*Original Research Article*

**Assessment of Growth Performance of Carp Species and Cucumber Plant (Cucumis sativus) Cultured in a Recirculating Aquaponic System**

### ABSTRACT

A 140-day experiment was conducted to identify the most effective species combination of indigenous carps (*Catla catla*, *Labeo rohita*) and exotic carps (*Cyprinus carpio*, *Ctenopharyngodon idella*) integrated with cucumber plant (*Cucumis sativus*) cultivation in an aquaponic system. Experimental design included three treatments with respective control, each replicated three times. The fish species compositions for the treatments were: *Labeo rohita* + *Catla catla* (T1), *Labeo rohita* + *Cyprinus carpio* (T2), and *Ctenopharyngodon idella* + *Cyprinus carpio* (T3), maintained at a 70:30 ratio with a stocking density of 2000 g/m³, and cucumber plantlets integrated at a density of 32 plants/m². Controls for each treatment had the same fish composition but were not integrated with plants. During experimental period, fish were fed at 4% of their body weight. Water quality parameters, including temperature, dissolved oxygen (DO), and pH, were monitored daily, while total hardness, alkalinity, ammonia, nitrite, and nitrate were measured at 20-day intervals. Although the concentrations of ammonia, nitrite, and nitrate were slightly higher in the control groups than in the treatments, and DO levels showed an opposite trend, the differences were not statistically significant, and all values remained within optimal ranges. Fish growth parameters, including weight gain, percentage weight gain, specific growth rate (SGR), daily weight gain, feed efficiency ratio (FER), and protein efficiency ratio (PER), were evaluated. The results showed that the highest individual weight gain was observed in *Catla catla* in T1 (89.76±0.20 g), followed by *Cyprinus carpio* in T3 (85.43±0.06 g), and *Ctenopharyngodon idella* in T3 (81.76±0.41 g), with the lowest observed in *Labeo rohita* in T2 (66.03±0.29 g). Overall, the highest combined body weight gain was recorded in T3, followed by T1 and T2, respectively. Plant performance parameters, including height gain (cm), percentage height gain, growth rate (cm/day), and fruit yield (kg/m²), were also measured, with no significant differences observed between treatments and controls. Among the treatments, the highest cucumber fruit yield was obtained in T3 (2580±19.3 g), followed by T1 (1782.4±14.6 g) and T2 (1082.2±15.4 g). Further research is recommended to explore higher stocking densities for both fish and plants to enhance productivity and profitability in this intensive aquaponic system while ensuring sustainability.

Key words: Aquaponic, *Cucumis sativus*, indigenous carp, exotic carp

### INTRODUCTION

The vertical and horizontal expansion of the fisheries and aquaculture sector intensifies global fish production. Due to intensive farming, various water parameters are severely affected due to accumulation of organic waste and depletion of available resources (Herath and Satoh, 2015). Water parameters are very critical factors in aquaculture and play a significant role in the growth and survival of aquatic animals (Dixit *et al.*, 2021). Poor water quality may produce a bad quality product with the generation of low profit and possess potential human health risk as well (Devi *et al.,* 2017). To overcome these problems diversified and eco-friendly culture technologies must be adopted by the farmers.

Intensive aquaculture effluents contain high levels of nutrients like N, P, and K which causes eutrophication in natural water bodies (Khan *et al*., 2005). It is understood that these wastes can be wealth if it is utilized efficiently (Khakyzadeh *et al*., 2015). There are many approaches for converting wastes into wealth like sewage-fed aquaculture (Kumar *et al*., 2015), recirculating aquaculture system (Masser *et al*., 1999) and biofloc system (Avnimelech, 2009). All of these are oriented towards the reduction of the concentration of wastes. None of these are utilized for both reductions of concentration of the wastes and also as nutrient supplementation for other crops.

