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Short Communication

Studies on the Wintering Effects on Growth and Survival of *Catla Catla* Fingerlings in Polyculture System Employing Greenhouse Technology

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SH and MA designed the experiment and supervised the study. KNW and TR performed the research work. KNW and SAN recorded and statistically analyzed the data. KNW did the literature survey, composed and finalized the manuscript.

Key words
***Catla catla, Labeo rohita, Cirrhinus mrigala*, Greenhouse, Growth, Survival**

ABSTRACT

This study was performed to elucidate the wintering effects with and without Greenhouse Cover on growth and survival rate of *Catla catla* fingerlings in polyculture system containing *Labeo rohita* and *Cirrhinus mrigala* during twelve-week period. The data obtained was subjected to Multivariate analysis of variance (MANOVA) to find out the statistically significant difference ($p<0.01$) between two treatments for their response to fish growth. The post-hoc test revealed that growth of Major carps was significantly higher with greenhouse as compared to without greenhouse (at $p < 0.05$). Growth and survival rate of *Catla catla* were found more pronounced as compared to the other two carps under greenhouse cover. The results facilitated the objectives of this research that greenhouse cover can be applied practically for improvement in the growth and survival rate of *Catla catla* fingerlings during winter season.

World population growth and scarcity of food essentials are the hot burning global issues. The accessibility of food per capita has declined with exponential increase in world population (Erlich, 1991). In order to amplify the effective food production to meet the global needs, it is essential to escalate the production time duration of food essentials. The winter season presents worst scenario with fairly significant differences in temperature during day and night. Hence, numerous techniques have been suggested for the storage of the solar energy received during the day and its use to heat the water body at night by the greenhouse structure (Omer, 2008). The three Indian major carps *viz.* catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) collectively comprised of the most valuable and popular local commodity of freshwater fishes cultured in Pakistan having high market values. Out of these, *C. catla* is a commercially important carp species and contributes a major share to the freshwater aquaculture production in the Indian subcontinent and has been cultured both in monoculture and polyculture systems and able of attaining a maximum size of 63 kg (Mohanty *et al*., 2013; Taju *et al*., 2013). It is a benthopelagic, potamodromous, inhibits freshwater and brackish areas, omnivorous, can attain 180 cm total length (Rao, 2009). It has a very high adaptability for various kinds of food and is widely distributed in India, Pakistan, Bangladesh, Myanmar and Siam (Gupta and Gupta, 2006; Jayaram, 2010). The low breeding response of *C. catla* together with the low survival at nursery stages compared to *L. rohita* and *C. mrigala* sometimes leads to shortage of its seed supply (FAO, 2011). In Punjab, high mortality and low survival of fry/fingerlings of *C. catla* has been observed during winter season. Resultantly, farmers are losing interest in culture of *C. catla* due to non-availability of the seed of this most popular local major carp. The techniques developed for the rearing of fingerlings of this species during winter season will encourage the farmers for its worldwide culture.

Materials and methods

The greenhouse experiment was conducted in the six earthen ponds present at Fisheries, Research and Training Institute, Manawan, Lahore for a period of twelve weeks starting from 1st December and lasting up till February 28th. It consisted of two treatments with three replicates: Ponds without greenhouse cover (T1= Control) and ponds

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with greenhouse cover (T2= Treatment). The treatments replicates were assigned Completely Randomized Design Model (CRD) i.e., completely at random to experimental subjects (Fish). Manuring and Fertilization was carried out only once by addition of cow dung, DAP and urea @ 500 kg, 9kg and 2kg per acre, respectively, as recommended by the Department of Fisheries Punjab. Hence, fertilizer dose applied was 31.25 kg cow dung + 0.56 kg DAP + 0.13 kg urea, respectively as per size of the earthen ponds (0.5 kanal each). No periodical manuring and fertilization was done as the season of experiment is winter. Physico-chemical studies of water including temperature, Dissolved Oxygen and pH were carried out on weekly basis following Eaton *et al*. (2012).

