Observation of Common Carp (*Cyprinus carpio*) Fry-Fingerlings Rearing in a Greenhouse during Winter Period

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ABSTRACT

An experiment was conducted in open and inside greenhouse condition to identify the influence of water temperature on fish growth and survival at the Indian Institute of Technology Delhi (IITD), India, during winter period (November, 2004 – February, 2005). The common carp (*Cyprinus carpio)* fry 26.15 $\pm$ 0.44 g (total mean weight $\pm$ S.D.) grew to 116.40 $\pm$ 0.92g, 112.80 $\pm$ 0.62g, 90.20 $\pm$ 2.45g and 81.30 $\pm$ 2.60 g in 105 days in tank 1, 2, 3 and 4, respectively. In all the tanks, the fish appeared healthy and no mortality was observed. Inside greenhouse fish production showed significantly ($p<0.05$) higher in comparison with open system. Days 0-15 specific growth rate increased and decreasing trend was observed between 15-90 days. The observed body weight was highly correlated ($r = 0.99$) with predicted body weight. Feed conversion efficiencies (FCE) differed among all tanks, the highest FCE being found inside greenhouse and lowest in open condition. Water quality parameters were acceptable range for fish culture in both the condition. Results show that in even span greenhouse, water temperature can be increased (3.58 – 6.79 ^{o}C) compared with outside tanks in the composite climate of New Delhi.

Keywords: Greenhouse, fish culture, common carp, growth, temperature

1. INTRODUCTION

Water temperature is the most important factors for fish growth were observed by Breett and Groves (1979) and Corey et al. (1983). Jobling (1993) investigated growth rate increases with increasing water temperature, but when the temperature becomes super optimal, it has a negative instead of a simulatory influence. During winter period, in many parts of our country the water temperature drops below 20 ^{o}C and also in Delhi it descends down to 12-15 ^{o}C. Halver (1972) and Jhingran (1985) noticed in low temperature regions, the metabolic activity of fish is greatly reduced, which affects the growth of fish. Since the water temperature in Delhi drops below the desirable range during the months of October- February and in the remaining seven months summer season does not suffice to allow economic yield. Thus, in the tropical climate, extension of the growth period is obligatory in order to enhance the fish production to be economically feasible.

Fish culture is carried out in a variety of systems. Zhu et al. (1998) reported greenhouse ponds are good alternatives to maintain the water temperature. Klemetson and Rogers (1985) studied on greenhouse or plastic shelter pond that could achieve a 2.8 – 4.4 ^{o}C increase in water temperature for each month of the year when compared with an open – air pond. Little and Wheaton (1987) used a solar energy based program to predict water temperature in a greenhouse covered aquaculture pond. It was expected that, on an average, a 9-10 ^{o}C increase in water temperature could be achieved by adding a greenhouse cover. Brooks and Kimball (1983) reported that a 9 ^{o}C rise in water temperature can be achieved in January in Phoenix, USA in a solar heated aquaculture pond. Recently, Sarkar and Tiwari (2005) developed a thermal modeling of a greenhouse fish pond and found even span greenhouse can increased on an average 5.08^{o}C higher water temperature as compared to open pond.

However, aquaculture practice in greenhouse is still in experimental stage in India due to lack of suitable design of greenhouse and not available easily. In addition, higher investments are required. In this field a few authors have claimed on enhance of fish growth inside greenhouse by using common carp species and it was demonstrated in a number of studies by Naegel (1977), Wisely et al. (1981), Wood and. Ghannudi [2] (1985), Bandyopadhyay et al. (2000), Kumar et al. (2000), Mohapatra et al. (2002) and Frei and Becker (2005). As far as fish growth and yield data are concerned in open pond, an extremely wide range is given in the literature, depending largely on the management practices and the species used.

Therefore, the aim of this study was to access the effects of water temperature on growth and survivability of common carp in open and greenhouse condition in winter months.

2. MATERIALS AND METHODS

2.1 Experimental Set-up/Design

An even span greenhouse experiment was carried out from November, 2004 to February, 2005. There were four treatments with triplicate for following condition:

- Case-I: the cylindrical tank of capacity 636 l is buried inside the greenhouse with water level 1.0 m (Tank-1).
- Case-II: the cylindrical tank of capacity 636 l is above the ground kept inside the greenhouse with water level 1.0 m (Tank-2).
- Case-III: the cylindrical tank of capacity 636 l with water level maintained at 1.0 m depth in open condition (Tank-3).
- Case-IV: the cylindrical tank of capacity 318 l with water level maintained at 0.5 m depth in open condition (Tank-4).

To conduct the biological experiment, PVC liner tanks were used (each tank size is 0.9 m diameter and 1.2 m height). Small aquarium aerator was fitted in each tank for providing aeration when the dissolved oxygen level was below the optimal level (Figs.1 shows the experimental set-up inside greenhouse and in open condition).