Concerning these problems, the aquaponic production system is one of the useful approaches which combine fish and plants with the recycling of waste and conservation of water. This technique combines recirculating aquaculture with hydroponics for the production of two products at a time by utilizing nutrients generated from the system for plant growth. In a conventional hydroponics system, a fertilizers source is provided outwardly to supply the plants with necessary nutrients but in aquaponics systems, the available fish waste in the water that is rich in nutrients is sufficient for plant growth. It is more advantageous than conventional aquaculture as there is no periodically siphoning taking place and the wastewater produced in this system is purified and finally back into the system (Rakocy *et al*., 2006). The aquaponics system also facilitates several economic benefits such as savings in the costs of the treatment of water in the aquaculture system, formulation of novel fertilizer for the hydroponics system, and increasing returns from both harvests of fish and vegetables, using one input, *i.e*. fish feed (Adler *et al*., 2000). Aquaponics is an efficient, cost-effective, and water-saving technology that consumes less water (McMurtry *et al.,* 1997).

Aquaponic structures combine the plant and fish in recirculating aquaculture units. The nutrients derived from the fish are used by the vegetation for their growth within the device. The balance between nutrient generation and utilization in plant growth also reduces the need for water quality monitoring. The aquaponic system works on the principle of the nitrogen cycle, where the wastes generated from the culture unit are effectively converted into plant nutrients by beneficial nitrifying bacteria which in turn are utilized for plant growth. In this scenario, an aquaponic system is a great solution for the emerging problems of the aquaculture industry, such as limited soil and water resources and wastewater disposal into the natural water bodies. A key to successful recirculating production systems is the use of cost-effective water treatment techniques. In addition to the ecological benefits, the aquaponic system also facilitates several economic benefits such as savings in the costs of the treatment of water in the aquaculture system, formulation of novel fertilizer for the hydroponics system, and increasing returns from both harvests of fish and vegetables, using one input, *i.e*. fish feed. Aquaponics is an efficient, cost-effective, and water-saving technology that consumes less water.

Vegetables are candidate plants mostly used in hydroponics systems as they readily accept the nutrients from nitrogen sources (nitrite, nitrate). Green fodder is the natural diet for livestock production. The plants produced in the aquaponic system are organic which is safer for human consumption (Khater and Ali, 2015). Among different plants suitable for aquaponic system cucumber is one of them. It suits the culture period of the present experiment. Cucumbers are members of the plant family Cucurbitaceae having several advantages like: 1. It's High in Nutrients · 2. It Contains Antioxidants · 3. It Promotes Hydration · 4. It May Aid in Weight Loss · 5. It May Lower Blood Sugar.

From time to time different fish and plant species have integrated in the aquaponic system. Generally, the hardy species were experimented by different researchers with a lean approach to the Indian major carps and exotic carps.

### MATERIALS AND METHODS

The present experiment was conducted for 140 days to find out the best species combination of indigenous carps (*Catla catla, Labeo rohita)* and exotic carps *(Cyprinus carpio, Ctenopharyngodon idella)* with the cucumber plant (*Cucumis sativus)* in an aquaponic system based upon their growth performances. The objective was also to access the plant growth, total yield and benefit-cost ratio of the aquaponic system. The description of the study area, experimental setup, materials used and the methods followed to undertake this research work are presented in this section.

**Location of the experiment**

The research was conducted in the College of Fisheries (OUAT), Rangeilunda, Ganjam, Odisha. The research period is from June 25th to October 22th, 2022. For conducting this experiment, a greenhouse was constructed first by using a knitted green shade net as roof and side walls supported by bamboo poles. (Location of the experiment: Latitude- 19°18’50’’N and Longitude- 84°52’10’’W)

### Experimental fish

Fishes chosen for this research work were catla (*Catla catla)*, rohu (*Labeo rohita)* belong to the family Cyprinidae. Carps were precure from Humari farm, Chhatrapur, Ganjam, Odisha about 18 km away from the experimental location. The fish is transported in oxygen pack @ 200 nos/pack from the respective area. Fishes from the farms are disinfected with KMnO4 solution (1mg/L). Acclimatization was done for a period of 20 days befor starting trial.

