe, unsealed siphon, tomato seeds, and Styrofoam. However, the materials used in the reconstructed aquaponics system consist of the drum, grow bed, grow media, water pump, air pump, bendable PVC pipe, unseals, siphons, and tomato seeds, as well as Styrofoam, directional control (DC) valves, pressure gauges, and small diameter pipes.

The researchers used descriptive statistics from the data gathered from the observation. It will determine the effect of the reconstructed aquaponic system on the new combination of plant and fish, the tomato seeds, and the betta fish. t-tests will determine the significant difference between traditional and reconstructed aquaponics systems.

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\left(s^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)\right)}}$$

wherein: t = t-value x1 × 2 mean s^2 = standard error $n_1 n_2$ = number of observations.

Result and discussion

The effects of the reconstructed aquaponics system in propagating tomatoes in terms of height, weight, number of fruits, and girth measurement

Table 1 shows the data from plants 1 to 6 in the reconstructed aquaponic system from week 1 of their observation of growth in height, weight, number of fruits, and girth measurements. Plant 1 is already 1.5 cm in height, 0.002 g in weight, 0 in number of fruits, and 0.073 cm in girth measurement. Plant 2 is 1 cm in height, 0.001 g in weight, 0 in number of fruits, and 0.08 cm in girth measurement. Plant 3 is 1 cm in height, 0.003 g in weight, 0 in number of fruits, and 0.075 cm in girth measurement. Plant 4 is 1.5 cm in height, 0.002 g in weight, 0 in number of fruits, and 0.075 cm in girth measurement. Plant 5 is the tallest among the plants, and it is 2 cm in height, 0.004 g in weight, 0 in the number of fruits, and 0.085 cm in girth measurements. Plant 6 is 1 cm in height, 0.002 g in weight, 0 in number of fruits, and 0.08 cm in girth measurement.

Table 2 shows the data from plants 1 to 6 in the reconstructed aquaponic system now in week 2 of their observation of growth in height, weight, number of fruits, and girth measurements. Plant 1 is already 3.1 cm in height, 0.012 g in weight, 2 in the number of fruits, and 0.25 cm in girth measurement. Plant 2 is 2 cm in height, 0.005 g

TABLE 1 | Week 1 observation using a reconstructed aquaponic system.

	Heights (cm)	Weights (g)	Number of Fruits	Girth Measurements (cm)
Plant 1	1.5	0.002	0	0.073
Plant 2	1	0.001	0	0.08
Plant 3	1	0.003	0	0.075
Plant 4	1.5	0.002	0	0.085
Plant 5	2	0.004	0	0.07
Plant 6	1	0.002	0	0.08

TABLE 2 | Week 2 observation using a reconstructed aquapon system.

	Heights (cm)	Weights (g)	Number of Fruits	Girth Measurements (cm)
Plant 1	3.1	0.012	2	0.25
Plant 2	2	0.005	3	0.10
Plant 3	2.3	0.008	1	0.15
Plant 4	3.9	0.021	2	0.9
Plant 5	3	0.009	2	0.6
Plant 6	2.3	0.008	1	0.95

in weight, 3 in the number of fruits, and 0.10 cm in girth measurement. Plant 3 is 2.3 cm in height, 0.008 g in weight, 1 in the number of fruits, and 0.15 cm in girth measurement. Plant 4 is the tallest among the plants now in week 2; it is 3.9 cm in height, 0.021 g in weight, 2 in the number of fruits, and 0.9 cm in girth measurement. Plant 5 is 3 cm in height, 0.009 g in weight, 2 in the number of fruits, and 0.6 cm in girth measurements. Plant 6 is 2.3 cm in height, 0.008 g in weight, 1 in number of fruits, and 0.95 cm in girth measurement.

Table 3 shows the data from plants 1 to 6 in the reconstructed aquaponic system now in week 3 of their observation of growth in height, weight, number of fruits, and girth measurements. Plant 1 is already 5.25 cm in size and the largest among the plants in week 3, with 0.035 g in weight, 2 in the number of fruits, and 0.90 cm in girth measurement. Plant 2 is 3.50 cm in height, 0.014 g in weight, 3 in the number of fruits, and 0.65 cm in girth measurement. Plant 3 is 2.5 cm in height, 0.09 g in weight, 4 in the number of fruits, and 0.30 cm in girth measurement. Plant 4 is the tallest among the plants in week 4, and it is 5.15 cm in height, 0.44 g in weight, 3 in the number of fruits, and 1 cm in girth measurement. Plant 5 measures 4.56 cm tall, 0.37 g in weight, 2 in several fruits, and 1.20 cm in girth. Plant 6 is 4.20 cm in height, 0.18 g in weight, 1 in the number of fruits, and 0.15 cm in girth measurement.

