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# Optimization of grass carp for supplementing feed and fertilizer in carp polyculture

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**Abstract**
An experiment in carp polyculture was conducted at Regional Agricultural Research Station, Parwanipur, Bara, Nepal for a culture period of six months (1st December 2014 to 31st May 2015) in a completely randomized design with five treatments (T1, T2, T3, T4, and T5) replicated thrice in 15 research units of 100 $m^2$ each. Silver carp, bighead carp, rohu, mrigal and common carp were used as stocking materials in all the treatments @ 0.4, 0.2, 0.3, 0.05 and 0.05 fish/$m^2$ respectively. Grass carp was used @ 0.0, 0.1, 0.2, 0.3, 0.4 fish/$m^2$ in T1 (Control), T2, T3, T4 and T5 respectively. Fertilization was performed biweekly with urea and di-ammonium phosphate @ 0.4g N/$m^2$/day and 0.1 g P/$m^2$/day. Supplementary feed (mustard oil cake and rice bran) was supplied @ 2% body weight of common carp and mrigal. Chopped fresh para grass was provided @ 20% body weight of grass carp. The water quality parameters were within suitable range for fish culture. Extrapolated net fish yield (t/ha/yr) was found the greatest in T5 (2.98±0.07) among all treatments. T3 (2.79±0.18) and T4 (2.72±0.23) were significantly different from T1 (2.04±0.14) ($p$<0.05), while T2 (2.58±0.09) was not significantly different from T1 ($p$>0.05). However, benefit cost ratio (B/C) was found the highest in T3 (2.86±0.17) among all treatments which was significantly different from T1 (2.20±0.11) ($P$<0.05) but not significantly different from T2 (2.62±0.18), T4 (2.68±0.21) and T5 (2.79±0.02) ($p$>0.05). The inclusion of grass carp reduced food conversion ratio of common carp and mrigal (1.59±0.11) in T3 as compared to T1 (2.07±0.48), which indicated that the excreta of grass carp acted as a source of feed for bottom feeders too. The result of this experiment indicated that grass carp stocked at 0.2 fish/$m^2$ (T3) in carp polyculture proved a more profitable and cost effective than rest all the treatments.

**Keywords:** Carp polyculture**,** grass carp, supplementary feed, para grass

## 1. Introduction
Carp polyculture is mainly practiced in southern tropical region of Nepal characterized by freshwater pond aquaculture involving three species of Indian major carps, rohu (*Labeo rohita*), catla (*Catla catla*) and mrigal (*Cirrhinus mrigala*), and species of large exotic carps including silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Aristichthys nobilis),* grass carp (*Ctenopharyngodon idella*) and common carp (*Cyprinus carpio*). Polyculture results in high yield as the pond niches are fully utilized by fish species of different feeding habits (Amir *et al*., 2013) [2].
Grass carp (*Ctenopharyngodon idella*) as the name signifies, feeds on soft and hard water weeds, leaves of plant and forages (Shrestha and Yadav 1998) [28]. Due to incomplete digestion, the major portion of plant consumed by the fish returns to the pond in form of excreta (Woynarovich, 1975) [31]. There are different forages and plants such as para grass (*Brachiaria mutica*), napier grass (*Pennisetum purpureum*) and leaves of banana (*Musa paradisica*) have been used as food for grass carp. Excreta of grass carp acts as a source of feed and fertilizer (Pandit *et al*., 2004 and Shaha *et al*., 2015) [21, 24]. Para grass (*Brachiaria mutica*) is high yielding tropical forage that is accepted by grass carp and can produce a reasonable yield (Guerrero *et al*., 1988) [10]. Farmers in this region sown para grass on pond bank which is perennial in nature.
Fertilization and feed supplementation in a pond is an effective way to increase growth performance in polyculture (Ekram, 2002) [7]. Fish feed alone consists of 60% of production cost and the protein component is the most expensive in overall feed cost (Sheunn *et al*., 2003 and Erondu *et al*., 2006) [26, 8]. So, to minimize the supplementary feed and its cost in carp polyculture, grass carp in different stocking rates might be tested to sustain other species. In the present study, the optimal stocking rate of grass carp fed with para grass has been determined in an economical way.