### Experimental plant

Plant species selected for the trial was cucumber (*Cucumis sativus*), a widely cultivated creeping vine plant in the Cucurbitaceae family that bears usually cylindrical fruits. Seeds of cucumber were procured from the local market Korapalli, Berhampur Odisha. Before sown in the ground, the seeds were soaked in the water for the 24 hrs. For the germination the seed were sown in the already prepared three-layer bed. The first layer composed of sands, the second layer of cow dung, and the third layer of coco peat. For 2 to 3 days it was kept under shady area after exposed to the sunlight for the maximum hours and the tray was covered with the mosquito net to prevent from the insects. Water was sprinkled on the bed @ 3 times a day to maintain proper temperature in the germination bed. The plantlets were transferred into the hydroponic trays (0.25m2) during the experiment after 15 to 20 days. Aquaponics trays were planted with @8 nos. of plantlets/0.25m2. The germination percentage of the seeds were calculated by the formula describes by Biasutti and Galinanes (2001):

Germination (%) = (Germination seeds/Total seeds) x1

### Setting up of system

Each one of the aquaponic recirculating units was made of a rearing fish tank of 200L capacity, a hydroponic vegetable growing tray of 0.25 m2 (0.57×0.44m) capacity, and a submersible pump (40-Watt capacity) with pipe arrangement. Pipeline installation was done for connection between fish rearing tank with a hydroponic bed for recirculation of water. Cleaned gravels of 1.5 to 2.0 cm size to a thickness of 13- 15cm were filled in the hydroponic grow beds and for creating a flood and drain system a bell siphon was installed at the middle of the gravel bed. By a 40W submersible pump, nutrient-rich wastewater from the experimental fish tank was pumped into the hydroponic plant grow bed and the water flow rate was maintained @180L/hr. throughout the experimental period. Pumping frequency was maintained at @10hrs. per day manually. Again, water from the hydroponic tray returned to the fish rearing tank by gravity through a PVC drain pipe which was connected to a bell siphon. For preventing the jumping of fish from the rearing tanks, the tanks were covered with 15mm mesh size nylon net. Before the implantation of plantlets in the hydroponic bed, the recirculating system was run for about 07 days with fish and water as recirculating aquaculture systems, allowing the nutrient levels (Nitrite and Nitrate) to increase.

### Experimental design

For the experimental setup nine tanks were connected with the aquaponics system and three tanks kept as control without aquaponics system. The water from the fish rearing tank was pumped by the submersible pump to the aquaponics tray. Aquaponics trays were filled with three different sizes of gravels, through which water was filtered and again send to the fish culture tanks in a recirculated manner. The research setup was consisted of three different treatments in triplicates. In the present trial 3 different species composition was made by composting indigenous and exotic carps and designated as T1, T2 and T3. Each treatment consisted of 1 control and was designated as C1, C2 and C3 where fish and plants were culture separately without aquaponic system as practiced by the farmers. In the present trial each FRP 8 tank were stocked @ of 2000g/m3 of fish with the plant cucumber @ 32 plantlets /m2. The experimental period will have consisted of 140 days. The details of species composition, its stocking density and planting density were presented in Table 1.

### Table 1. Stocking density of fish and plants in different treatments

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatment** | **Species** | **Stocking density of fish(g/m3)** | **Stocking density of cucumber seeds (nos./ m2)** |
| **T1** | Rohu + Catla | 2000 | 32 |
| **T2** | Rohu + C.C | 2000 | 32 |
| **T3** | G.C + C.C | 2000 | 32 |
| **C1** | Rohu + Catla | 2000(without plants) | 32(without fish) |
| **C2** | Rohu + C.C | 2000(without plants) | 32(without fish) |
| **C3** | G.C + C.C | 2000(without plants) | 32(without fish) |

**Stocking:**

The finger lings of catla (*Catla catla)*, rohu (*Labeo rohita)*, common carp (*Cyprinus carpio)* and grass carp (*Ctenopharyngodon idella)* were stocked with initial weight of 12.5±0.17 g, 10.40±0.20 g, 10.2±0.26 g, and 10.50±0.15g respectively and length of, 6.5±0.29 cm, 7.3±0.12 cm, 6.7±0.51 cm and 6.4±0.14 cm respectively. During transplanting, the length of cucumber plantlets was 10.6±0.1 cm.

