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***Original Research Article***

# ASSESSMENT OF GROWTH AND SURVIVAL RATE OF *CYPRINUS CARPIO* USING AQUAPONICS TECHNOLOGY

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**Abstract:** *Aquaponics is an integrated system that combines hydroponics and aquaculture, enabling the cultivation of plants and fish together. It is increasingly popular in non-traditional agricultural settings such as warehouses and marginal soils, as it allows for local food production without synthetic pesticides, chemical fertilizers, or antibiotics.* ***Objective:*** *The study aimed to utilize fish waste and surplus feed as fertilizers for plant growth, producing multiple food products within a single production unit while optimizing space usage.* ***Methods:*** *A 90-day experimental study was conducted from March to May 2022 at the Fish Biodiversity Hatchery Chashma in Mianwali, Punjab, Pakistan. The study involved control and aquaponic treatments, both managed in outdoor tanks. Fifty fingerlings of common carp (Cyprinus carpio) were stocked in each tank. The fish were fed a diet containing 30% crude protein twice daily. The study compared the growth of fish and plants (mint, spinach, tomato) in both treatments. Critical parameters measured included feed conversion ratio (FCR), specific growth rate, and water quality. Statistical analyses were performed using a significance level of* $p \leq 0.05$. ***Results:*** *The surplus feed in the aquaponic system facilitated better growth for Cyprinus carpio and plants. The aquaponic system demonstrated a significantly higher growth rate than the control (*$p \leq 0.05$*). The average FCR was 1.86 in the aquaponic system and 2.22 in the control, indicating more efficient feed utilization in the aquaponic setup. Water quality parameters showed no significant differences between the two treatments.* ***Conclusion:*** *The aquaponic system proved to be more effective than the control in improving the growth performance and survival rate of fish and supporting plant growth. This system represents a viable and sustainable alternative for food production, maximizing space utilization and resource efficiency.*

**Keywords:** Aquaponic, Aquaculture, Stocking of Fish, Crude Protein, *Cyprinus Carpio*

## Introduction

According to the FAO (2020), more than 800 million people worldwide suffer from chronic malnutrition, and the world population is anticipated to reach 9.6billion people by 2050. Worldwide, aquaculture has yet to face severe challenges of effluents discharged from organic matter, toxic metabolites, nitrogenous compounds, the highest amount of chemicals from industries, and detergents from domestic wastages in the aquatic environment (1). Furthermore, aquaculture is constantly dealing with the shortage of land, water, ingredients in food and their price volatility, the introduction of exotic species, dispersal of pathogens, development of antibiotic resistance genes, and the competition for overfishing to obtain fish meal and fish oil which are the other serious problems (2). Thus, to overcome these enormous challenges, numerous strategies are required. In this regard, the aquaponic culture in the aquaculture system is also the best technology to solve some of the above global challenges and revolutionize aquaculture. This technology has a massive potential to become the future farming method that provides year-roundproduction of high-quality fish and vegetables in a sustainable way and at a relatively low cost (3). Food security, population growth, water scarcity, soil degradation, and climate change are just a few of the significantdifficulties that the world is dealing with when it comes to order to meet the demands of a fast-growing human population (4). In this adverse situation,aquaculture significantly reduces hunger, promotes health, supports the livelihoods of hundreds of millions, eliminates poverty, and creates millions of jobs and economic opportunities (5). The term aquaponic was invented in the 19th century but has been practiced since ancient times.In the late 1970s and early 1980s, Bangladeshpioneered the contemporary aquaponics system concept (6). It was created in response to the demand for aquaculture waste nutrient recycling. Now, it is one of the twenty-first century's most efficient and environmentally sustainable farming methods (7). Considerably, itis gaining popularity worldwide as a bio-integrated food production system, mainly forsmall-scale production systems. It produces fish and plants in a complementary system (8). It is a new technology that could fulfill our dietary needs as well. Aquaponics is a growing ecosystem incorporating fish culture and genuine hydroponic plant growth (9). This circulatory aquaculture system is used for non-renewable resources. It is an evolutionary technique to produce food from dissolved nutrients by using biological filtration and recirculation of the water, and it is grown quickly in different varieties of healthy plants (10). It is the most economically beneficial aquaculture system because of the saving cost of water treatment and formulated feed of fish. This technique depends upon the natural food growing method. It eliminates the need to discharge any water or filtrate, as well as the requirement to add chemical fertilizers to the environment (11). Compared to the traditional aquaculture system in which toxic metabolites, feedstock residues that lead to eutrophication in water bodies, and very high-water volume are used, closed recirculation is used to minimize the above disadvantages aquaculture systems have been developed (12). The basic premise of aquaponics is to clean the water from the wastes producedby the fish and fish feeds, generating one continuous cycle. This system is based entirelyon the nitrogen cycle. This technique is used to remove unconsumed feed of fish and undesirable wastes produced by aquatic fish and transform insoluble material into a soluble form by the action of microbes (13). In these integrated fish farming systems, cultivated plants absorb the nutrients excreted by fish or the breakdown of organic and inorganic by-product materials and clean water (14). In this system, plants improve water quality through biological filters by using effluent, eliminating toxins (nitrogen and phosphorous) produced in fish farming tanks, and creating a healthy environment. Leafy plants (fruity) with little or no root structures tend to grow well in an aquaponic culture system compared to rooted vegetables (15). The current study aimed to use the wastes of fish and surplus feed as fertilizer for the growth ofplants and to produce two or more food products from one production unit by the use of less space.