Figure 1a. Photograph of experimental set-up inside greenhouse

Figure 1b. Photograph of the experimental set–up in open condition

2.2. Description of the Experimental Greenhouse

A roof type of even span greenhouse with effective floor area of 6 x 4 m^2 was used for experimental purposes and covered with transparent UV-stabilized low density polyethylene of 1000 gauge. This type of greenhouse was quite convenient and suitable for Indian climatic condition (Tiwari, 2003). The experimental greenhouse was located in the campus of Indian Institute of Technology (IITD), New Delhi, India (Latitude-$28^o 35^{/}$ N, Longitude – $77^o 12^/$ E and altitude 216 m from mean sea level). The orientation of the greenhouse was from east to west direction. The inclinations of north and south roof were 27^o and 27^o from the horizontal plane to obtain higher solar radiation. Its northern side was made up of a brick wall of 27.5 cm thick. The height to the ridge and the height of north wall were 3m and 2m, respectively. Two vents each of

1m x 1m size were provided one on the north roof and other on the south roof for natural ventilation purposes during over heating inside greenhouse, if any. Two exhaust fans and a door (2 m x 1 m) was also provided in the east wall of the greenhouse for forced ventilation.

2.3. Instruments

Water (T_w), ambient air (T_a) and inside greenhouse air temperature (T_g) were measured by calibrated alcohol- filled, glass- bulb thermometer (least count was 1^oC). An electronic weighing m/c (6kg) with least count of 0.1g was used to measure the weight of fish. The solar intensity was measured with a solarimeter, locally name suryamapi. It measure the solar radiation in (mW/cm^2) having a least count of 2 mW/cm^2 with $\pm$ 2% accuracy over the full-scale range of 0-120 mW/cm^2.

2.4. Biological Experiment

The 105 days growth trial was carried out in triplicate in greenhouse as well as in open condition to evaluate growth performance and survivability during winter months without soil base. The same quantity of water was filled in first three tanks and half in tank 4. Common carp (*Cyprinus carpio*) fry were obtained from Central Institute of Freshwater Aquaculture, Bhubaneswar. After 15 days of acclimatization, the fish were weighed individually following one day of food deprivation with an initial total weight of 26.15 $\pm$ 0.44 g (total mean weight $\pm$ S.D.) were transferred to the rearing tank 1, 2, 3 and 4 @ 4 lakhs/ha (25 nos/tank), respectively. Supplementary feed (Ground nut oil cake 50% and rice bran 50%) was given @ 2% of body weight twice a day. The diet was contained 30% crude protein level. The fish were fed to satitation twice a day (about 10:00 and 15:00). Feed supplied was recorded and uneaten feed was collected after two hours through siphoning everyday. Aeration was provided for duration of half an hour twice in a day. To keep the water temperature remain stable, only 15-20 l water was exchanged everyday which was collected through Siphoning along with uneaten feed and during sampling time only 75% water was replaced with ground water. Since in this locality, there are no alternatives sources to use other than ground water. Ground water was collected in a cemented tank and treated with lime ($CaCO_3$ @ 0.25 mg/l) to maintain desired pH and CO_2 level before using for fish culture. The fish sampling was done once in 15 days interval through out the experiment to obtained length and weight for each species following one day food deprivation.

The observations such as water (T_w), ambient air (T_a) and inside greenhouse air temperature (T_g) were recorded at hourly basis (60 minute interval) for 24 hours once in a week. The obtained observations for T_a, T_g and Tw, have been given in Table 1.

2.5. Monitoring of the Water Quality Parameters

Water samples of the entire period were recorded once in a week at 8.00 and 16.00 hours for pH, dissolve oxygen, total alkalinity and free CO_2. BOD, ammonium nitrogen, nitrate nitrogen and phosphate phosphorus were also measured twice in a month. Water samples were analyzed using standard methods (APHA, 1985). Secchi disk visibility and pH were measured with a Secchi disk and pH meter, respectively.

Table 1: Values of ambient air, inside greenhouse air and water temperature (^{o}C) during the experimental period (mean $\pm$ S.D.)

Week	Ambient air	Inside greenhouse air	Water temperature (greenhouse)		Water temperature (open)	
			Tank-1	Tank-2	Tank-3	Tank-4
0	20.08 ± 4.96	24.16 ± 8.02	24.12 ± 0.83	24.17 ± 1.12	20.67 ± 0.97	20.15 ± 0.78
1	19.38 ± 5.05	23.42 ± 8.32	24.07 ± 0.91	24.01 ± 1.72	20.58 ± 0.86	19.35 ± 0.95
2	18.50 ± 6.05	22.83 ± 8.48	23.62 ± 1.09	23.81 ± 2.20	20.33 ± 1.56	19.65 ± 1.25
3	20.34 ± 3.34	23.42 ± 5.56	22.81 ± 0.54	22.62 ± 1.01	21.07 ± 1.15	20.65 ± 1.10
4	19.92 ± 4.59	24.26 ± 7.62	23.58 ± 0.81	24.25 ± 2.34	20.90 ± 1.22	20.90 ± 1.56
5	18.34 ± 4.27	22.03 ± 6.63	22.32 ± 0.50	21.85 ± 1.47	19.10 ± 1.04	19.23 ± 1.29
6	15.96 ± 5.51	19.97 ± 8.34	20.49 ± 0.76	21.04 ± 2.29	17.66 ± 1.19	17.31 ± 1.22
7	13.99 ± 1.72	18.46 ± 3.39	21.47 ± 0.49	20.55 ± 0.78	17.00 ± 0.46	16.30 ± 0.78
8	10.74 ± 5.28	15.98 ± 7.60	17.53 ± 1.64	17.12 ± 1.86	13.33 ± 1.23	10.74 ± 5.28
9	11.49 ± 4.22	16.07 ± 6.78	18.42 ± 1.04	18.02 ± 1.98	14.53 ± 1.16	14.13 ± 1.14
10	13.58 ± 4.39	18.59 ± 8.21	18.33 ± 0.64	18.63 ± 1.43	14.94 ± 1.00	14.38 ± 1.24
11	12.91 ± 4.12	18.00 ± 7.59	18.95 ± 1.28	18.79 ± 1.37	14.94 ± 1.26	14.46 ± 1.08
12	12.41± 4.23	18.42 ± 8.14	18.41 ± 1.16	18.92 ± 1.43	15.12 ± 1.39	14.62 ± 1.13
13	12.62 ± 5.16	19.09 ± 9.54	18.95 ± 1.06	19.73 ± 1.67	16.18 ± 1.43	15.38 ± 1.41
14	15.46 ± 4.85	23.04 ± 9.42	22.08 ± 1.18	22.30 ± 2.36	19.51 ± 2.28	18.73 ± 1.96

