**Comparative study on growth performances of Indian major carp and Exotic carp in aquaponics system with Cucumber plant (*Cucumis sativus*)**

### ABSTRACT

A 120 days experimental study was conducted to reveal 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 experimental set-up consisted of 3 treatments in triplicates having a control in each trial. The species composition in different treatments were rohu + catla, rohu + common carp and grass carp + common carp in 70: 30 ratio @ 2000 g/m3 integrating cucumber plantlets @32/ m2 in T1, T2 and T3 respectively. The control in each treatment consisted of the same species composition but without plants. Fishes were fed @ 4% of their body weight during the trial period. Water quality parameters such as temperature, dissolved oxygen and pH were observed daily where as hardness, alkalinity, ammonia, nitrite and nitrate were recorded @ 20 days intervals. Though the values of ammonia, nitrite and nitrate were found to marginally higher in controls compared to treatments and reverse trend found in the values of dissolved oxygen there were no significant variation in the values and were in its optimal range. 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. The result revealed that highest body weight gain was in 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 in the rohu in T2 (66.03±0.29g). The highest overall body weight gain combining the both fish species of the system was found in T3 followed by T1 and T2 respectively. From the experiment it was concluded that that in an aquaponic system with grass carp with common carp, 2000g/m3 in combination with cucumber at 32plants/m² will be economically viable for farming practices. 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.

Key words: Aquaponic, indigenous carp, exotic carp

### INTRODUCTION

The vertical and horizontal expansion of the fisheries and aquaculture sector intensifies global fish production. This sector, in India, achieved a lot of success with the production of 0.75 million tonnes to 17.545 million tonnes within the span of 72 years from 1950-51 to 2023-24 due to semi-intensive and intensive farming (Handbook of fisheries statistics 2023). 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; Naughton *et al.,* 2020). To overcome these problems diversified and eco-friendly culture technologies must adopted by the farmers.

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; Liang and Chien, 2013). Aquaponics is an efficient, cost-effective, and water-saving technology that consumes less water (McMurtry *et al.,* 1997). 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. 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.

### MATERIALS AND METHODS

The present experiment was conducted for 120 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.

### Location of the experiment

The research was conducted in the College of Fisheries (OUAT), Rangeilunda, Ganjam, Odisha. The research period is 120 days carried out 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)*, common carp (*Cyprinus carpio)* and grass carp (*Ctenopharyngodon idella)* belong to the family Cyprinidae. The exotic carps were brought from the Government hatchery Bhanjanagar, Ganjam, Odisha about 90 km away from the research cite in and indigenous carps were 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. Travel from the Bhanjanagar was 4hours and from the Humari it took 45 minutes. Then the fishes from the farms are disinfected with KMnO4 solution (1mg/L) to remove ectoparasites and released in 4 FRP tanks of 500 L capacity species wise. Acclimatization was done for a period of 20 days. Regular siphoning was made to remove the metabolites. Water exchange was done each alternate day to avoid stress.

### 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 tank were stocked @ of 2000g/m3 of fish with the plant cucumber @ 32 plantlets /m2. The experimental period will have consisted of 120 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 and Stocking**  **density(70:30)** | **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 of Catla, Rohu, Common carp, and Grass carp were fed with the commercial feed. The feeding was done at 4% of their body weight per day. Morning feeding was done at 08:00 hours and evening time at 16:00 hours. The proximate composition of the feed used in research period in Table 2.

### Table 2: The proximate composition of commercial 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 |

### 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.

### 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

### Assessment of nutritional indices of Feeds

**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) =

### Water quality parameters

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

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

The present experiment was conducted for 120 days, experimental set-up consisted of 3 treatments in triplicates having a control in each trial. The species composition in different treatments were rohu+ catla, rohu + common carp and grass carp + common carp in 70: 30 ratio @ 2000 g/m3 integrating cucumber plantlets @32/ m2 in T1, T2 and T3 respectively. The control in each treatment consisted of the same species composition but without plants. 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 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 120 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)

### **Water quality parameters**

The various water quality parameter such as temperature (0C), pH, dissolved oxygen (mg/l), total alkalinity (mg/l), hardness (mg/l) of different experimental tanks ranged from 28.30C to 28.4 0C, 7.8 to 8.2, 5.9 to 6.4 mg/l, 141 to 152 mg/l and 144 to 151 mg /l, respectively during the 120 days of feeding trial (Table 3). The observations indicated that the parameters of all the experimental tanks were well within the ideal range, providing a suitable environment for growth of a warm water fish (Saha and Ray, 2011; Ayyappan, 2011; Choudhary, 2002) and hence, not considered as a factor to affect the result of the experiment.

**Growth parameters of fish**

In the present study, various growth parameters of fish (*Labeo rohita, Catla catla, Ctenopharyngodon idella, Cyprinus carpio*) such as initial length and weight, final length and weight, percentage weight gain (PWG), final weight gain (WG), daily weight gain (DWG), specific growth rate (SGR), various nutritional indices such as feed conversation ratio (FCR), feed efficiency ratio (FER), protein efficiency ratio (PER) were calculated using a standard protocol.

Average body weight highest in the T3 (92.23±0.20g & 95.80±0.20g) followed by the T1 (83.30±0.64g & 102.30±0.23g) and T2 (76.50±0.50g & 84.96±0.52g).

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 findings of other workers (Saseendran *et al.,* 2021 and Wang *et al*. 2017).

Similarly, 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±76.2 respectively. 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.

The final average body length (cm) of the fish is during the research period mentioned in Table. The average body length of the Rohu and Catla in the T1 is (18.1±0.11cm > 17.3±0.30cm and 20.4±0.37cm> 19.1±0.46cm). The final average body length of the rohu and common carp in the T2 was (17.2±0.17cm> 16.8±0.32cm and 16.4±0.17cm >16.0±0.23cm). The final average body length of the grass carp and common carp in the T3 was (19.4±0.56cm > 18.6±0.26cm and 17.3±0.47cm > 16.8±0.32cm). Among the treatment the final average body length was highest in the catla in T1 (20.4±0.37cm) followed by grass carp in T3 (19.4±0.56cm) and rohu in the T1 (18.1±0.11cm) and the lowest was recorded in the common carp in the T2 (16.4±0.17cm

CONCLUSION

From present study it may be concluded that: 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)* @ stocking density of 2000 g/m3 integrating cucumber plantlets @32/ m2 with species ratio of 70: 30 respectively.

Catla grows best followed by grass carp and rohu being the least among selected species.

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

**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)**

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