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Effect of Greenlight on the Growth Enhancement of Indian Major Carp in Bhopal, Madhya Pradesh

Pearl Manapchi R Sangma[1*], Anubhuti Minare[2*], Vipin Vyas[3*]

[1]*Department of Zoology and Applied Aquaculture Barkatullah University Bhopal*

[2]*Department of Zoology and Applied Aquaculture at Barkatullah University, Bhopal Madhya Pradesh*

[3]*Professor, Department of Zoology and Applied Aquaculture, Barkatullah University, Bhopal.*

Abstract

The present study investigates the effect of green LED light exposure on the growth enhancement of Indian Major Carp (*Labeo rohita*) under controlled laboratory conditions. A 100-day experimental trial was conducted from September to November 2023 at the Department of Zoology and Applied Aquaculture, Barkatullah University, Bhopal (23.19894°N, 77.45225°E). Juvenile Labeo rohita were stocked in two fiber-reinforced plastic (FRP) tanks: one exposed to green LED light (520 nm) and another subjected to a standard photoperiod. Physico-chemical parameters such as temperature, dissolved oxygen (DO), pH, carbon dioxide (CO_2), and alkalinity were monitored weekly and remained within suitable ranges for carp culture. Fish were fed commercial floating pellets to satiation twice daily, and water was continuously aerated. Growth performance was assessed through regular measurement of fish length and weight. Initial length and weight of fish were 4 cm and 0.6 g, respectively. By the end of the experiment, fish reared under green light conditions exhibited slightly higher growth (final weight 1.25 g; length 6.05 cm) compared to those in the standard photoperiod tank (final weight 1.19 g; length 5.9 cm). Survival rates were also favorable, recorded at 92.5% in the green light tank and 88% in the control tank. The study indicates that green LED lighting can positively influence the growth and survival of Labeo rohita, making it a promising strategy for enhancing aquaculture productivity in controlled environments.

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1 Introduction

Aquaculture, often considered the aquatic equivalent of agriculture, has experienced significant growth in recent decades. Today, it produces nearly as many fish and shellfish as capture fisheries (FAO, 2014). As natural fisheries face increasing pressure, aquaculture is emerging as the primary strategy for enhancing food production from aquatic ecosystems. However, its expansion poses biodiversity risks due to resource consumption such as land (or space), water, seed, and feed, and the transformation of these into products desired by society. This process also leads to the release of various byproducts into the environment, including greenhouse gases, uneaten feed, faeces, urine, chemical treatments, and the spread of parasites, pathogens, and non-native species (Max Troell, 2017). Aquaculture involves the breeding and cultivation of aquatic organisms such as aquatic plants, fish, and shellfish (e.g., oysters, mussels, clams, shrimp, crabs, and crawfish) in controlled or semi-controlled settings. It serves diverse purposes: from restocking natural water bodies for recreational or commercial fishing, conserving endangered species, to producing marketable aquatic crops in ponds, rivers, or coastal areas. In essence, aquaculture mirrors agriculture, with water serving as the medium instead of soil. Depending on the species, cultivation may occur in freshwater, brackish, or marine environments.

Freshwater fish typically grow best at temperatures between 25 and 30°C. Among the Indian major carps, Rohu (*Labeo rohita*) is particularly significant in carp polyculture systems (Nadia Nazish and Abdul Mateen, 2010). This species is eurythermal, although it does not perform well at temperatures below 14°C. Under standard farming conditions, Rohu is a fast-growing fish that can reach lengths of 35–45 cm and weights of 700–800 grams within a year. Similarly, Mrigal is also eurythermal, tolerating temperatures down to 14°C. As a bottom feeder, Mrigal helps maintain environmental balance in polyculture systems by consuming organic debris. When natural food resources become scarce, supplementary feeding becomes necessary, with energy rather than protein often being the limiting nutrient. Feed costs typically represent 40–60% of the total expenses in freshwater fish farming. The use of artificial feed, particularly in fertilized ponds, can significantly improve growth and production rates compared to fertilization alone (Diana et al., 1994). However, both high and low stocking densities can impede growth, with high densities also causing undesirable changes such as darker skin coloration in fish (Marandi et al., 2018; Wallace et al., 1988; Zeng et al., 2010).