2.6. Growth Parameters

In aquaculture, several models applicable to the concave portion of the growth curve have been used. The formula most commonly used is the ″instantaneous growth rate″ or ″specific growth rate″ (SGR) and is based on the natural logarithm of body weight. The growth was estimated by weighing all fish on 0, 15, 30, 45, 60, 75, 90 and 105 days after a fasting period of 24 h. The specific growth rate (SGR) was calculated as % change in body weight per day according to Brett and Groves (1979)

$$SGR\ (\%) = 100*(\ln FBW - \ln IBW)/day \quad (1)$$

where FBW and IBW are the final and initial mean body weights respectively.
Interindividual variations in body weight were assessed by calculation of the coefficient of variation (CV) was calculated as
CV_w (%) =100* standard deviation* mean body weight.

Changes in the coefficient of variation ($\Delta\ CV_{w,}$ %) during the growth period were calculated as:

$$\Delta\ CV_w(\%) = CV_{t=105} / CV_{t=0} \quad (2)$$

The predicted growth rate in relation to water temperature was calculated based on Cho and Woodward (1989) and Cho (1990).

Thermal unit growth coefficient (TGC) is given by

$$TGC= (FBW^{1/3}–IBW^{1/3})/\sum (temp (^{o}C)*days) \quad (3)$$

and estimated Final body weight (FBW) is given by

$$FBW= [IBW^{1/3}+\sum (TGC*temp (^{o}C) *days)]^{3} \quad (4)$$

Feed conversion efficiency (FCE)

The Feed conversion efficiency (FCE) of the supplementary feeding was calculated as:

$$FCE= (M_f–M_i)/F \quad (5)$$

where M_f is the final fish body mass (g), M_i is the initial fish body mass (g) and F is the total feed dry matter (g)

2.7. Data Analysis

All results are expressed as mean $\pm$ S.D. Comparison of mean values was made by one way-analysis of variance (ANOVA), followed by Duncan's multiple range test at a significance level of $p < 0.05$. Statistical analysis of the data was performed with a statistical package (MS Windows)

3. RESULTS

3.1. Ambient Air, Inside Greenhouse Air and Water Temperature

A higher rearing temperature significantly increased the fish production inside greenhouse, showing down development rate at lower temperature in open condition. A maximum mean ambient and greenhouse air temperature of 20.34 $\pm$ 3.34 ^{o}C and 24.26$\pm$ 7.62^{o}C were observed in the month of November, while the lowest recorded 10.74 $\pm$ 5.28^{o}C and 15.98 $\pm$ 7.60^{o}C in the month of December in open and greenhouse condition, respectively. Regarding water temperature, a maximum value of 24.12 $\pm$ 0.83 ^{o}C, 24.17 $\pm$ 1.12 ^{o}C, 21.07 $\pm$ 1.15 ^{o}C and 20.90 $\pm$ 1.56 ^{o}C were noticed in the month of November for case 1, 2, 3 and 4, respectively. Minimum water temperature of 17.53 $\pm$ 1.64 ^{o}C, 13.75 $\pm$ 1.16 ^{o}C, 13.33 $\pm$ 1.23 ^{o}C and 10.74 $\pm$ 5.28 ^{o}C were recorded in the month of December. The water temperature in greenhouse tanks showed significantly higher values than that of open tank throughout the experimental period (Table 1). Figure 2 showed the hourly variations of water, ambient and inside greenhouse air temperature for a typical day. From this figure it was observed that case-1 showed uniform water temperature throughout the day and night, while case-2 showed higher fluctuations of water temperature. Inside greenhouse air temperature remained higher than the open condition.