## 2. Materials and Methods

### 2.1. Experimental design

The experiment was conducted in completely randomized design (CRD). There were five treatments and each with three replications. The stocking rates of silver carp, bighead carp, rohu, mrigal and common carp were 0.4 fish/m$^2$, 0.2 fish/m$^2$, 0.3 fish/m$^2$, 0.05 fish/m$^2$ and 0.05 fish/m$^2$ in T1, T2, T3, T4 and T5 respectively and those of grass carp were 0.1 fish/m$^2$, 0.2 fish/m$^2$, 0.3 fish/m$^2$, 0.4 fish/m$^2$ in T2, T3, T4 and T5 respectively being T1 as control (Table 1). The stocking proportion of silver carp, bighead carp, rohu, mrigal, common carp were 40:20:30:5:5 respectively in all treatments and those of grass carp were maintained 10:20:30:40 in T2, T3, T4 and T5 respectively.

### 2.2. Experimental site and Pond preparation

The experiment was conducted at Regional Agricultural Research Station, Parwanipur, Bara, Nepal from 1st December 2014 to 31st May 2015 (182 days) in three earthen ponds of 500 m$^2$ each having five partitions of 100 m$^2$ with nylon mosquito net so as to maintain 15 research units (Figure 1). Calcium carbonate was then applied @ 5kg/100 m$^2$ (Gupta and Rai, 2011) [11] to each research unit and left for one week. The dip boring water was stored in a tank from which water was filled simultaneously to research units. The water depth of 0.80 m was maintained throughout the experimental period. Research units were fertilized with inorganic fertilizers i.e. urea and di-ammonium phosphate (DAP) @ 0.4g N/m$^2$/day and 0.1 g P/m$^2$/day (Shrestha and Pandit, 2007) [27] before a week of fish stocking and repeated biweekly.