Table 4 shows the data from plants 1 to 6 in the reconstructed aquaponic system now in week 4 of their observation of growth in height, weight, number of fruits, and girth measurements. Plant 1 is already 7.4 cm in height, 0.50 g in weight, 4 in several fruits, and 2.90 cm in girth measurement. Plant 2 is 5 cm in height, 0.25 g in weight, 5 in the number of fruits, and 2.80 cm in girth measurement. Plant 3 is 5.5 cm in height, 0.20 g in weight, 5 in number of fruits, and 2.5 cm in girth measurement. Plant 4 is the tallest among the plants in week 4, and it is 7.5 cm in height, 0.70 g in weight, 6 in the number of fruits, and 3.10 cm in girth measurement. Plant 5 is 7 cm in height, 0.65 g in weight, 7 in the number of fruits, and 3.30 cm in girth measurements. Plant 6 is 6.5 cm in height, 0.30 g in weight, 5 in the number of fruits, and 2.70 cm in girth measurement.

TABLE 3 | Week 3 observation system using reconstructed Aquapon.

	Heights (cm)	Weights (g)	Number of Fruits	Girth Measurements (cm)	
Plant 1	5.25	0.035	2	0.90	
Plant 2	3.50	0.014	3	0.65	
Plant 3	2.5	0.09	4	0.30	
Plant 4	5.15	0.44		1	
Plant 5	4.56	0.37	3	1.20	
Plant 6	4.20	0.18	2	1	0.15

TABLE 4 | Week 4 observation using a reconstructed aquaponic system.

	Heights (cm)	Weights (g)	Number of Fruits	Girth Measurements (cm)
Plant 1	7.4	0.5	4	2.90
Plant 2	5	0.25	5	2.80
Plant 3	5.5	0.2	5	2.5
Plant 4	7.5	0.7	6	3.10
Plant 5	7	0.65	7	3.30
Plant 6	6.5	0.3	5	2.70

The effects of the traditional aquaponics system in propagating tomatoes in terms of height, weight, number of fruits, and girth measurement

Table 5 shows the data from plants 1 to 6 in traditional aquaponics now in week 1 of their observation of growth in height, weight, number of fruits, and girth measurements. Plant 1 is already 1 cm in height, 0.004 g in weight, 0 in the number of fruits, and 0.1 cm in girth measurement. Plant 2 is 0.5 cm in height, 0.002 g in weight, 0 in number of fruits, and 0.08 cm in girth measurement. Plant 3 is 0.5 cm in height, 0.004 g in weight, 0 in number of fruits, and 0.06 cm in girth measurement. Plant 4 is 1 cm in height, 0.005 g in weight, 0 in number of fruits, and 0.09 cm in girth measurement. Plant 5 is 1.5 cm in height, 0.007 g in weight, 0 in number of fruits, and 0.8 cm in girth measurements. Plant 6 is 0.25 cm in height, 0.001 g in weight, 0 in number of fruits, and 0.08 cm in girth measurement.

TABLE 5 | Week 1 observation using a traditional aquaponic system.

	Heights (cm)	Weights (g)	Number of Fruits	Girth Measurements (cm)
Plant 1	1	0.004	0	0.1
Plant 2	0.5	0.002	0	0.08
Plant 3	0.5	0.004	0	0.06
Plant 4	1	0.005	0	0.09
Plant 5	1.5	0.007	0	0.08
Plant 6	0.25	0.001	0	0.08

TABLE 6 | Week 2 observation using a traditional aquaponic system.

	Heights (cm)	Weights (g)	Number of Fruits	Girth Measurements (cm)
Plant 1	2	0.009	1	0.3
Plant 2	1	0.003	0	0.09
Plant 3	1.5	0.007	0	0.07
Plant 4	3	0.012	1	0.2
Plant 5	2.5	0.014	1	0.3
Plant 6	1.5	0.007	0	0.1

TABLE 7 | Week 3 observation using a traditional aquaponic system.

	Heights (cm)	Weights (g)	Number of Fruits	Girth Measurements (cm)
Plant 1	5	0.021	2	0.5
Plant 2	3	0.009	1	0.3
Plant 3	3.5	0.015	1	0.1
Plant 4	5	0.018	2	0.5
Plant 5	5.5	0.02	1	0.7
Plant 6	4	0.015	2	0.3

TABLE 8 | Week 4 observation using a traditional aquaponic system.