Light is a critical environmental factor that significantly influences fish development. It serves as a natural signal for seasonal biological activities, playing a key role in regulating circadian rhythms as well as various physiological and behavioral functions. Light characteristics such as spectrum, intensity, and photoperiod vary greatly across aquatic environments, making it a highly dynamic element in aquaculture settings. Among these, the spectral composition of light is especially important for fish biology. Light-emitting diodes (LEDs) are increasingly being adopted in aquaculture due to their efficiency and ability to emit narrow light bandwidths. This allows for spectrum customization to suit the specific visual and physiological sensitivities of target fish species (Villamizar et al., 2009; Yeh et al., 2014). Specific light wavelengths have been shown to enhance fish growth and bolster their innate immune responses. Furthermore, different wavelengths can influence the secretion of melanin-concentrating hormone (MCH) a key appetite-regulating hormone in the brain—thereby stimulating increased feeding activity in fish.

Carp farming is the most ancient form of aquaculture known globally, and today, carps make up approximately two-thirds of the total fish produced. Belonging to the family Cyprinidae, which includes carps and their relatives, this group is recognized as the largest family of freshwater fishes and, in fact, the largest vertebrate family overall. The term "Cyprinidae" originates from the Ancient Greek word for carp. In India, carps form the foundation of aquaculture. The three Indian major carps Catla (*Catla catla*), Rohu (*Labeo rohita),* and Mrigal (*Cirrhinus mrigala*)—along with three exotic species Silver carp, Grass carp, and Common carp account for over 85% of the country’s aquaculture output.

Determining the mathematical relationship between fish length (total or standard) and weight is a fundamental aspect of applied fisheries science. Length–weight relationships are essential for estimating the weight of individual fish based on their length or for calculating biomass from length-frequency data (Froese, 1998; Koutrakis et al., 2003). These relationships are also useful for evaluating the growth pattern of fish—whether it follows an isometric (proportional) or allometric (disproportional) pattern (Le Cren, 1951; Ricker, 1975). Extensive studies on the length–weight relationship and growth dynamics of Indian major carps have been conducted by researchers including Jhingran (1952, 1957, 1959), Sinha (1972), Choudhary et al. (1982), Johal et al. (1992), Zafar et al. (1992), Ahmed et al. (1996), Jain (2000), and Saxena et al. (2009).The purpose of this study was to determine and compare the growth rate of the fishes cultured in green light and controlled tank and to investigate the effects of LEDs on the fish.

2 Materials and Methods

Study area and Duration

A 100-day experimental study was carried out from September to November 2023 at the Department of Zoology and Applied Aquaculture, located in Bhopal, Madhya Pradesh (coordinates: 23.19894°N, 77.45225°E).

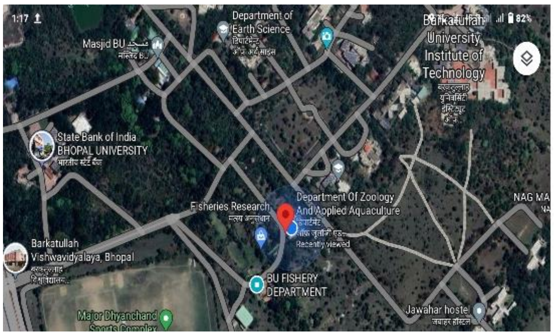


Fig 1 Study area and Duration

Tank Preparation

Firstly, the tanks were collected and cleaned with water. Further, the tanks were washed with KMnO4 and then washed again with water to rinse off the excess $KMnO_4$ from the tank in order to prevent any kind of contamination.

Fig 2: Roughly cleaning of tank

Fig 3: Tanks being washed

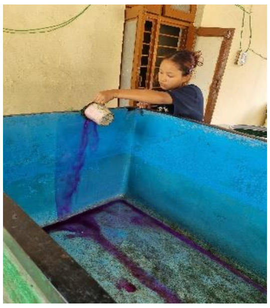


Fig 4: KMnO4 rinse

Experimental fishes and feeding

The fish seeds used in this study were sourced from a culture facility in Bhadhbada Fisheries Federation, Bhopal. They were transported to the laboratory of the Department of Zoology and Applied Aquaculture at Barkatullah University, Bhopal, using oxygen-filled live fish bags. Upon arrival, the fish were placed in tanks for further experimentation. The fish were fed commercially floating granules 2 times daily to satiation. Water was continuously aerated.