## Methodology

The experiment was conducted at the Fish Biodiversity Hatchery Chashma, District Mianwali, Punjab, Pakistan.
Two systems were developed for treatment: one was a control, and the second was the aquaponic system. After acclimatization, the fish was transferred into the power and aquaponic fish tanks, respectively. Both systems were comprised of fish-holding cemented tank with a diameter (300 cm), fifty fingerlings of *C. carpio* fish (1 inch), electric water pump (50W), 100W Channel Blower (LP-100, AIR PUMP, China), PVC pipe (4cm) diameter, small pebbles or stones with a diameter of 8-10 cm, hydroponic tank with 12'x12' diameter and different plants (tomato, mint and spinach).
Fifty (1-inch) *C.carpio* fingerlings collected from Chashma Fish Biodiversity Hatchery were used as experimental fish. Twenty percent of the fish's body weight was fed a feed containing 30 percent protein twice a day in both the aquaponic and control tanks. The system was checked at least two times a day. Special efforts were made to observe the tank and check for signs of unconventional fish behavior and any other problems.
Water spinach, tomato, and mint plants were sown in the hydroponic tank. The waste material produced by fish and supplementary feed in the tank was used as fertilizers for the plants. The denitrifying bacteria that convert the wastes into nutrients for the plants and make the water clean for fish before returning to the tank again were used. Only fish tank water was used for watering the plants. No fertilizers were used in the vegetable beds.
The water quality parameters, consisting of temperature (°C), pH, and dissolved oxygen (DO), were monitored weekly in both tanks using scientific instruments. A temperature detector measured temperature. YSI DO200 and YSI pH100 checked dissolved oxygen (DO) and pH. At the end of the experiment, weight gain (g), length gain (cm), food conversionratio (FCR), survival rate (%), mortality rate (%), and specific growth rate (SGR) were calculated.
Collected evaluation and growth performance data were analyzed through an independent t-test using SAS software (version 9.1.). The level of significance wasconsidered as $p \leq 0.05$.

## Results

The mean values of water quality parameters under the influence of the aquaponic system and control tank are presented in (Table 1). The average mean water temperature values in control and aquaponic tanks were 27.59 ± 0.28 and 27.14 ± 0.33, respectively. There was no significant difference in control and aquaponic tanks ($p \leq 0.05$). The mean average values of pH in control and aquaponic tanks were 7.97 ± 0.07 and 7.18 ± 0.09, respectively. There was no significant difference in control and aquaponic tanks ($p \leq 0.05$). The average DO values in the control and aquaponic tank were 6.45 ± 0.08 and 6.54 ± 0.09. In both tanks, no significant difference was observed.
The growth performance of *Cyprinus carpio* in aquaponic and control groups is given in (Table 2). The mean initial length of fish 2.54 ± 0.000 was observed, which was the same in both control and aquaponic tanks. The mean final length of fish was 67.11 ± 1.68 in the control tank and 85.196 ± 2.38 in the aquaponic treatment tank. The aquaponic treatment tank has shown more significant results than the control ($p \leq 0.01$). The mean initial weight gain (g) in control and aquaponic tanks were 4.95 ± 0.29 and 6.45 ± 0.059, respectively. The mean final weight gain (g) in control and aquaponic tanks were 98.41 ± 0.29 and 148.10 ± 0.059, respectively. The aquaponic tank showed more significant results than the control tank. From the current study, the Average values of FCR in control and aquaponic tanks were 2.22 ± 0.026 and 1.86 ± 0.056, respectively. No significant difference was measured in the starting weeks of the experiment. In the final weeks of the experiment, the aquaponic group showed less significant results as compared to the control tank ($p \leq 0.0001$). The average values of the specific growth of fishes were 2.46 ± 0.058 and 2.18 ± 0.043 in aquaponic and control tanks, respectively.
Fish mortality was higher in the control tank than in the biofloc system (Table 3). Results showed that 85.95 ± 1.16 was the average survival rate of fish in an aquaponic treatment. On the other hand, low average survival was observed at 67.57 ± 1.67 in the control treatment. It has been noticed that the mortality and survival of fishin control and aquaponic tanks were significantly different. The mortality of fish wasseen at the starting period, which may be due to a fish's lack of immediate tolerance capacity to modify the environment of the water in the tank. Therefore, the highest mortality, 14%, and 22% was observed in both treatments during the 1st week of stocking in the controltank due to anxiety and different ecosystems. However, the mortality rates in both treatments increased in the second week, 17.5% and 23%, respectively. The highest mortality occurred in the control tank, where 23 fishout of 50 died in 12