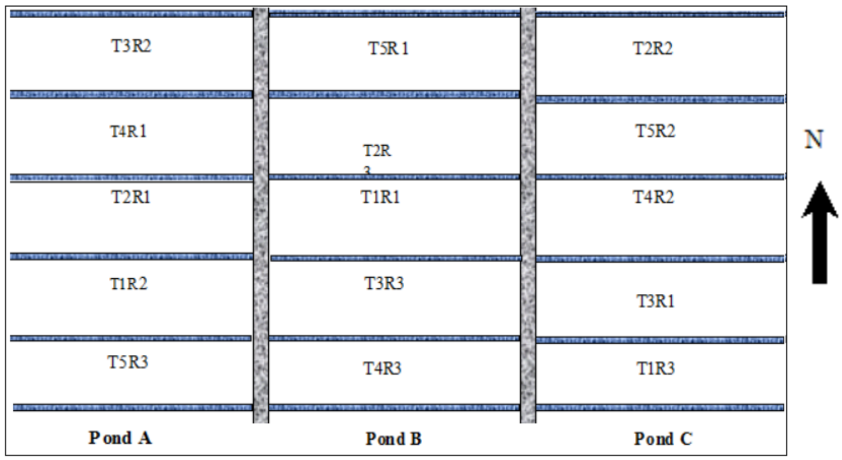


**Fig 1:** Randomly distributed research units

**Table 1:** Experimental design

| Treatments | No. of replication | Stocking rate (fish/m$^2$) and number of individual species (figures in the brackets represent stocking ratios) in each treatment | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Silver carp | Bighead carp | Rohu | Mrigal | Common carp | Grass carp | Stocking density |
| T1 | 3 | 0.4(40) | 0.2(20) | 0.3(30) | 0.05(5) | 0.05(5) | 0 | 100 |
| T2 | 3 | 0.4(40) | 0.2(20) | 0.3(30) | 0.05(5) | 0.05 (5) | 0.1(10) | 110 |
| T3 | 3 | 0.4(40) | 0.2(20) | 0.3(30) | 0.05(5) | 0.05(5) | 0.2(20) | 120 |
| T4 | 3 | 0.4(40) | 0.2(20) | 0.3(30) | 0.05(5) | 0.05(5) | 0.3(30) | 130 |
| T5 | 3 | 0.4(40) | 0.2(20) | 0.3(30) | 0.05(5) | 0.05(5) | 0.4(40) | 140 |

### 2.3. Feeding Schedule

Finely chopped para grass, as a feeding material was used @ 20% total body weight (BW) of grass carp. Supplementary feed having 25% crude protein (CP) was prepared by mixing 93.4% of mustard oil cake (26.2% CP) and 6.6% of rice bran (8.2% CP). It was supplied @ 2% body weight of common carp and mrigal daily at 2-3 p.m. Fish were fed all the day except Saturday, so as to allow them to feed on residues and to improve the pond water quality. The ration was adjusted monthly after fish sampling. Proximate analyses of para grass and feed ingredients were done using AOAC (1980) [3].

### 2.4. Water quality parameters

Water quality parameters like dissolved oxygen (DO) and temperature, pH, total dissolved solids, conductivity and transparency were measured using DO meter (Orion-1230), pH meter (HANNA-HI-96107), TDS meter (HANNA-HI-98302), conductivity meter (HANNA-HI-8633) and secchi disk respectively in every two weeks *in situ* at 7.00-9.00 from depth of 25 cm starting from 1st December 2014.

### 2.5. Fish Growth Measurement

15% of cultured fish species were captured randomly using drag net for monthly sampling. Growth parameters like total weight gain (kg/100 m$^2$), gross fish yield (GFY), net fish yield (NFY), survival rate and Feed conversion ratio (FCR) were calculated at the end of harvest.

### 2.6. Economic analysis

Benefit cost ratio (B/C) was performed to estimate the net profit in carp polyculture. The local market prices of all inputs and outputs in Bara district of Nepal were used in the economic analysis. The analysis excluded the labour cost as rural farmers use family members to get the work done.

### 2.7. Statistical analysis

Experimental data were analyzed by using MSTATC (version 1.3, 2075). One way ANOVA was performed for test of significance at alpha level of 0.05 ($p$<0.05). Means were compared by DMRT ($p$<0.05). All means were given with ± standard error (S.E.).

## 3. Results

Proximate composition (%) of fresh para grass and feed ingredients is presented in Table 2. Chopped para grass contained crude protein of 7.21% and crude fibre of 36.12%. Mustard oil cake and rice bran contained crude protein of 26.2% and 8.2% respectively.

**Table 2:** Proximate composition (%) of fresh para grass and feed ingredients (Mean ± S.E.)

| Parameters | Fresh para grass | Mustard oil cake | Rice bran |
|---|---|---|---|
| Dry matter (%) | 20.67±1.45 | | |
| Crude protein (%) | 7.21±0.30 | 26.2±0.56 | 8.2±1.02 |
| Crude fiber (%) | 36.12±0.65 | | |
| Crude fat (%) | 6.67±0.12 | | |
| Ash (%) | 12.0±1.30 | | |
| Nitrogen Free Extract (NFE) | 38±4.20 | | |

NFE= (100- other constituents)

The biweekly mean dissolved oxygen during the course of experiment ranged from 5.8-10 mg/l (Table 3 and Figure 2), water temperature ranged from 14-30.4˚C (Table 3 and Figure 3), pH ranged from 7.6-8.9 (Table 3 and Figure 4), conductivity ranged from 270- 446.3 µs/cm (Table 3 and Figure 5), total dissolved solids ranged from 110-144 mg/l (Table 3 and Figure 6) and transparency ranged from 20-41 cm (Table 3 and Figure 7) respectively. All of the water quality parameters measured during the experimental period were not significantly different among treatments ($p>0.05$; Table 3).