### Feeding

Fish fingerlings were fed with a commercial diet (Table 2) at 4% of their body weight per day. Morning feeding was done at 08:00 hours and evening time at 16:00 hours.

### Sampling

Fish sampling was done in 20 days intervals for studying the growth and health condition of fish. The daily feed ratio was adjusted accordingly. A graduated ruler and graph paper were used for length measurement and an electronic balance was used for weight measurement. Similarly, Plant growth was observed by taking the measurements of plant height with the help of a flexible thread and a graduated ruler. An electronic balance was used for the weight measurement of plants.

### Assessment of growth parameters

The weight of the fishes was measured using a digital mono pan balance 0.01 g accuracy (Wenser, IND/09/08/466). Using these data, the average initial weight, average final weight of fishes reared in each tank was calculated. Other growth parameters such as weight gain, daily weight gain, percentage weight gain and specific growth rate and survival rate were computed using the methods/ formulae given below.

### Table 2: The proximate composition of formulated feed

|  |  |
| --- | --- |
| **Parameter** | **%As on D.M. Basis** |
| Moisture | 9.43 |
| Total dry matter | 90.57 |
| Crude Protein | 33.8 |
| Ether Extract | 6.8 |
| Crude Fiber | 5.4 |
| Total Ash | 12.8 |
| Total Carbohydrate | 38.93 |

### Weight Gain(g)

Weight gain of the fishes after the end of the experimental period was calculated by using the following formula:

Weight gain (WG) = Final weight (W2) – Initial weight (W1)

### Daily Weight Gain (DWG)

 Daily weight gain (DWG) (g) = Final weight−Initial weight ×100

Experimental period

### Percentage Weight Gain (%)

PWG (%) = Final weight of fish(g)−Initial weight of the fish(g)

×100

Initial weight of the fish(g)

### Specific Growth Rate (% day-1)

SGR = ln(Final weight)−ln(Initial weight) × 100

Experimental period

### Survival rate (%)

The following formula is used to calculate it.

F

Survival rate(%)= I ×100

Where, F = Final no of fish species harvested I = Initial no of fish species stocked

### Plant Height Gain (cm)

Plant height gain (cm) = Final height – Initial height

### Plant Growth Rate (cm/day)

Plant Growth Rate (cm/day) =

Height gain Culture period

### Assessment of nutritional indices of Feeds

1. **Feed Conversation Ratio (FCR)**

Feed conversion ratio (the quantity of feed required for 1 kg weight gain in fishes) was calculated using the following formula.

Total dry feed intake (g)

Feed conversion ratio (FCR) =

Total live weight gain(g)

### Feed Efficiency Ratio (FER)

Feed efficiency ratio (FER) =

### Protein efficiency ratio (PER)

Total live weight gain(g) Total dry feed intake(g)

Protein efficiency ratio (PER) =

Total weight gain(g) Total protein intake(g)

**Water quality parameters**

Important physical and chemical parameters of water like temperature, dissolved oxygen and pH were observed daily whereas hardness, alkalinity, free Carbon dioxide, ammonia, nitrite, nitrate, and phosphate were recorded @ 20 days intervals.

### Statistical Analysis

Statistical tool for Social Science (SPSS 22.0 for windows) was used for performing statistical analysis. Experiments were run in triplicate using three different stocking densities of fish and all data were analyzed by one-way Analysis of Variance (ANOVA) using Duncan’s Multiple Range Test (DMRT) to compare the means. Fish production performances, plant growth, and physic-chemical parameters of water were determined and expressed as mean ± standard error. All the analysis has been done with a significance level of 0.05.