weeks. A significant difference was found in both tanks ($p \leq 0.0001$). The average fish mortality (%) was 14.05 ± 1.06 in the aquaponic and 32.08 ± 1.17 in the control tank.
Plant mortality was observed in aquaponic and control tanks (Table 4). The survival and mortality of plants had a significant effect ($p$=0.0001). In the aquaponic tank, the highest growth in terms of percentage was observed in spinach which was 96.48%, followed by 90.01% and 82.52% in both tomato and mint, respectively. In the case of control, the highest survival rate in terms of percentage was observed in spinach, which was 76.51%, followed by the tomato and mint, which was 60.31% and 56.25%, respectively. In control and aquaponic tanks, there was no significant difference in the growth of plants.

**Table 1: Comparison of water quality parameters of *Cyprinus carpio* between aquaponic and control tank**

| Parameters | Aquaponic | Control | p-value |
|---|---|---|---|
| Temp°C | 27.14 ± 0.33 | 27.59 ± 0.28 | 0.0012 |
| pH | 7.18 ± 0.09 | 7.97 ± 0.07 | 0.0086 |
| DO (mg/l) | 6.54 ± 0.09 | 6.45 ± 0.08 | 0.0016 |

**Table 2: Comparison of growth performance traits of *Cyprinus carpio* between aquaponic and control tank**

| Parameters | Aquaponic | Control | p-value |
|---|---|---|---|
| Mean initial length (cm) | 2.54 ± 0.000 | 2.54 ± 0.000 | -- |
| Mean final length (cm) | 85.196 ± 2.38 | 67.11 ± 1.68 | 0.0001 |
| Mean initial weight (g) | 6.45 ± 0.059 | 4.95 ± 0.29 | 0.0049 |
| Mean final weight (g) | 148.10 ± 0.059 | 98.41 ± 0.29 | 0.0022 |
| Amount of dry feed kg | 85.95 ± 1.03 | 67.51 ± 1.21 | 0.0004 |
| FCR | 1.86 ± 0.056 | 2.22 ± 0.026 | 0.0031 |
| SGR | 2.46 ± 0.058 | 2.18 ± 0.043 | 0.0001 |

**Table 3: Comparison of survival and mortality rate of *Cyprinus carpio* between aquaponic and control tank**

| Parameters | Aquaponic | Control | p-value |
|---|---|---|---|
| Survivability % | 85.95 ± 1.16 | 67.57 ± 1.67 | 0.0004 |
| Mortality % | 14.05 ± 1.06 | 32.08 ± 1.17 | 0.0019 |

**Table 4: Comparison of growth of plants between aquaponic and control tank**

| Parameters | Aquaponic | Control | p-value |
|---|---|---|---|
| Mint (%) | 82.52± 0.11 | 56.25± 0.18 | 0.0043 |
| Spinach (%) | 96.48± 0.21 | 76.51± 0.13 | 0.0061 |
| Tomato (%) | 90.01± 0.16 | 60.31± 0.10 | 0.0029 |