**Table 3:** Summary of water quality parameters in different treatments during experimental period (Mean±S.E.). Figures in the brackets denote ranges.

| Parameters | Treatments | | | | |
|---|---|---|---|---|---|
| | T1 | T2 | T3 | T4 | T5 |
| Dissolve oxygen(mg/l) | 7.1±0.3<br>(6 - 7.3) | 7.1±0.3<br>(6 - 9.93) | 7.1±0.3<br>(6.2-9.7) | 7.0±0.3<br>(6.1-10) | 6.8±0.3<br>(5.8-7.7) |
| Temperature (̊C) | 22.3±1.4<br>(14-30.4) | 22.2±1.4<br>(14-30.2) | 22.7±1.4<br>(14-30.6) | 22.7±1.4<br>(14-30.5) | 22.6±1.4<br>(14-30.3) |
| pH | 8.0±0.08<br>(7.6-8.7) | 8.1±0.08<br>(7.6-8.7) | 8.0±0.08<br>(7.6-8.7) | 8.0±0.07<br>(7.6-8.7) | 8.1±0.08<br>(7.8-8.9) |
| Conductivity (µs/cm) | 355±15.3<br>(280-429.6) | 346.5±15.3<br>(270-429.0) | 353.7±16.4<br>(270-435.6) | 358.1±16.4<br>(270-433.6) | 354.3±15.3<br>(270-446.3) |
| Total dissolved solid (mg/l) | 126.6±2.6<br>(117.3-144) | 124.7±2.4<br>(115-143) | 125.2±2.6<br>(115.3-142) | 126.8±2.9<br>(110-143.7) | 126.5±2.5<br>(115-142.7) |
| Transparency (cm) | 32±1.0<br>(26-35) | 32±1.4<br>(21-41) | 30±1.4<br>(22-41) | 28±1.0<br>(23-34) | 24±1.4<br>(20-38) |

Mean values with different superscript letters in the same row are significantly different ($P<0.05$)