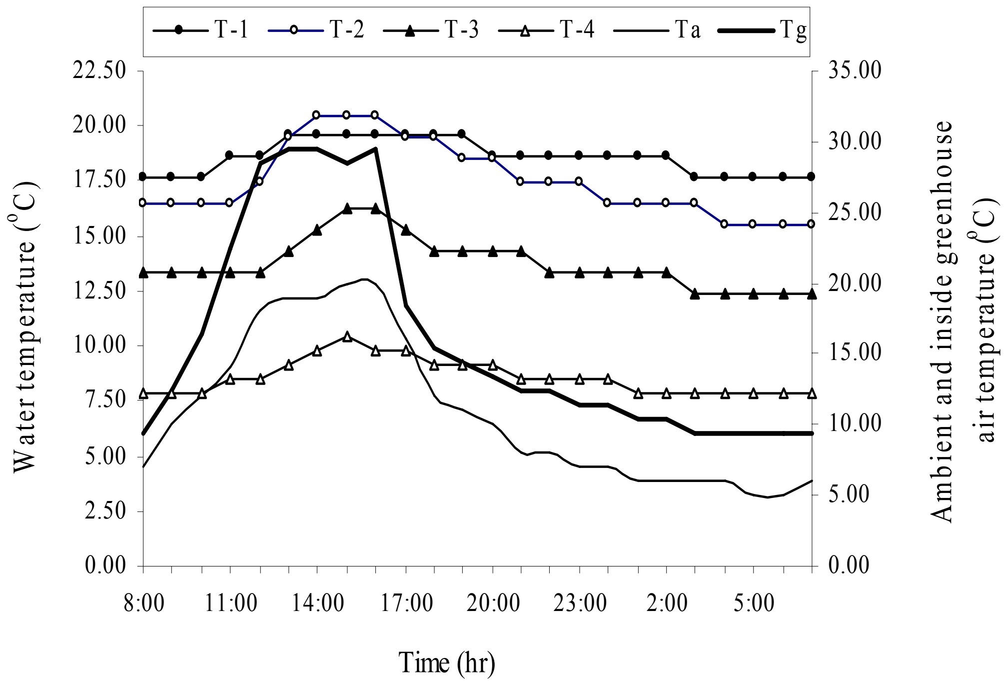

Figure 2. Hourly variations of water, ambient and inside greenhouse air temperature in open and greenhouse condition on 28.12.2004

3.2. Water Quality Parameters

Some water quality parameters are given in Table 2. Water temperature was more in greenhouse and less in open condition during the experimental period. Mean pH in all the tanks ranged from7.6 $\pm$ 0.28 to 8.26 $\pm$ 0.11. There was no significant difference in morning pH value ($p>0.05$), while mean pH value in tank 3 and 4 was significantly higher than that of other tanks ($p<0.05$, Table 2) in the afternoon. Dissolved oxygen level was higher in the afternoon. In the morning significant high dissolved oxygen was in tank 3 and lowest in tank 4, but it was not significantly different from that in the greenhouse tanks. Maximum dissolved oxygen level in the afternoon was found in tank 3, being significantly different from tank 1 and 4 ($p<0.05$, Table 2). Free CO_2 was higher in the morning. The lowest value was in tank 3 being sufficiently different from other tanks in the morning as well as in the afternoon. Total alkalinity was found in the range of 364.36 $\pm$ 39.44 to 405.36 $\pm$ 27.91mg/l as $CaCO_3$. There was significant difference between tank 1 and 4 ($p<0.05$) in the morning and same pattern was followed in the afternoon. No significant differences were found for mean NH_4^+-N, NO_3-N, PO_4-P, BOD and turbidity among all the tanks ($p>0.05$, Table2).

3.3. Growth Performance and Feed Efficiency

Mean individual weight of common carp in all the tanks increased over the 105 days of the experiment (Fig.3). The tank 1 and 2 showed highly significant between days 90-105 only, but for other tanks were highly significant through out the experimental period. Variations in total weight of common carp fry reared in greenhouse and open condition are enumerated in figure 4. From this figure it was observed that the total body weight increased from 26.15 $\pm$ 0.44 g to 116.40 $\pm$ 0.92 g, 112.80 $\pm$ 0.62 g, 90.20 $\pm$ 2.45 g and 81.30 $\pm$ 2.60 g for tank 1, 2, 3 and 4, respectively. There were significant differences among all the treatments ($p<0.05$). In all the tanks, the fish appeared healthy and no mortality was observed. Common carp growth in the tank-1 was best in terms of weight gain and significantly higher than that in tank 2. However, yield performance in both the tanks inside greenhouse was significantly higher than that in the open condition. The increasing order of weight gain through out the experimental period was followed by tank-1>2>3>4. Figures 5 showed the variations of observed and predicted body weight using TGC and SGR growth coefficient. The observed body weight was compared with predicted body weight and showed highly correlated with a coefficient of correlation ($r = 0.99$) in all the cases and root mean square percent deviation in the range of ($e = 4.87–5.23\%$), respectively. There were no significant differences of specific growth rate between tank 1 and 2 ($p>0.05$), but in other tanks it was significantly different ($p<0.05$, Table 3). Days 0-15 specific growth rate increased and decreasing trend was observed between 15-90 days. Further, specific growth rate was increased from 90-105 days. Feed conversion efficiencies (FCE) differed among all tanks, the highest FCE being found in tank 1, and lowest in tank 4. The differences of FCE values in tank 1 and 2 was not significant ($p>0.05$) where as, others were highly significant ($p<0.05$, Table 3). Significant differences in coefficient of variations for individual mean weight related to different tanks were observed ($p<0.05$). Coefficient of variations (ΔCV) being higher in tank 3 and lower in tank 1. In case of tank 1 and 2 Δ CV was not significant ($p>0.05$), while there was significant differences observed in tank 3 and 4 ($p<0.05$, Table 3).