Experimental conditions

The fishes were poured into two different FRP tanks (2 m length × 1 m breadth × 0.75 cm height) one kept at the outside and the other in a dark room. The tank was given a greenlight (520nm) condition by placing 4 green LED bulbs above it and filled with water (~ L) with a temperature of 27-35°C. The photoperiod was given a 24-h light: dark photoperiod, respectively.

For the experiment, the fishes were transferred to a dark room and were exposed to green LED light bulbs

Fig 5: Controlled tank

Fig 6: Experimental tank with green LEDs.

Light exposure method

The LED light used in the experiment was purchased from a local shop in Baksewaniya, a district in Bhopal, Madhya Pradesh. The lights were bought in a quantity of four and were suspended above the tank for a more distributed spectrum. The lights were suspended 30 cm- 40 cm above the water surface of the tank.

Fig 7: Green LEDs used in the experiment

Sampling method

Growth evaluation of fish were randomly collected from each tank (10 days difference) for weight measurement using a digital balance. The total length of the fish was measured on a measuring board.

Fig 8: Digital weighing machine

Fig 9: Wooden measuring board

Physico-Chemical parameters

Water quality parameters- Physico-chemical parameters like water temperature, dissolved oxygen (mg/l), carbondioxide (mg/l), pH, and alkalinity (mg/l) of the tank were measured at a 7-day interval, and data were recorded on sampling dates.

pH

pH is a crucial parameter in aquaculture, reflecting the acidity or alkalinity of water or soil. Fish are unable to survive for extended periods in environments where the pH falls below 4 or rises above 11. The pH value is determined by the concentration of hydrogen ions (H^+) in the water. Measured on a scale from 1 to 14, a pH of 7 is considered neutral—neither acidic nor alkaline. Values below 7 indicate acidity, while those above 7 indicate alkalinity. For aquaculture practices, an ideal pH range generally lies between 6.5 and 9.0.

Temperature

Temperature significantly influences the growth and survival of aquatic organisms. It is especially critical for species like fish and shrimp, which are poikilothermic (cold-blooded), meaning their body temperature fluctuates with their environment. In artificial ponds with typical depths of 1 to 2 meters, the temperature difference between surface and bottom water is usually minimal.

Dissolved Oxygen (DO)

Dissolved oxygen is vital for the survival of fish and other aquatic organisms. The water's capacity to retain oxygen is largely temperature-dependent—warmer water holds less oxygen than cooler water. Most pond ecosystems can support oxygen concentrations between 10 to 12 mg/L. However, decomposition of organic matter—such as dead plants, animals, or waste—can lower oxygen levels. When dissolved oxygen drops below 6 mg/L, it may begin to negatively impact aquatic life.

Carbon Dioxide (CO_2)

Fish can generally tolerate carbon dioxide concentrations below 10 mg/L, although tolerance levels vary among species. CO_2 levels in water are influenced by the respiration and photosynthesis of aquatic organisms, the quality of incoming water, and the decomposition of organic materials, which can significantly elevate CO_2 in nutrient-rich environments.

Alkalinity

Alkalinity refers to the concentration of basic substances in water, primarily carbonates, bicarbonates, hydroxides, phosphates, and borates. Among these, carbonates and bicarbonates play the most significant roles in maintaining water quality. Alkalinity is a measure of water's ability to neutralize acids and is expressed in milligrams per liter (mg/L) or parts per million (ppm) as calcium carbonate ($CaCO_3$). It indicates the buffering capacity of water to resist changes in pH.