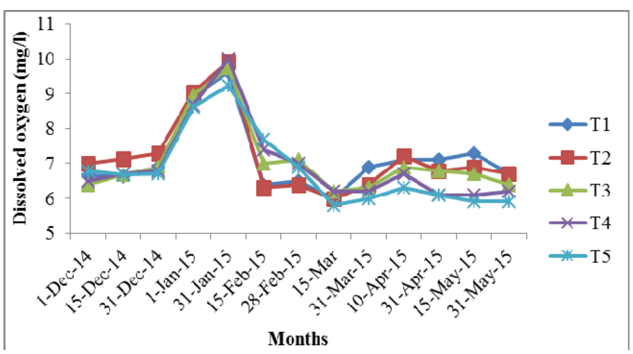


**Fig 2:** Biweekly mean dissolved oxygen (mg/l) in different treatments.

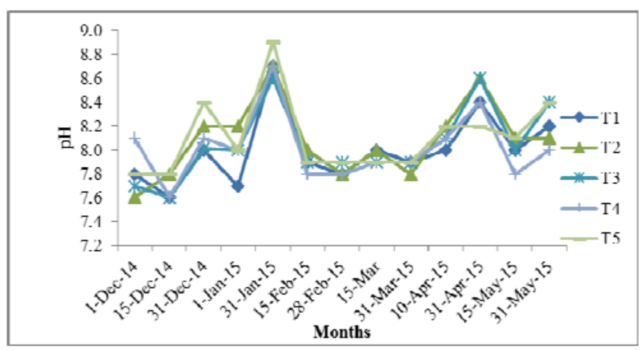


**Fig 4:** Biweekly mean pH in different treatments

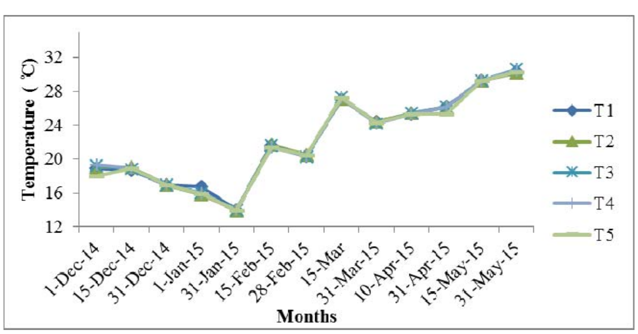


**Fig 3:** Biweekly mean temperature (˚C) in different treatments

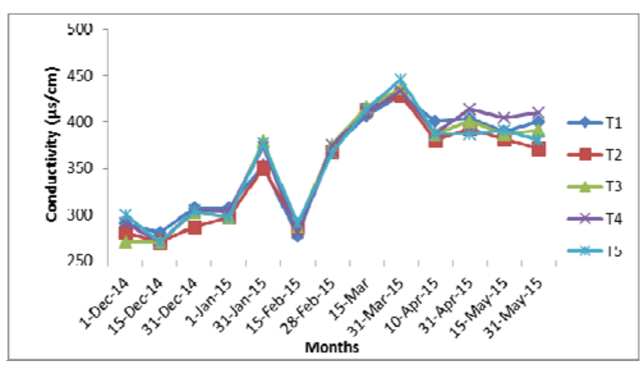


**Fig 5**: Biweekly mean conductivity (µs/cm) in different treatments

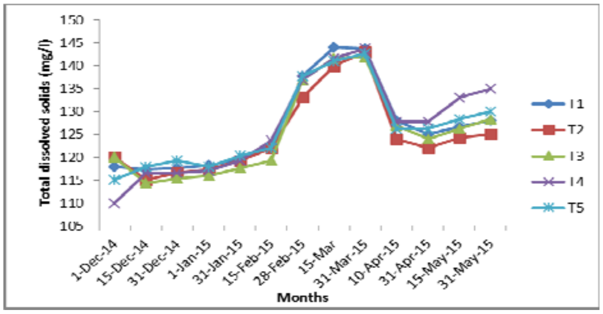


**Fig 6:** Biweekly mean total dissolved solids (mg/l) in different treatments

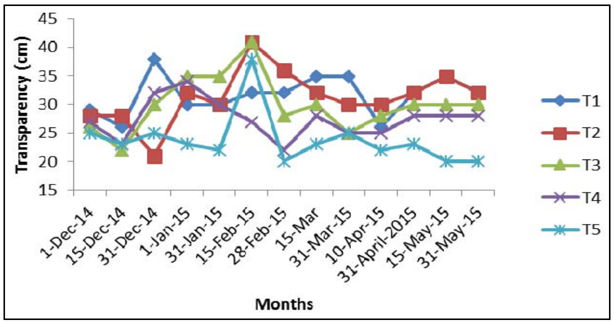


**Fig 7:** Biweekly mean transparency (cm) in different treatment

Initial mean weight (wt) of different species (silver carp, bighead carp, rohu, mrigal, common carp and grass carp) were not significantly different among treatments ($p$>0.05; Table 4). Final mean wt was greatest in T2 (165.85±7.60 g) followed by T3 (156.18±10.02 g), T4 (154.20±14.64 g), T5 (148.41±3.42 g) and T1 (144.18±11.81 g) which were not significantly different ($p$>0.05; Table 4). Total wt gain was obtained the greatest in T5 (14.86±0.34 kg) among all treatments which was significantly different from T1 (11.28 ±0.74 kg) ($p$<0.05), but not significantly different from T2 (12.88±1.10 kg), T3 (13.93±0.91 kg) and T4 (13.55±1.15 kg) ($p$>0.05). Total harvest wt (kg/pond) was found greatest in T5 (17.03±0.11 kg) followed by T3 (16.35±1.10 kg), T4 (15.96±1.14kg), T2 (14.72±0.90 kg) and T1 (11.85±0.81 kg) among which T2, T3 and T4 were not significantly different from T5 ($p$>0.05) but were significantly different from T1 ($p$<0.05). Extrapolated gross fish yield and net fish yield were found the greatest in T5 among all treatments. T3 and T4 were significantly different from T1 ($p$<0.05) while T2 was not significantly different from T1 ($p$>0.05; Table 4). Survivality of different species were not significantly different among treatments ($P$>0.05; Table 4).