4. DISCUSSION

4.1. Ambient Air, Inside Greenhouse Air and Water Temperature

The temperature is an important parameter for fish growth. In an open - air pond, temperature variation of only a few degrees represents a proportionally large change for fish growth and survivability (Wurtsbaugh and Davis, 1977; Cui and Wootton, 1988). Water temperature can be maintained higher in greenhouse fish pond system (Klemetson and Rogers, 1985; Little and Wheaton, 1987 and Zhu et al., 1998). From our study, it can be observed that inside greenhouse air temperature higher than in open condition. The rise in temperature due to greenhouse effect and reduced heat losses from greenhouse to ambient condition are responsible for the increase of greenhouse air temperature. Water temperature inside greenhouse tanks also showed higher than in open condition. The tank 2 showed higher water temperature in day time between 13:00-16:00 hours due to large variations of water and inside greenhouse air temperature resulting higher fluctuations of water temperature and fast release of heat in night time. Incase of tank 1, which was buried in the ground showed uniform water temperature through out the day due to contact with earth, which has higher heat capacity. Temperature of ground at the depth of about 1 m is constant (ASHRAE, 1982). For the climate of Delhi, this temperature remains in the range of 22-28 ^{o}C (Khatry et al., 1978), which is normally higher in winter and lower in summer than the temperature of ambient air. Hence, water temperature in tank 1 showed uniform due to exchange of heat between soil and water through conduction. The tank 3 and 4 in open condition shows lower water temperature due to continuous heat losses from the tanks to the ambient through conduction, convection, evaporation and radiation (Tiwari, 2002 and 2003). While in tank 4 water temperature is quite below in comparison with tank 3. The solar radiation do not reaches at the surface of water due to smaller water depth in comparison with height of the tank resulting shadow on the water surface. Results show that in greenhouse, water temperature can be increased (3.58 – 6.79 ^oC) compared with outside tanks in the climatic condition of New Delhi.

4.2. Water Quality Parameters

According to Goldman (1983), values of pH provide an index of general chemical environmental conditions of any aquatic ecosystem. The pH of all the tanks showed almost alkaline during the experimental period due to more bicarbonate ion present and less in organic matter. The decline in pH value during morning was probably due to surplus amount of free CO_2 present in water. Higher pH in open tanks suggests an increased rate of photosynthesis as compared to the greenhouse tanks. During experimental period tank 3 showed significantly lower free CO_2 concentration compared to other tanks due to higher dissolved oxygen. Dissolve oxygen level at morning was rather low in all cases. In contrast, dissolve oxygen level in the afternoon was quite high due to lower water temperature. Similar results were obtained by Kumar et al. (2000), Frei and Becker (2005).

Total alkalinity recorded higher values during daytime, which may be due to accumulation of larger quantities of bicarbonates by the liberation of CO_2 in the process of decomposition of organic matter, which primarily resulted in the conversion of insoluble carbonates of calcium into soluble bicarbonates. Due to lower BOD values in all the tanks indicated the occurrence of lower amount of organic matters and thereby, less possibilities of oxygen depletion. Phosphorous is considered as the most critical nutrient element in the maintenance of pond productivity (Jhingran, 1985). The availability of PO_4-P in all the tanks was less than optimum range due to higher pH value. No significant differences were found for NH_4^+-N and NO_3-N, Secchi disk visibility is a simple measure for turbidity. However, results of the present study did not show any significant difference between greenhouse and open tanks.

4.3. Growth Performance and Feed Efficiency

There are very few reports available of common carp rearing in greenhouse in India and abroad. Studies on several fish species have prevailed that with increase in water temperature, the specific growth rate (SGR) increases at higher levels and decreases at lower levels (Wurtsbaugh and Davis, 1977; Cui and Wootton, 1988). In this study prevailing higher water temperature inside greenhouse showed higher specific growth rate (SGR) in comparison with open condition. Tilapia and common carp cultured in greenhouse showed significant increase in weight (Naegel, 1977).

Table 2: Values of water quality parameters measured in open and inside greenhouse tanks (mean ± S.D.)

Parameters	No. of observation	Sampling Time (hrs)	Greenhouse		Open	
			Tank-1	Tank-2	Tank-3	Tank-4
pH	14	8.00	7.6 ± 0.28 [a]	7.72 ± 0.26 [a]	7.77 ± 0.29 [a]	7.74 ± 0.13 [a]
	14	16.00	7.78± 0.09 [b]	7.84 ± 0.12[b]	8.10 ± 0.10 [a]	8.26 ± 0.11 [a]
Dissolved oxygen (mg/l)	14	8.00	5.53 ± 0.19 [b]	5.56 ± 0.18 [b]	5.77 ± 0.35 [a]	5.43 ± 0.11 [b]
	14	16.00	7.48 ± 0.44 [b]	7.88 ± 0.66 [a]	8.06 ± 0.57 [a]	7.41± 0.54 [b]
Free carbon dioxide (mg/l)	14	8.00	22.36 ± 3.25 [b]	21.36 ± 3.08 [b]	16.79 ± 2.67 [a]	21.93 ± 3.71 [b]
	14	16.00	10.64 ± 3.86 [b]	9.71± 3.45 [b]	8.36 ± 2.92 [a]	12.00 ± 4.04 [b]
Total alkalinity (mg/l)	14	8.00	364.36 ± 39.44 [b]	371.79 ± 40.27 [ab]	393.57 ± 43.30 [ab]	396.79 ± 44.70 [a]
	14	16.00	381.07 ± 42.57 [b]	394.14 ± 29.94 [ab]	404.29 ± 26.74 [ab]	405.36 ± 27.91 [a]
NH_4^+ - N (mg/l)	7	-	0.02 ± 0.1 [a]	0.02 ± 0.01 [a]	0.02 ± 0.01 [a]	0.04 ± 0.01 [a]
NO_3 - N (mg/l)	7	-	0.21 ± 0.08 [a]	0.20 ± 0.04 [a]	0.19 ± 0.03 [a]	0.24± 0.04 [a]
PO_4-P (mg/l)	7	-	0.07 ± 0.01 [a]	0.07 ± 0.01 [a]	0.06 ± 0.01 [a]	0.04 ± 0.01 [a]
BOD (mg/l)	7	-	4.84 ± 1.42 [a]	5.44 ± 1.45 [a]	5.46 ± 0.53 [a]	6.06 ± 1.39 [a]
Turbidity (cm)	7	-	29.57 ± 11.91 [a]	28.86 ± 7.10 [a]	29.86 ± 12.20 [a]	32.00 ± 10.68 [a]