### RESULTS AND DISCUSSION

The present experiment was conducted for 140 days to find out the best species combination of indigenous carps (*Catla catla, Labeo rohita)* and exotic carps *(Cyprinus carpio, Ctenopharyngodon idella)* with the cucumber plant (*Cucumis sativus)* in an aquaponic system. The fish growth parameters such as weight gain, percentage weight gain, specific growth rate, daily weight gain, feed efficiency ratio, and protein efficiency ratio were calculated. In the present experiment, various plant growth parameters such as height gain (cm), percentage height gain (%), plant growth rate (cm/day), and yield (kg/m2) were also recorded. Fish production performances, plant growth, and physic-chemical parameters of water were determined and expressed as mean ± standard error. All the analysis has been done with a significance level of 0.05.

### Table 3: Water quality parameters during 140 days experimental period for different treatments

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **Temperature (0C)** | **pH** | **Dissolved****oxygen (ppm)** | **Total****hardness (ppm)** | **Total****alkalinity (ppm)** | **Ammonia (ppm)** | **Nitrite (ppm)** | **Nitrate (ppm)** |
| T1 | 28.4±0.17 | 7.9±0.08b | 6.4±0.08a | 146.8±1.1b | 141.5±2.3c | 0.29±0.01d | 0.22±0.01d | 17.2±0.05b |
| T2 | 28.4±0.20 | 7.8±0.07b | 6.3±0.05ab | 144.0±2.7b | 149.7±0.2a | 0.24±0.01e | 0.17±0.01e | 16.3±0.12c |
| T3 | 28.4±0.19 | 7.9±0.05ab | 5.9±0.03c | 151.9±1.2a | 143.4±1.9bc | 0.36±0.01c | 0.26±0.01c | 19.2±0.03a |
| C1 | 28.3±0.23 | 8.2±0.10a | 6.4±0.06a | 146.8±0.8b | 145.1±1.4bc | 0.60±0.01a | 0.82±0.01b | 13.2±0.04e |
| C2 | 28.4±0.22 | 7.8±0.04b | 6.2±0.07ab | 145.6±1.9b | 152.1±0.7a | 0.57±0.01b | 0.90±0.01a | 13.7±0.03d |
| C3 | 28.4±0.26 | 8.0±0.05ab | 6.1±0.05b | 148.6±0.5ab | 147.8±1.2ab | 0.60±0.01a | 0.83±0.01b | 11.6±0.12f |

**\*Values are expressed in mean ± standard error**

### \* Values in a row with different superscript differ significantly (P<0.05)

**Table 4: Comparison of growth parameters among treatments**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Treat ment | Spec ies | Initial length (cm) | Final length (cm) | Initial wt (g) | Final wt (g) | Leng th gain (cm) | Lengt h gain rate (%) | Weight gain (g) | Weight gain rate (%) | DWG(g) | SGR | Biomass (g) | FCR | FER | PER | Survi val rate (%) |
| T1 | Rohu | 7.3±0.15a | 18.1±0.11b | 7.3±0.15a | 83.30±0.64e | 7.7±0.1a | 74.1±2.3ab | 72.90±0.45e | 701.3±10.4b | 0.61±0.004e | 1.73±0.01b | 3193.9±78.6c | 2.02±0.02b | 0.44±0.004a | 2.51±0.01e | 95.8±1.7 |
| Catla | 6.3±0.10b | 20.4±0.37a | 6.3±0.10b | 102.30±0.23a | 7.8±0.4a | 62.7±2.6c | 89.76±0.20a | 835.2±1.1b | 0.75±0.002a | 1.74±0.01b | 3921.7±96.5a | 95.8±2.2 |
| T2 | Rohu | 7.3±0.12a | 17.2±0.17c | 7.3±0.12a | 76.50±0.50f | 6.8±0.1b | 65.0±2.5bc | 66.03±0.29f | 631.5±14.2c | 0.55±0.002f | 1.65±0.02c | 2957.6±42.1d | 2.26±0.01b | 0.43±0.002a | 2.39±0.01f | 96.6±1.6 |
| C.C | 6.1±0.10b | 16.4±0.17d | 6.1±0.10b | 84.96±0.52d | 6.1±0.1c | 58.5±1.6a | 74.60±0.66d | 720.1±17.3b | 0.62±0.006d | 1.75±0.01b | 3285.6±46.3c | 96.6±0.8 |
| T3 | G.C | 6.4±0.14b | 19.4±0.56a | 6.4±0.14b | 92.23±0.20c | 8.2±0.1a | 78.4±1.9a | 81.76±0.41c | 782.3±23.4a | 0.68±0.003c | 1.81±0.02a | 3566.1±55.1b | 2.18±0.01b | 0.45±0.002a | 2.57±0.01c | 96.6±1.6 |
| C.C | 6.3±0.12b | 17.3±0.47d | 6.3±0.12b | 95.80±0.20b | 6.9±0.4b | 67.0±5.3bc | 85.43±0.06b | 824.5±12.7a | 0.71±0.001b | 1.85±0.01a | 3704.4±89.2ab | 96.6±2.2 |