**Table 4:** Growth parameters of different species for carp polyculture including grass carp (Mean±S.E.)

| Parameters | Treatments | | | | |
|---|---|---|---|---|---|
| | T1 | T2 | T3 | T4 | T5 |
| Initial mean weight (g/fish) | 17.57±2.23$^{a}$ | 16.70±2.14$^{a}$ | 20.17±2.73$^{a}$ | 18.57±1.74$^{a}$ | 15.27±1.94$^{a}$ |
| Final mean weight (g/fish) | 144.18±11.81$^{a}$ | 165.85±7.60$^{a}$ | 156.18±10.02$^{a}$ | 154.20±14.64$^{a}$ | 148.41±3.42$^{a}$ |
| Total weight gain (kg/100 $m^2$) | 11.28±0.74$^{b}$ | 12.88±1.10$^{ab}$ | 13.93±0.91$^{ab}$ | 13.55±1.15$^{ab}$ | 14.86±0.34$^{a}$ |
| Total harvest weight (kg/100 $m^2$) | 11.85 ±0.81$^{b}$ | 14.72±0.90$^{a}$ | 16.35±1.10$^{a}$ | 15.96±1.14$^{a}$ | 17.03±0.11$^{a}$ |
| Survival (%) | 82.72±6.36 $^{a}$ | 81.67±7.88 $^{a}$ | 87.17±5.56 $^{a}$ | 79.39±8.3 4$^{a}$ | 84.56±7.19 $^{a}$ |
| Extrapolated Gross Fish Yield (t/ha/yr) | 2.39±0.16 $^{b}$ | 2.95±0.18$^{ab}$ | 3.28±0.2 2$^{a}$ | 3.20±0.23$^{a}$ | 3.41±0.02 $^{a}$ |
| Extrapolated Net Fish Yield (t/ha/yr) | 2.04±0.14$^{b}$ | 2.58±0.09$^{ab}$ | 2.79±0.18$^{a}$ | 2.72±0.23$^{a}$ | 2.98±0.07$^{a}$ |

Mean values with different superscript in the same row are significantly different ($P$<0.05)

Variable costs (NRs/100 $m^2$) involved in fish production was found the greatest in T5 (1570±7.75) followed by T4 (1511.4±6.31), T3 (1457.2±2.40), T2 (1416.4±3.55) and T1 (1366.2±16.34), which were significantly different ($P$<0.05; Table 5). Total gross return (NRs/100 $m^2$) was found the greatest in T5 (4374.2±40.61) among all treatments which was significantly different from T1 (2971.6±174.6) ($P$<0.05) but not significantly different from T2 (3712.0±256.85), T3 (4171.6±245.01) and T4 (4052.0±327.07) ($P$>0.05). Gross margin obtained in T5 (2804.2±37.45) was the greatest among all treatments which was significantly different from T1 (1605.4±161.04) ($P$<0.05) but not significantly different from T2 (2295.6.0±257.06), T3 (2714.4±243.57) and T4 (2541.1±321.05) ($P$>0.05), while T1 and T2 were not significantly different ($P$>0.05). However benefit cost ratio (B/C) was found the greatest in T3 (2.86±0.17) among all treatments which was significantly different from T1 (2.20±0.11) ($P$<0.05) but not significantly different from T2 (2.62±0.18), T4 (2.68±0.21) and T5 (2.79±0.02) ($P$>0.05).