	Heights (cm)	Weights (g)	Number of Fruits	Girth Measurements (cm)
Plant 1	7	0.03	5	2.5
Plant 2	5	0.015	5	2.3
Plant 3	5.5	0.025	4	2
Plant 4	7	0.03	3	2.5
Plant 5	7.5	0.031	3	2.7
Plant 6	6	0.02	6	2.3

Table 6 shows the data from plants 1 to 6 in traditional aquaponics now in week 2 of their observation of growth in height, weight, number of fruits, and girth measurements. Plant 1 is 2 cm in height, 0.009 g in weight, 1 in number of fruits, and 0.3 cm in girth measurement. Plant 2 is 1 cm in height, 0.003 g in weight, 0 in number of fruits, and 0.09 cm in girth measurement. Plant 3 is 1.5 cm in height, 0.007 g in weight, 0 in number of fruits, and 0.07 cm in girth measurement. Plant 4 is 3 cm in height, 0.012 g in weight, 1 in number of fruits, and 0.2 cm in girth measurement. Plant 5 is 2.5 cm in height, 0.014 g in weight, 1 in number of fruits, and 0.3 cm in girth measurements. Plant 6 is 1.5 cm in height, 0.007 g in weight, 0 in number of fruits, and 0.1 cm in girth measurement.

Table 7 shows the data from plants 1 to 6 in traditional aquaponics now in week 3 of their observation of growth in height, weight, number of fruits, and girth measurements. Plant 1 is already 5 cm in height, 0.021 g in weight, 2 in several fruits, and 0.5 cm in girth measurement. Plant 2 is 3 cm in height, 0.009 g in weight, 1 in the number of fruits, and 0.3 cm in girth measurement. Plant 3 is 3.5 cm in height, 0.015 g in weight, 1 in the number of fruits, and 0.1 cm in girth measurement. Plant 4 is 5 cm in height, 0.018 g in weight, 2 in the number of fruits, and 0.5 cm in girth measurement. Plant 5 is the tallest among the plants, and it is 5.5 cm in height, 0.020 g in weight, 1 in the number of fruits, and 0.7 cm in girth measurements. Plant 6 is 4 cm in height, 0.015 g in weight, 2 in the number of fruits, and 0.3 cm in girth measurement.

Table 8 shows the data from plants 1 to 6 in traditional aquaponics now in week 4 of their observation of growth in height, weight, number of fruits, and girth measurements. Plant 1 is already 7 cm in height, 0.030 g in weight, 5 in some fruits, and 2.5 cm in girth measurement. Plant 2 is 5 cm in height, 0.015 g in weight, 5 in the number of fruits, and 2.3 cm in girth measurement. Plant 3 is 5.5 cm in height, 0.025 g in weight, 4 in the number of fruits, and 2 cm in girth measurement. Plant 4 is 7 cm in height, 0.030 g in weight, 3 in the number of fruits, and 2.5 cm in girth measurement. Plant 5 is the tallest among the plants, and it is 7.5 cm in height, 0.031 g in weight, 3 in several fruits, and 2.7 cm in girth measurements. Plant 6 is 6 cm in height, 0.020 g in weight, 6 in the number of fruits, and 2.3 cm in girth measurement.

The significant difference between traditional aquaponics and reconstructed aquaponics systems for propagating tomatoes

Table 9 shows the total mean and standard deviation of the reconstructed aquaponic system in weeks 1–4. The result indicates that Week 1 has a mean score of 1.333 and a standard deviation of 0.408 in height, a mean score of 0.002 and a standard deviation of 0.001 in weight, a mean score and standard deviation of 0 in several fruits, and a mean

TABLE 9 | Mean and Standard Deviation from Week 1 to 4 in Reconstructed Aquaponics Systems.

Variables	Mean Week 1	Mean Week 2	Mean Week 3	Mean Week 4
Height	1.333	2.767	4.193	6.4
Weight	0.002	0.011	0.165	0.55
Number of Fruits	0	1.833	2.5	5.333
Girth Measurement	0.078	0.492	0.7	2.85
	Standard Deviation Week	**Standard Deviation Week**	**Standard Deviation Week**	**Standard Deviation Week**
Variables	1	2	3	4
Height	0.408	0.703	1.05	1.049
Weight	0.001	0.002	0.18	0.218
Number of Fruits	0	0.753	1.049	1.032
Girth Measurement	0.006	0.379	0.411	0.286

TABLE 10 | Mean and standard deviation from weeks 1 to 4 in traditional aquaponics Systems.