### \*Values expressed as mean ± standard error

**\* Values in a row with different superscript differ significantly (P<0.05)**

### Plant growth parameters

In the present experiment, various plant growth parameters such as height gain (cm), percentage height gain (%), plant growth rate (cm/day), and total yield (Kg/m2) were recorded and presented in Table 4.

### Height gain (cm)

The height gain of plants was found between the treatments which were given in Table 4 and Figure 1. Average height gain was found in T1 and its control as 184.6±1.1 cm & 175.2±2.6, in T2 and its control was 164.8±2.2cm & 159.0±0.8 cm where as in T3 and its control was 200.6±0.9 cm & 192.3±0.2cm respectively. Among the treatments highest height gain was found to be in T3 (200.6±0.9 cm) followed by T1 (184.6±1.1 cm) and T2 (164.8±2.2cm).

### Percentage height gain (%)

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The percentage height gain of plants was found between the treatments which are given in Table 4 and Figure 1. Percentage height gain in T1 and its control was found to be 1775.0±9.5% &1690.3±17.4% and in T2 and its control was 1498.3±26.4% &1457.3±59.3% where as in T3 and its control was 1857.0±27.0% &1825.6±48.4% respectively. Among the treatments highest percentage height gain was found to be in T3 (1857.0±27.0%) followed by T1 (1775.0±9.5%) and T2 (1498.3±26.4%).

### Plant growth rate (cm/day)

In T1 and its control it was found to be 1.62±0.01cm/day&1.58±0.03cm/day and in T2 and its control it was 1.45±0.01 cm/day & 1.32±0.02cm/day, where as in T3 and its control it was 1.76±0.01 cm/day & 1.69±0.1 cm/day respectively (Table 4, Fig. 1). Among the treatments growth rate of plants was found to be highest in T3 (1.76±0.01cm/day) followed by T1 (1.62±0.01cm/day) and T2 (1.45±0.01cm/day).

### Fruit Yield (g / 0. 25 m2)

The average yield of cucumber plants was found between the treatments which are given in Table 4 and Figure 1. The average yield of cucumber in T1 was found to be 1782.4±14.6 g, T2 1082.2±15.4g, T3 2580±19.3g, C11359.3±20.6g, C2704.8±28.1g and C31942.3±51.1 g respectively. Highest yield observed in T3 (2580±19.3g) followed by T1 (1782.4±14.6g) and T2 (1082.2±15.4g).