**Discussion**

The present study demonstrated the valuable effects of fish waste and surplus feed on the growth performance of *C.carpio*. The water quality parameters are critical in an aquaponic system for sustaining health and productivity (16). The current study showed that the temperature was slightly more significant in the aquaponic tank as compared to the control. No significant difference ($p \leq 0.05$) was found in control and aquaponic tanks. According to Tyson *et al.* (2007), the ideal water temperature for fish culture ranged from 25°C to 35°C. The claim indicates that the water temperature in the current study was within the acceptable range. The findings suggested that the temperature during the study's observation period was still within the typical range for carp growth. Carp rearing was still tolerable when the standard carp raising temperature ranged from 26 to 27 °C. This study is in line with Effendi et al.'s (17) research findings, which found that fish grow best at temperatures between 25 and 32 °C. This study is correlated with the findings of Putra *et al.* (18).
The results of this study showed that the pH value was optimal but found to be within the normal range in the aquaponic tank compared to the control treatment every week, according to the work of Abdulkhader (19). The result of my study indicated a slightly different pH between both treatments. No significant difference ($p \leq 0.05$) was found. Higher pH values could predict algae growth in fish and hydroponic tanks. In contrast, lower pH levels could result from nitrification bacteria activity, which agrees with the results of Najim and Majeed (20) on pH ranges in aquaponic systems. This study is correlated with the work of Rahmatullah *et al. (21) and Makori et al.* (22).
In my study, the amount of dissolved oxygen in the water ranged from 4.0 to 5.2 mg/l, within the acceptable range for raising carp. This is in line with Shete *et al.* (23). No significant difference was found ($p \leq 0.05$). The concentration of dissolved oxygen in my study was 6.54 and 6.45 in aquaponic and control systems, respectively, which is productive and appropriate for fish culture. Similar findings were also reported (24, 25).
The growth performance (length and weight) in the aquaponics treatment was substantially superior to the control in my study, as in Knaus and Palm's (26) study. Growth performance (body length and weight) was significantly greater in the current study ($p \leq 0.05$) in an aquaponic as compared to control. The findings revealed that *C.carpio's* growth differed significantly ($p \leq 0.05$) between control and aquaponic systems. The current study detected the highest mortality rate during an experiment due to stress and a new environment. The current study observed lowered average mortality (14.81 ± 1.06 and 32.08 ± 1.17) both in an aquaponic and control system, respectively, and increased survival rates in an aquaponic

treatment which was 85.95 ± 1.16 and 67.57 ± 1.67 in both, systems respectively—the findings of my study supported by Hussain *et al.,* (27). At the start of the experiment, the feed conversion ratio (FCR) was observed to be comparatively low, but as the experiment proceeded, its range changed in both tanks. It was noted that the aquaponic tank has a lower FCR than the control tank, according to the results of Kledal and Thorarinsdottir(28). Sirakov *et al.* (29) also noted that the FCR value significantly differed between aquaponic and control tanks. It had been shown that the specific growth rate of fish in the control and aquaponic tanks was significantly different ($p \leq 0.05$). Greenfeld *et al.* (30) additionally reported that the SGR of Koi carp (*Cyprinus carpio*), whose initial weight of 4.24 g grown in an aquaponic system, reduced with increasing density of fish.Maucieri *et al.* (27) also observed a significant decrease in SGR with increasing stocking density in juveniles of tilapia grown in aquaponic systems. The current study showed the same results as mentioned by Hussain et al. (31).

In the current study, plant growth indicated a significant difference between control and aquaponic systems. The average growth of the plant presented a significant difference $p \leq 0.05$).All plants produced in an aquaponic tank was healthy, showing that the waste water caused no significant toxicities or mineral shortages. Fish wastes were fertilizer for plants' growth and provided clean water to the fish tank again (32). The current study's findings were equivalent to Endut *et al.* (33). The yield of plants at the end of 12 weeks varied significantly ($p \leq 0.05$). According to Akter *et al. (34), water spinach was grown for three months (90 days), and they found that the production of water spinach is significantly high as compared to others,* including tomato and mint. Similarly, my study results showed spinach was one of the best plants for growth out of tomato and mint. Salam et al. (35) and Buzby and Lin (36) also found the same results.

## Conclusion

The current study showed that the aquaponic system has multiple benefits. Some benefits include the nitrites changing into nitrates, the ammonia, and the pH being transported from the fish tank to the plant box. Because of those nutrients, we believe the tomato plants turned out healthy. The outcomes of the present study showed that using aquaponic technology improves fish growth performance, survival rate, and FCR while maintaining the same fish quality. Therefore, it could be argued that aquaponic technology would be the most excellent alternative method for growth performance and production rate.

## Declarations

**Data Availability statement**
All data generated or analyzed during the study are included in the manuscript.
**Ethics approval and consent to participate**
Approved by the department concerned.
**Consent for publication**
Approved
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**Conflict of interest**

The authors declared the absence of a conflict of interest.

**Author Contribution**

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*Data entry and data analysis, as well as drafting the article.*
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*Conception of Study, Development of Research Methodology Design, Study Design, Review of manuscript, final approval of manuscript.*
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*Coordination of collaborative efforts.*
***HAFIZA MALEEHA RAFIQUE***
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