Mean values with different superscript letters in the same row were significantly different ($p< 0.05$).

Table 3: Values of specific growth rate, feed conversion efficiencies and changes in coefficients of variation of body weight after 105 days of rearing in open and greenhouse (mean ± S.D., n =3).

Treatment	SGR (%/day)	FCE	Δ CV (%)
T-1	1.40 ± 0.05^{a}	0.80 ± 0.05^{a}	0.18 ± 0.01^{a}
T-2	1.38 ± 0.06^{a}	0.78 ± 0.03^{a}	0.23 ± 0.04^{a}
T-3	1.18 ± 0.03^{b}	0.67 ± 0.04^{b}	0.58 ± 0.03^{b}
T-4	1.10 ± 0.03^{c}	0.53 ± 0.04^{c}	0.39 ± 0.02^{c}

Mean values with different superscript letters in the same column were significantly different ($p < 0.05$).

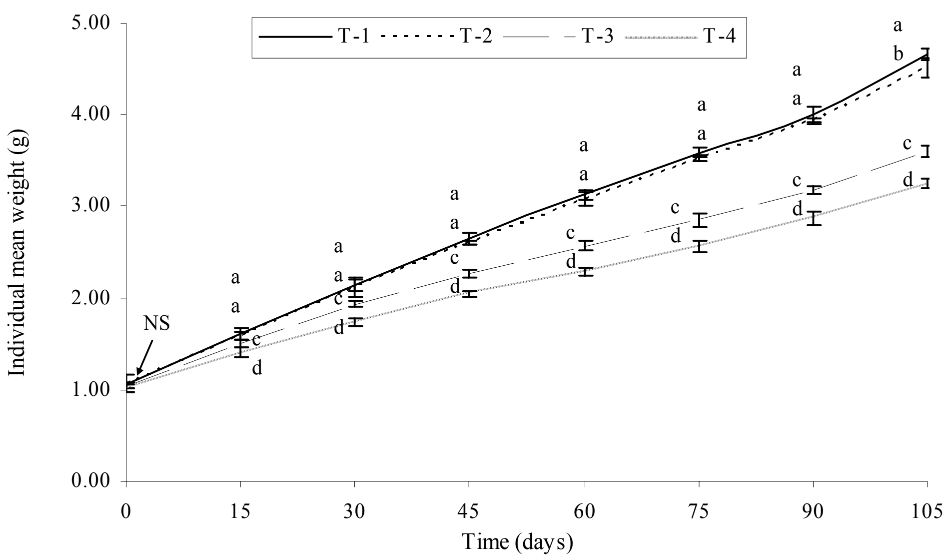

Figure 3. Changes of mean weight over time in open and inside greenhouse tanks

(mean ± S.D., n =3)