### Table 5: Plant growth parameters during the experimental period (140 days)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Parameters | T1 | T2 | T3 | C1 | C2 | C3 |
| Plant height initial (cm) | 10.4±0.1fg | 11.0±0.06d | 10.8±0.3cd | 10.6±0.1e | 10.6±0.4c | 11.2±0.2c |
| Plant height final (cm) | 195.0±1.2b | 175.8±2.1b | 211.4±1.2b | 184.8±2.7b | 163.6±1.2b | 200.5±0.4b |
| Height gain (cm) | 184.6±1.1c | 164.8±2.2b | 200.6±0.9b | 175.2±2.6b | 159.0±0.8b | 192.3±0.2b |
| Percentage height gain (%) | 1775.0±9.5a | 1498.3±26.4a | 1857.0±27.0a | 1690.3±17.4a | 1457.3±59.3a | 1825.6±48.4a |
| Plant growth rate (cm/day) | 1.62±0.01g | 1.45±0.01d | 1.76±0.01d | 1.58±0.03e | 1.32±0.02c | 1.69±0.1c |
| No. of fruits per plant | 8.3±0.3g | 6.9±0.3d | 10.2±0.3d | 7.3±0.3e | 6.2±0.3c | 8.7±0.5c |
| First flowered in the plant (day) | 27.1±0.01d | 31.8±2.8c | 28.7±1.7c | 28.3±1.6cd | 30.6±1.6c | 28.3±1.6c |
| The proportion of undeveloped fruit | 20.7±1.0.9e | 15.0±2.9c | 10.3±1.6cd | 11.6±1.6de | 13.3±1.6c | 15.0±2.8c |
| Fruit length(cm) | 9.5±0.1g | 8.5±0.2d | 10.7±0.3d | 8.1±0.7e | 6.6±1.0c | 9.1±0.4c |
| Fruit weight(g) | 42.6±0.3f | 37.4±0.4cd | 49.8±0.4cd | 33.7±0.5c | 30.8±0.6c | 40.7±0.7c |

**\*Values expressed as mean ± standard error**

### \* Values in a row with different superscript differ significantly (P<0.05)

### Fish growth parameters

In the present investigation, no significant variation in growth of fishes was found which might be due to the equal stocking density during the experiment. Normally in aquaponics research work with hardy fishes like tilapia, climbing perch, and koi carp were selected by several workers. In the present trial as candidate species indigenous carps (*Catla catla, Labeo rohita)* and exotic carps *(Cyprinus carpio, Ctenopharyngodon idella)* were selected for different treatments.

Among the treatments, WG was highest in the catla in the T1 (89.76±0.20g) followed by common carp in T3 (85.43±0.06 g) and grass carp in the T3 (81.76±0.41g) and the lowest WG in the rohu in T2 (66.03±0.29g). Percentage weight gain was also follows the same trend as WG with highest in the catla in the T1 (835.2±1.1%) followed by common carp in T3 (824.5±12.7%) and grass carp in the T3 (782.3±23.4%) and lowest in the rohu in T2 (631.5±14.2%). Among the treatment SGR highest in the in grass carp T3 (2.15±0.04%/day) followed by common carp in T3 (2.14±0.01%/day) and catla in the T1 (1.88±0.01%/day) and lowest SGR recorded in the rohu in T1 (1.74±0.01%/day). Similarly, SGR was highest in the in grass carp T3 (2.15±0.04%/day) followed by common carp in T3 (2.14±0.01%/day) and catla in the T1 (1.88±0.01%/day) and lowest SGR recorded in the rohu in T1 (1.74±0.01%/day). Higher growth was observed in T3 *i.e*. body weight gain was higher in its candidate species selected which belongs to exotic carps. They were stated to be hardy and have the ability to with stand the stress of confined small tank culture system. Since catla is having potential of being growing faster in similar conditions as compared to the selected species in the present investigation the growth rate in T1 is next to T3. It agrees with the findings of Rayhan *et al.*(2018) and (Rahmatullah R *et al*., 2010) who opined that the hardy species grows better than others in an aquaponics system.

In this trial the nutritional indices such as FCR highest was in the T2 (2.26±0.02) followed by in T3 (2.18±0.03) and the lowest FCR was recorded T1 (2.02±0.02).The highest FER was found in T3 (0.45±0.004) followed by T1 (0.44±0.003) And the lowest FER recorded among the treatments are T2 (0.43±0.004).Similarly, PER was highest in the T3 (2.57±0.01) followed by T1 (2.51±0.01) and the lowest PER was found in rohu in T2 (2.3±0.01).The trend of this observed result matches with the result obtained by Ridha (2005), Hasan (2007) and Rahsid (2008) who found relationship between the better bodyweight gain and lower feed conversion ratio.

Among the treatment the lowest survival rate was in the T1 catla and rohu (95.8±1.7% & 95.8±2.2%). The highest survival rate was recorded in the both T2 and T3 (96.6±1.6& 96.6±0.8) & (96.6±1.6% & 96.6±2.2%) respectively.