Bamboo skeleton with 10 feet height at the center were made in an oval shape and were fixed under the guidance of researchers of this project, to all the corners of three randomly selected earthen ponds like a camp. This frame was then covered with a transparent polythene plastic sheet such that it covered all the four sides of the ponds fully and completely to trap the heat inside this cover. Fingerlings of *L. rohita*, *C. mrigala* and *C. catla* were procured from Fish Seed Nursing Farm Farooqabad, district Sheikhupura during September, reared up to November and then shifted to the selected earthen ponds. Stocking density of fish was kept 14,400/ acre; since each pond has an area equal to 0.5 kanal, hence a total of 900 fish fingerlings was added to each pond with a breakup of 300 fingerlings of each selected fish species. Water level was maintained up to the height of four feet in each pond during the entire experiment. Feeding was carried out at the rate of 3% of fish body weight with crude protein level 26.37%, twice a day according to the recommendations of Javaid *et al*. (1988). Fish growth was monitored on fortnightly basis in terms of wet body weight. During test netting, 10 individuals of each species i.e. *L. rohita, C. mrigala* and *C. catla* from each pond were sampled randomly. At the final fortnight, total fish was harvested by draining off the total pond water and weighed to record the total production obtained exactly without any error.

Statistical analysis of the mean values of the data was carried out through SPSS programme (version 16.0) to find out statistically significant differences in growth performance of experimental fish species under both treatments through one-way analysis of variance at $P<0.05$. The post-hoc separate univariate ANOVAs test as a "step down analysis" after Multivariate analysis of variance (MANOVA) was applied on the experimental data.

Results

The results of physico-chemical parameters of water have been shown in Supplementary Table I. The temperature in T1 remained from a minimum of 15.2 °C to a maximum of 23.1°C while in T2 remained maintained from a minimum of 22.1°C to 26.5°C which actually instigated this research to become successful. The data showed that greenhouse cover pronounced the effect of temperature by intensifying it to a certain level which was satisfactory for fish growth enhancements. This is in accordance with the report of FAO (2011) that *C. catla* is a eurythermal species that grows best at water temperature between 25-30°C. The dissolved Oxygen in T1 was found in the ranges from 3.05 mgL^{-1} to 7.69 mgL^{-1} while in T2 between 2.08 mgL^{-1} to 6.78 mgL^{-1}. The data showed that greenhouse cover reduced the DO level but not to too much lower extent and even after reduction, the DO was even then in the suitable range required for fish culture operations. The reduced DO values suggested that the photosynthesis rate was reduced in the treatment with greenhouse cover. Similar findings were attained by Vromant *et al*. (2001) as well as by Frei and Becker (2005) in a study conducted by them who explained that DO reduction may be attributed as a result of amplified mineralization of soil nutrients and their overindulgence into the pond water. The pH for T1 was observed to be from a low level of 8.01 to 8.90 while in T2 from 8.03 to as high as 8.69; which showed not much difference between both the treatment and pH was in suitable ranges.

Table I. Effect of greenhouse cover on ponds on average survival rate (%) of *Labeo rohita, Cirrhinus mrigala* and *Catla catla.*

Sr. No.	Fish species	without cover (n=3)	with cover (n=3)
1	*Labeo rohita*	65%	69%
2	*Cirrhinus mrigala*	57%	73%
3	*Catla catla*	22%	75%

Survival (%) of the *L. rohita, C. mrigala* and *C. catla* fingerlings was calculated by counting total fish at the end of the experiment which remained 65%, 57% and 22% under Treatment 1 and 69%, 73% and 75% in Treatment 2, respectively. The overall Survival rate of total fish in T1 and T2 was observed to be 48% and 72% which is a very prominent difference and made this research a remarkable victory (Table I). Fish growth was determined on fortnightly basis for six fortnights in terms of wet body weight; the results have been presented in Table II. The post-hoc test; multivariate analysis of variance (MANOVA) was applied to test the effect of (with or without) greenhouse system on the weight gain by three selected fish species in polyculture system (Supplementary Table II). Initially,

Table II. Effect of greenhouse cover on ponds on body weight (g, mean ± SD) of *Labeo rohita, Cirrhinus mrigala* and *Catla catla* on fortnightly basis for six fortnights.