Variables	Mean Week 1	Mean Week 2	Mean Week 3	Mean Week 4
Height	0.792	2.083	4.6	6.333
Weight	0.004	0.01	0.015	0.023
Number of Fruits	0	0.5	1.5	4.333
Girth Measurement	0.067	0.177	0.4	2.383
	Standard Deviation Week	**Standard Deviation Week**	**Standard Deviation Week**	**Standard Deviation Week**
Variables	1	2	3	4
Height	0.459	0.736	0.822	0.983
Weight	0.002	0.004	0.006	0.011
Number of Fruits	0	0.548	0.548	1.211
Girth Measurement	0.029	0.106	0.21	0.24

score of 0.078 and a standard deviation of 0.006 in girth measurement. Week 2 had a mean height score of 2.767 and a standard deviation of 0.703, a mean eight score of 0.011 and a standard deviation of 0.002, a mean number of fruits score of 1.833 and a standard deviation of 0.753, and a mean girth measurement score of 0.492 and a standard deviation of 0.379.

Week 3's mean height is 4.193, and the standard deviation is 1.050, while the mean weight is 0.165, the standard deviation is 0.180, and the mean number of fruits is 2.5. Week 4 includes a mean height score of 6.4 and a standard deviation of 1.049; a mean weight score of 0.55 and a standard deviation of 0.218; a mean number of fruits score of 5.333 and a standard deviation of 1.032; and a mean girth measurement score of 2.85 and a standard deviation of 0.286.

The total mean and standard deviation of the observations from weeks 1 to 4 in the traditional aquaponic system are shown in **Table 10**. The result indicates that Week 1 has a mean score of 0.792 and a standard deviation of 0.459 in height, a mean score of 0.004 and a standard deviation of 0.002 in weight, a mean score and standard deviation of 0 in the number of fruits, and a mean score of 0.067 and a standard deviation of 0.029 in girth measurement. Week 2 contains a mean height score of 2.083 and a standard deviation of0.736, a mean weight score of 0.010and a standard deviation of 0.004, a mean score of 0.5 and a standard deviation of 0.548 in the number of fruits score, and a mean girth measurement score of 0.177 and a standard deviation of 0.106.

In Week 3, the mean height was 4.6 with a standard deviation of 0.822, the mean weight was 0.015 with a standard deviation of 0.006, the mean number of fruits was 1.5 with a standard deviation of 0.548, and the mean girth measurement was 0.4 with a standard deviation of 0.210. Week 4's mean height is 6.333 with a standard deviation of 0.983, the mean weight is 0.023 with a standard deviation of 0.011, the mean number of fruits is 4.333 with a standard deviation of 1.211, and the mean girth is 2.383 with a standard deviation of 0.240.

In **Table 11**, the two-tailed comparison between traditional and reconstructed aquaponic systems is not significant since the p-value of its height is greater than 0.05, with the t-values of −2.16 in Week 1 and −1.64 in Week 2, 0.52 in Week 3, and −0.11 applied for the calculating t-test. The two-tailed comparison of traditional and reconstructed aquaponic systems is not significant since its weight has a p-value of more than 0.05, with the t-values of 1.53 in Week 1, 0.22 in Week 2, and 2.13 in Week 3. However, with a p-value of 0.0009, the two-tailed test was significant in Week 4.

However, it does not correspond to the t-value and p-value of tomatoes' number of fruits from their first week because they just recently began to grow, resulting in it being not significant. However, when a t-value of 4 calculates the

TABLE 11 | The significant difference between traditional a reconstructed aquaponic systems based on weekly observation height, weight, number of fruits, and girth measurement.

Heights	t-values	p-values	Descriptions
Week 1	−2.16	0.05	Not Significant
Week 2	−1.64	0.13	Not Significant
Week 3	0.52	0.62	Not Significant
Week 4	−0.11	0.91	Not Significant
Weight	**t-values**	**p-values**	**Descriptions**
Week 1	1.53	0.15	Not Significant
Week 2	0.22	0.82	Not Significant
Week 3	2.13	0.05	Not Significant
Week 4	4.85	0.0009	Significant
Number of Fruits	**t-values**	**p-values**	**Descriptions**
Week 1	0	0	Not Significant
Week 2	4	0.01	Significant
Week 3	1.73	0.14	Not Significant
Week 4	1.16	0.29	Not Significant
Girth Measurement	**t-values**	**p-values**	**Descriptions**
Week 1	1.86	0.67	Not Significant
Week 2	1.96	0.07	Not Significant
Week 3	2.97	0.03	Significant
Week 4	3.28	0.008	Significant

t-test in Week 2, the *p*-value is 0.01, which shows that it is significant because it is less than 0.05. Meanwhile, the two-tailed comparison between the traditional and reconstructed aquaponic systems is insignificant in Weeks 3 and 4, with the *t*-values of 1.73 and 1.16, respectively.