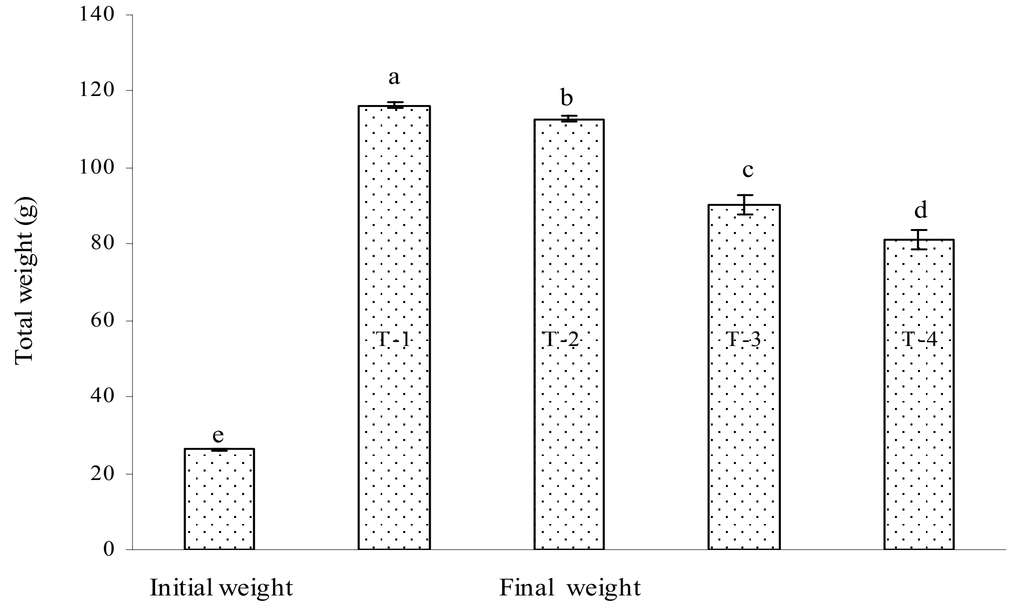

Figure 4. Total weight at the begging of the growth trial and after 105 days of rearing in open and inside greenhouse (mean ± S.D., n = 3). Significance differences between groups are indicated with different letters.

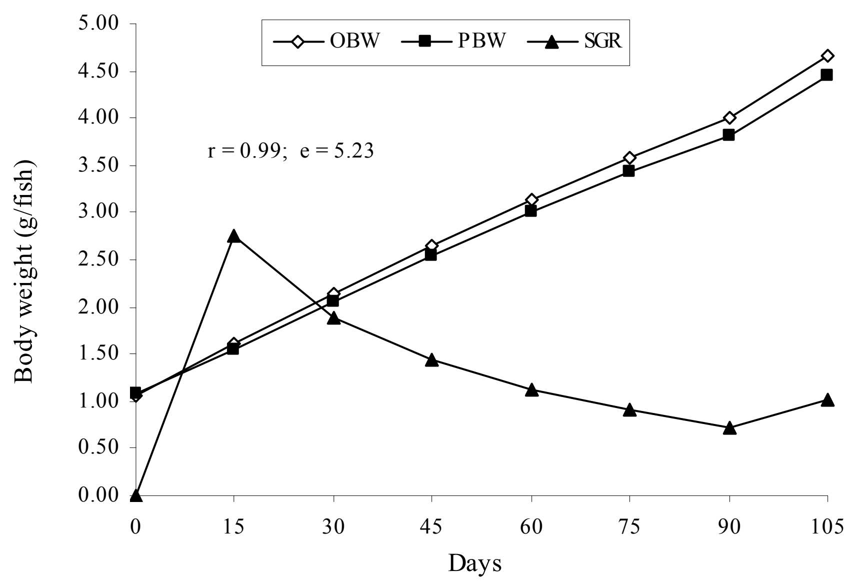

Fig. 5a Variations of observed and predicted body weight using TGC and SGR growth coefficient in tank-1

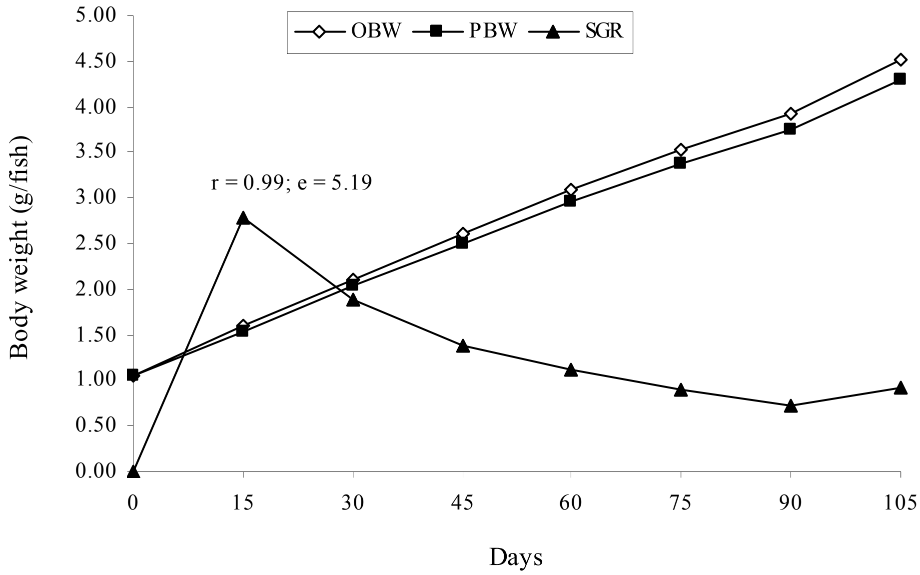

Fig. 5b Variations of observed and predicted body weight using TGC and SGR growth coefficient in tank-2