Fish	Without cover				With cover			
	0 (n=3)	1 (n=3)	3 (n=3)	6 (n=3)	0 (n=3)	1 (n=3)	3 (n=3)	6 (n=3)
Labeo rohita	9.1±2.78	9.6±2.44	11.8±3.73	16.7±4.91[a]	9.1±1.55	12.9±2.58	18.7±2.56	28.7±9.05[a]
Cirrhinus mrigala	12.7±2.14	16.1±2.4	17.5±2.37	20.0±3.67[b]	12.2±2.39	17.3±1.75	20.7±4.57	31.8±4.96[a]
Catla catla	8.8±1.66	9.6±2.4	12.3±3.10	16.2±4.41[a]	8.6±1.74	9.9±1.86	19.5±5.12	39.3±10.20[b]

there was no significant difference in weights of carps in both treatments but gradually statistically significant differences were obtained between the body weights of three carps. There was no significant difference between the initial weights of carps of both treatments as regards *C. mrigala* and *C. catla,* however, only *L. rohita* differed significantly in body weight gain during 1st fortnight. The 2nd fortnight MANOVA results revealed that there were statistically significant differences obtained between the body weights of *L. rohita* and *C. catla* of two treatments (F= 7.321, p= .001) while that of *C. mrigala* remained non-significant. The post-hoc test (MANOVA) also revealed that body weight of two carps i.e. *L. rohita* and *C. catla* were significantly higher in T2 (with green house) as compared to T1 (without green house) at $p < .05$. Significant differences for all three species i.e. *L. rohita, C. mrigala* and *C. catla* were also observed during 3rd fortnight and found to be F= 26.402, p= .000. The body weights of three species differed significantly at the end of 4th, 5th and 6th fortnights at $p < .05$ and the weights of all the three species were higher in T2 as compared to T1 as is evident from Supplementary Table II. Mean fish body weight increase of *C. catla* was non-significant with *L. rohita* but was significant with *C. mrigala* in T1 while in T2, Mean fish body weight increase of *C. catla* was non-significant with both the other species and remained at the highest. The greenhouse cover had a positive effect on the growth of *C. catla* in the polyculture system with the other major carp species.

Discussion

Fish culture under the greenhouse technique represents an important alternative method of maintaining water temperatures within the acceptable range for fish survival and thereby obtaining high growth rates with low feed conversion rates, due to the effect of temperature on fish metabolism and consequently on food consumption. Our research has been supported by the studies taken up by García-Trejo *et al*., 2016; Hashem *et al*., 2011; Alatorre-Jácome *et al*., 2011. In our experiment, water temperature of fish ponds was increased by using the technique of greenhouse cover. Due to increase in temperature in T2 from 7 to 11 degrees as compared to T1, the survival rate (%) of the carp fingerlings calculated by total counting at the end of the experiment was achieved up to 72% as compared to T1 in which it was only 48%. However, in conventional nursery ponds, the survival rate of *C. catla* is normally lower than that for *L. rohita* and *C. mrigala*. As can be seen in T1 (without greenhouse cover) the survival rate of *C. catla* remained at 22% only as compared to *L. rohita* which was highest with 69% followed by *C. mrigala* with 57% survival rate. But this study showed that under greenhouse cover (T2), the survival rate of *C. catla* was enhanced up to 75% which was even higher than the *L. rohita* (69%) and *C. mrigala* (73%) which made this study a success. Green and Fisher (2004) research also supported our study and proved that higher temperature at 28°C has better impacts on growth, duration and maximum swimming speed of marine fish species *Amphiprion melanopus* as compared to temperatures lower than 25°C. Moreover, the growth data in T1 showed that *L. rohita* attained a maximum average body weight up to 16.7 g which was comparable with *C. catla* with maximum weight up to 16.2 g, however, *C. mrigala* showed better performance than both having 20.0 g at the end of twelve-week experiment. On detail study of data obtained from T2, it was observed that all three fish species have higher growth rates as compared to T1. *L. rohita* had attained a maximum average body weight up to 28.7 g (1.7 times higher than in T1), *C. mrigala* was at 31.8 g (1.6 times higher than in T1) and *C. catla* was at 39.3 g (2.4 times higher than in T1). Among all three carp species cultured in Polyculture system, it was revealed that the performance of *C. catla* was much higher with greenhouse cover.

Conclusion

The study concluded that greenhouse technique has provided amplified survival rates along with magnified growth rates with respect to all the three major carp species cultured in polyculture system, however, the lead remained with *C. catla* which showed maximum growth rates with greenhouse cover. This technique represented a valuable substitutive method for sustaining the water temperature within the desirable ranges in the cold seasons. However,

the main focus of this learning can be visualized from the results shown by *C. catla* where not only the survival rates have been improved but also enhanced growth rate and overall increased production was obtained in comparison to *L. rohita* and *C. mrigala*.

Supplementary material

There is supplementary material associated with this article. Access the material online at: https://dx.doi.org/10.17582/journal.pjz/20200421070402

Statement of conflict of interest

The authors have declared no conflict of interest.

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