Table 11 has a value of 1.86 in Week 1 and 1.96 in Week 2 used to calculate the *t*-test, resulting in its two-tailed comparison between traditional and reconstructed aquaponic systems. The p-value of its height is less insignificant than 0.05. With a *t*-value of 2.97 in Week 3 and 3.28 in Week 4, the *p*-value was less than 0.05, indicating it to be significant.

Conclusion and recommendation

Planting tomatoes and fish is possible and practical when using traditional and reconstructed aquaponic systems. The study showed that the plants grow much faster and can produce various fruits in a short period of time. The research study revealed the significance of aquaponics because it will assist farmers in producing a more nourished crop faster than traditional methods.

Additionally, it provided a more convenient aquaponics system than usual. The research study revealed the significance of aquaponics, which will allow farmers to have a more nourished crop faster than traditional methods.

The reconstructed aquaponics system's higher growth yield results in a much more nourished crop than the traditional aquaponics system. It is superior in its number of fruits, height, weight, and girth measurement. Moreover, the reconstructed aquaponics system is proven to eliminate all the hindrances present in the traditional aquaponics system, which are overcrowding of fish, algae growth, pest problems, contaminated water, and dead fish.

Within the following weeks of observations, the reconstructed aquaponics system, in terms of height, weight, several fruits, and girth measurements, has shown an undeniably better result than the traditional aquaponic system. The size, weight, number of fruits, and girth measurement of the reconstructed aquaponics system were superior to the traditional. The height is taller, the weight is heavier, the production of fruits is merrier, and the girth measurement is larger.

The traditional aquaponic system was created as a result of the usual effects of growth in aquaponic systems. The observation yielded a height of 7.5 cm, the longest; a weight of 0.031, the heaviest; six fruits; and a thickness of 2.7 cm in four weeks and hence proved the following result to be inferior to the reconstructed aquaponic system: When traditional and reconstructed aquaponic systems are compared, the reconstruction has the most beneficial effects. It is based on the test, using significant and not significant.

As described in the six planted tomatoes, there are differences. The result of height in weeks 1–4 is not significant. The impact of weight is not substantial in weeks 1–3 and effective in week 4; the result in the number of fruits is not marked in weeks 1, 3, and 4, and significant in week 2; the result in girth measurement is not substantial in weeks 1–2 and effective in weeks 3–4. These results mean that the significant description implies that the two aquaponics do not have a difference, and the not substantial difference means that the two aquaponics do have a difference.

Aquaponics is the future of agriculture because crop production is 10 times higher than on traditional plantations; it reduces water consumption and minimizes energy consumption. Additionally, crops produced in aquaponics are resilient to floods and droughts. Through this study, the researchers learned that the combination of plants and fish is endless and possible, especially when the researchers planted tomatoes alongside the fish using a traditional and reconstructed aquaponic system.

Further research is also needed. In addition, the researchers suggest using salt water to see if it can help the plants grow and the fish survive. Moreover, the researchers encountered a hindrance in using the air pump because its pressure is so high. So, the researchers suggest acquiring a more costly air pump to attain better air pressure in the aquaponics system.

Appendix

The statement of the problem addresses the research problems and provides a definitive solution to them. This study compares the traditional aquaponics system with the reconstructed aquaponics system for propagating tomatoes. This research seeks to answer the following questions:

1. What are the effects of the reconstructed aquaponics system on propagating tomatoes?
   a. Height
   b. Weight
   c. Number of fruits
   d. Girth measurement
2. What are the effects of the traditional aquaponics system on propagating tomatoes?
   a. Height
   b. Weight
   c. Number of fruits
   d. Girth measurement
3. What is the significant difference between traditional aquaponics and reconstructed aquaponics systems propagating tomatoes?

Place of Observation: Los Banos, Laguna	Date: 05/01/22	
	Yes	No
1. The crop planted is tomatoes.	__/__	__
2. All needed tools are available.	__/__	__
3. Work animals are fish.	__/__	__
4. The lava ring is well prepared.	__/__	__
5. The fertilizer used is fish's stool.	__/__	__
6. Electrical construction is properly created.	__/__	__ __
7. Contamination is controlled.	__/__	__
8. Improved aquaponic practices are not evident.	__/__	__ __
9. Water distribution is equal.	__/__	__
10. The fish and plant growth are increasing.	__/__	__

Observation checklist

Name of observation:

A comparison of traditional aquaponics systems and reconstructed aquaponics systems for tomato propagation.

Factors to be observed

1. Fish Growth
2. Plant Growth
3. Water Parameters
4. Water Distribution
5. Contamination
6. Electrical Construction

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