There was no significant difference between the both the T2 and T3. Survibility of exotic carp was better than indigenous carpin an aquaponic system which agrees to

the total biomass The Biomass of the grass carp and common carp in the T3 and its control was 3566.1±55.1 & 3420.0±57.1 and 3704.4±89.2 & 3289.3±76.2respectively. Among the treatments biomass was highest in the in the catla in T1 (3921.7±96.5) followed by common carp in T3 (3704.4±89.2) and grass carp in T3 (3566.1±55.1). Since the biomass of rohu was the least the overall biomass was highest in T3. Therefore, both better survival and better growth rate might be reason for highest biomass in T3. The findings of El-Saidy and Hussein (2015), Patil *et al*. (2019) and Sabwa AJ (2021) opined similar views in their respective research works.

Among the treatments highest height gain was found to be in T3 (200.6±0.9 cm) followed by T1 (184.6±1.1 cm) and T2 (164.8±2.2cm). Similarly, Highest yield observed in T3 (2580±19.3g) followed by T1 (1782.4±14.6g) and T2 (1082.2±15.4g). The fruit production is more due to more metabolites produced during the culture period by the candidate species in T3 *i.e.* grass carp and common carp. More metabolites leads to the production of more plant nutrient nitrate by the nitrifying bacteria present in the aquaponic system. Hayat, M. A., *et al*., (2018), Nica *et al*.,(2020), and Subhasmita *et al.,* (2022) in their respective experiments suggested that the plant growth rate was more in the culture tanks where more metabolites are produced due to higher stocking densities which is in agreement with the findings of present research work.

### Plant growth parameters

Cucumber plant growth and fruit production in the present study resulted in the high cucumber growth in the soil compared to cucumber plant growth in the aquaponics tray. It shows required nutrients for cucumber plant growth are not fulfilled in the aquaponics system. In the present research, the highest yield was recorded in C3 (1076.3±51.1 g) followed by C1(974.6±20.6 g), C2(845.4±28.1 g) and the lowest yield found in control T2 (386.8±15.4b g). All the growth parameters of cucumber plant analysed and recorded during the experimental period were observed higher in C3 followed by C1, C2, T3 and T1 and lowest yield found in T2.

In the present research among the treatments highest height gain was found to be in T3 (200.6±0.9 cm) followed by T1 (184.6±1.1 cm) and T2 (164.8±2.2cm). Similarly, Highest yield observed in T3 (2580±19.3g) followed by T1 (1782.4±14.6g) and T2 the findings of other workers (Saseendran *et al.,* 2021 and Wang *et al*. 2017). Similarly, (1082.2±15.4g). The fruit production is more due to more metabolites produced during the culture period by the candidate species in T3 *i.e.* grass carp and common carp. More metabolites leads to the production more plant nutrient nitrate by the nitrifying bacteria present in the aquaponic system. Hayat, M. A., *et al*., (2018), Nica *et al*.,(2020) and Subhsmita *et al.,* (2022) in their respective experiments suggested that the plant growth rate was more in the culture tanks where more metabolites are produced due to higher stocking densities which is in agreement with the findings of present research work.

### CONCLUSION

From present study it may be concluded that:

* 1. Exotic carps *(Ctenopharyngodon idella, Cyprinus carpio)* perform better than the indigenous carps (*Catla catla, Labeo rohita)* or a combination of indigenous carps (*Labeo rohita)* with exotic carps *(Cyprinus carpio)* in an aquaponic system with the cucumber plant (*Cucumis sativus)*
	2. Catla grows best followed by grass carp and rohu being the least among selected species.
	3. The benefit cost ratio, total fish and plant yield was more in T3 *i.e.* a combination of Exotic carps *(Ctenopharyngodon idella, Cyprinus carpio)* with plant cucumber (*Cucumis sativus)* therefore may recommended for aquaponic.
	4. Further, more research may be carried out to increase the stocking density of both fish and plants to get maximum profit from this intensive aquaponic system with sustainable strategies. Also efforts should be made to sell the organically produce fruit at higher rate to get better BCR.

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