3 Growth Parameters

- The length gain (cm), weight gain (g), and survival rate were calculated using the following formulas:
- **Length gain (cm) =** Mean final length – Mean initial length
- **Weight gain (g) =** Mean final weight – Mean initial weight

- **Average body weight (ABW) =** Total weight of fishes / No. of fishes
- **Biomass =** ABW × No. of fishes stocked / 1000
- **Feed / Day =** Biomass × percentage of feed/100
- **(ADG) Average daily growth**

$$ADG = \frac{\text{(Final body weight – initial body weight)}}{\text{(No. of feeding days)}}$$

- **Feed Conversion ratio (FCR)**

$$FCR = \frac{\text{Feed Consumed by fishes}}{\text{Biomass Gained}}$$

- **Survival rate =** After completion of the experiment at 180th day, the number of total live fingerlings in the rearing pond was counted separately for calculation of the survival rate.

$$\text{Survival rate (\%)} = \frac{\text{Number of fish at harvest} \times 100}{\text{Total no. of fish stocked}}$$

Result

Physico-chemical parameters

Physico-chemical parameters like water temperature, dissolved oxygen (mg/l), carbon dioxide(mg/l), pH, and alkalinity(mg/l) of the tank were measured at 7-day intervals and data were recorded and observed.

Table 1 Water quality parameters for greenlight tank

Parameters	Aug		Sept		Oct		Nov		Dec	
	05	20	05	20	05	21	06	20	05	20
Temperature	25	26	29	28	27	26	22	21	23	21
D.O(ppm)	6.3	6.5	7.0	7.2	7.3	7.5	7.1	7.3	7.2	7.1
CO2	0.5	0.3	0.6	0.5	0.8	0.6	0.3	0.5	0.4	0.6
pH	7.0	6.9	7.4	8.0	7.5	7.9	7.4	7.6	7.3	7.2

Length-weight of the fishes

The length and weight of the fishes were taken in the time interval of around 7 days and further changed to 10 days in the winters. Initial length of the fishes were 4 cm and weight were 0.6gm respectively. The experiment took place in the month of September and lasted till December. A total of 10 readings were taken during the experiment in the interval of 4 months.

Table 2 Length and weight of Greenlight tank (*Labeo rohita*)

Month	Length	Weight
August	3.2	0.38
September	4	0.6
October	5.325	0.8675
November	5.85	1.1675
December	6.05	1.25

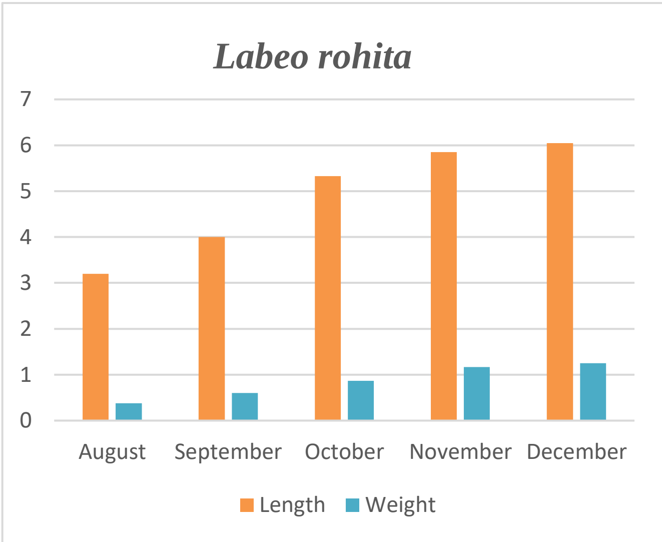


Table 3: Length and weight of photoperiod tank

Month	Length	Weight
August	3.2	0.38
September	3.75	0.54
October	4.525	0.7775
November	5.725	1.01
December	6	1.11