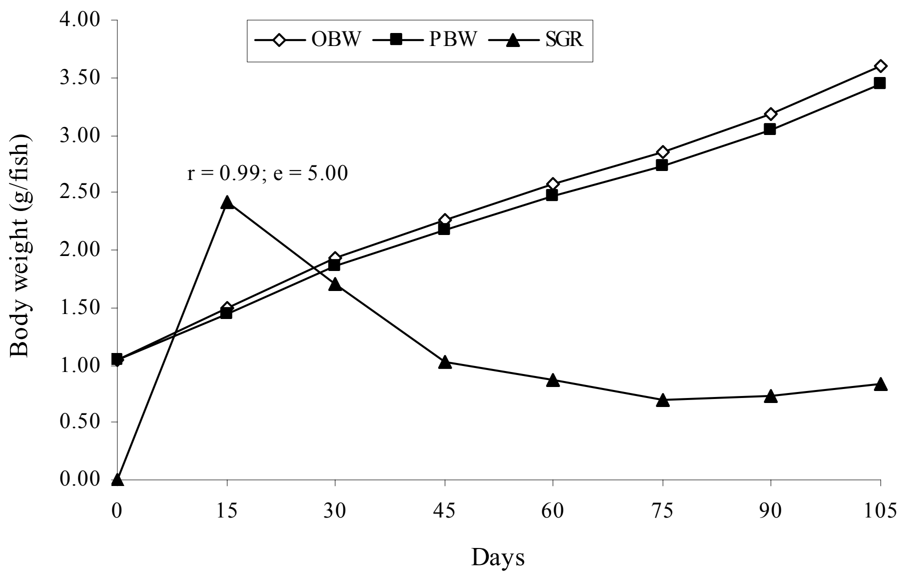

Fig. 5c Variations of observed and predicted body weigh using TGC and SGR growth coefficient in tank-3

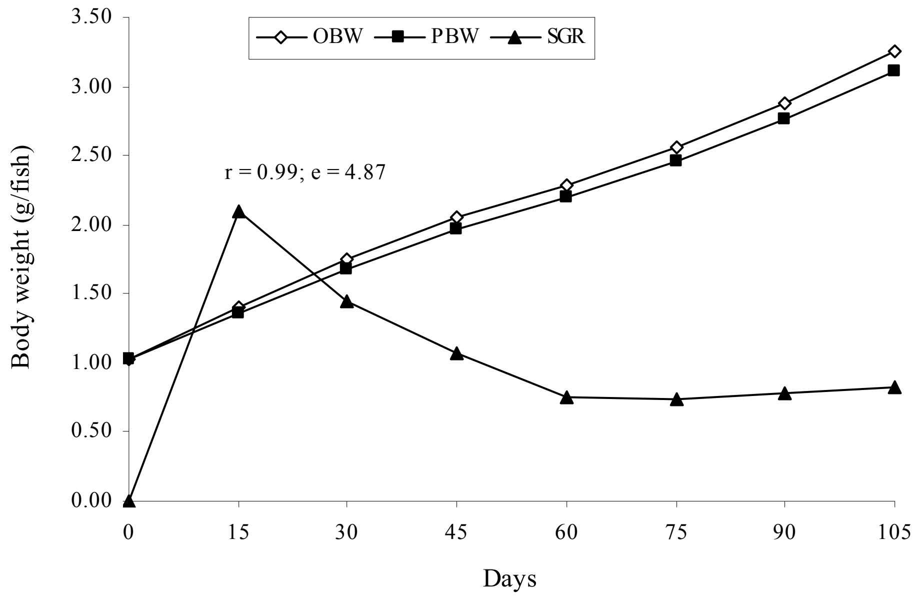

Fig. 5d Variations of observed and predicted body weight using TGC and SGR growth coefficient for tank-4

Another study was carried out in Libyan (Wood and Ghannudi[2], 1985) stated steady increase in growth except winter months. Kumar (2000) reported common carp fingerlings rearing in a greenhouse pond in the Himalayan region@ 10,000/ha and found higher growth rate inside greenhouse 81% and 11% in open condition for five months. In a field experiment Mohapatra et al. (2000) reported 45% growth rate of common carp spawn in the greenhouse pond for 20 days. Our results showed significantly better growth and yield performance of common carp, compared to open tanks. However, yield was quite below due to higher stocking density. Greenhouse tanks were attributed apparently to more water temperature available resulting higher weight gain at significant level, while daily specific growth rate was not significant. On the other hand, the fish reared in open condition delivered a lower fish yield due to lower water temperature. From this study it was noted that specific growth rate (SGR) increase as temperature increased and vice-versa. It is clearly indicated that specific growth rate (SGR) is strongly dependent on water temperature. The results of this study predicted at 0-15 days period SGR was more in all the tanks compared to other periods of exposure due to higher water temperature during this period. The SGR of common carp fry was affected to a similar degree by under ground and above the ground tanks inside greenhouse; where as, for tank 4 specific growth rate declined to a great extent as compared to tank 3 in open condition, which reflects higher stocking density in tank 4, fishes have to spend more energy towards their maintenance to overcome the environmental stress. Coefficients of variation of weight (Δ CV) changed little over time and were not similar between greenhouse and open tanks.

In open condition, growth rate was markedly dropped due to poor feed intake. The best feed conversion was found in tank 1 and 2 inside greenhouse due to prevailing higher water temperature though the FCE values are quite below the desirable range. The observation showed that in open pond, the fishes did not accept the supplementary feed, might be attributed to very low temperature causing severe stress to the fish as reported by Halver (1972). It can be concluded that the decrease in specific growth rate with increase in body size was mainly caused by a decrease in relative food intake.

5. CONCLUSION

The use of greenhouse allows aquaculture operations to be sited in colder climates or closer to markets where conventional heating may not be economical. Hence by adopting greenhouse fish pond technology, the year round growth of fish could be achieved through controlled environment.

On an average, the passive even span greenhouse with north brick wall can increase 3.58 – 6.79 ^{o}C higher temperature, as compared with the outdoor pond in the composite climate of Delhi.

For uniform water temperature inside the greenhouse, the tank should be buried in the ground.

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