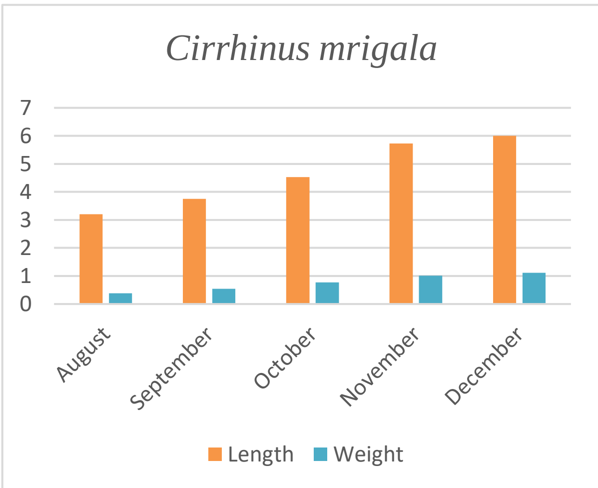
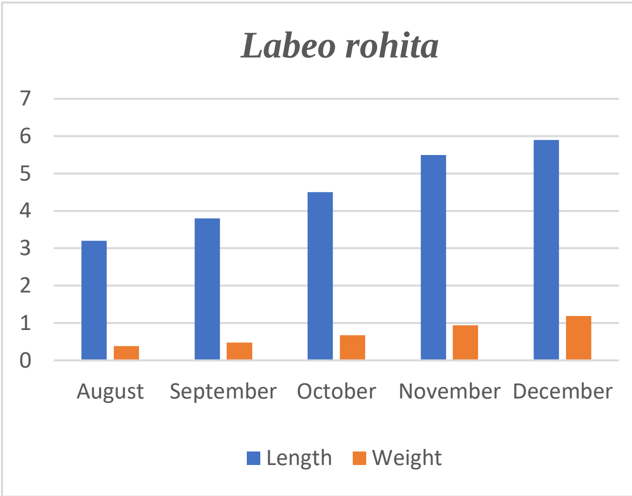
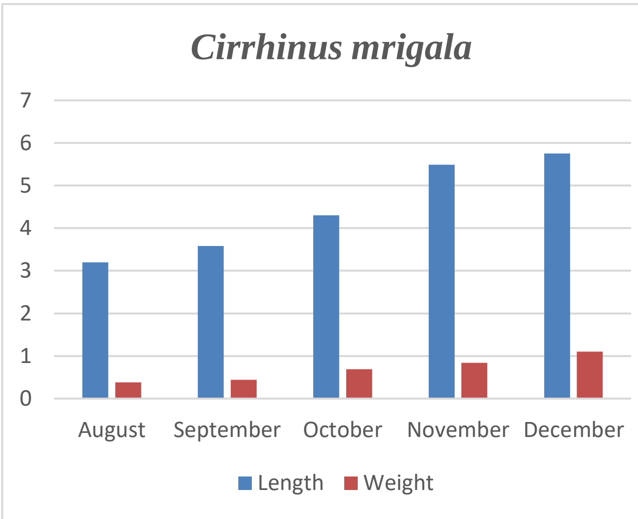


Table 4 Length and weight of photoperiod tank

Month	Length	Weight
August	3.2	0.38
September	3.8	0.48
October	4.5	0.67
November	5.5	0.94
December	5.9	1.19



Month	Length	Weight
August	3.2	0.38
September	3.58	0.44
October	4.3	0.69
November	5.49	0.84
December	5.75	1.1

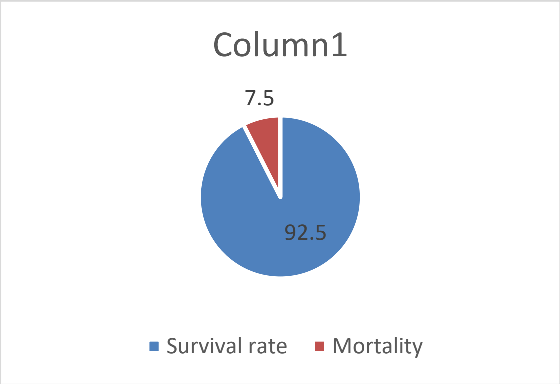


SURVIVAL RATE

$$\text{Survival}(\%) = \frac{\text{Number of species survived at end of experiment}}{\text{Number of species stocked}} \times 100$$

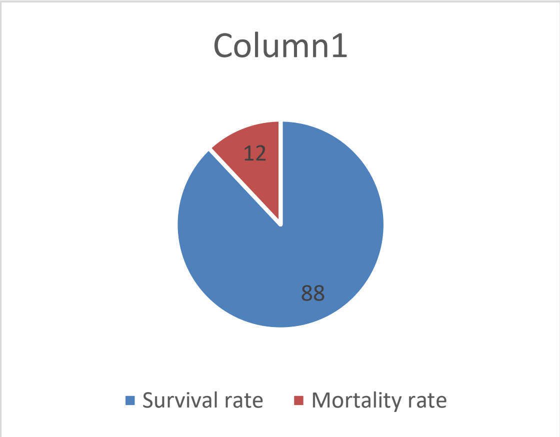
Greenlight tank

Survival rate	Mortality rate
92.5	7.5



Photoperiod tank

Survival rate	Mortality rate
88	12



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