**Table 5:** Economic analysis of different treatments based on 100 $m^2$ pond in Nepalese currency (NRs) during experimental period (Mean±S.E.)

| Variables | Treatments | | | | |
|---|---|---|---|---|---|
| | Total cost in NRs./100$m^2$/182days | | | | |
| | T1 | T2 | T3 | T4 | T5 |
| **Gross Return** | | | | | |
| Total Gross Return | 2971.6±174.46$^{b}$ | 3712.0±256.85$^{a}$ | 4171.6±245.01$^{a}$ | 4052.0±327.07$^{a}$ | 4374.2±40.61$^{a}$ |
| **Variable cost** | | | | | |
| Lime | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 |
| Feed | 170.2 | 170.4 | 161.2 | 165.5 | 174.0 |
| Urea | 226 | 226 | 226 | 226 | 226 |
| DAP | 420 | 420 | 420 | 420 | 420 |
| Carp fingerlings | 500.0 | 550.0 | 600.0 | 650.0 | 700.0 |
| Total variable cost | 1366.2±16.34$^{e}$ | 1416.4±3.55$^{d}$ | 1457.2±2.40$^{c}$ | 1511.4±6.31$^{b}$ | 1570.0±7.75$^{a}$ |
| Gross margin (100 $m^2$) | 1605.4±161.04$^{b}$ | 2295.6±257.06$^{ab}$ | 2714.4±243.57$^{a}$ | 2541.1±321.05$^{a}$ | 2804.2±37.45$^{a}$ |
| Gross Margin (“000”) (NRs/ha/yr) | 321.96±32.30$^{b}$ | 460.40±51.55$^{ab}$ | 544.40±48.84$^{a}$ | 509.6±64.38$^{a}$ | 562.40±7.51$^{a}$ |
| Benefit cost ratio | 2.2±0.11$^{b}$ | 2.62±0.18$^{ab}$ | 2.86±0.17$^{a}$ | 2.68±0.21$^{ab}$ | 2.79±0.02$^{a}$ |

Mean values with different superscript in the same row are significantly different ($P$<0.05)

FCR of feed to common carp and mrigal and para grass to grass carp were not significantly different among treatments (*P*>0.05; Table 6).

**Table 6:** Food conversion ratio (FCR) of feed to total production of common carp and mrigal and FCR of para grass to grass carp (Mean±S.E.).

| Food conversion ratio (FCR) | Treatments | | | | |
|---|---|---|---|---|---|
| | T1 | T2 | T3 | T4 | T5 |
| FCR for common carp and mrigal | 2.07.±0.48[a] | 1.92±0.67[a] | 1.59±0.25[a] | 1.71±0.50[a] | 1.55±0.24[a] |
| FCR for Grass carp | - | 20.75±2.95[a] | 16.74±2.27[a] | 21.75±1.58[a] | 22.12±1.73[a] |

Mean values with different superscript in the same row are significantly different (*P*<0.05)

## 4. Discussions

Water quality parameters were found within a suitable range for fish production in the present experiment. Temperature is an important water quality parameter which was found to be influenced by season. The suitable range of water temperature for freshwater aquaculture is about 25-32 °C (Das, 1997) [6]. The optimum water temperature recorded during March to May ranges from 24.3 °C to 30.4 °C which was nearer to above value and lower during December to February ranged from 14 °C to 21.5 °C which was closer to Shahin *et al.*, (2011) [25] reported as 16.1 °C to 19.4 °C. Hossain (2000) [14] has reported optimum water temperature of ponds ranged from 26.0 °C to 32.4 °C. The concentration of dissolved oxygen (DO) ranged from 5.8mg/l to 10 mg/l which was slightly higher than those reported by Shaha *et al*., (2015) [24] of 4.3 mg/l to 6.8 mg/l. The higher value in present experiment might be due to decreased water temperature in winter season as well as lower accumulation of wastes produced by grass carp with respect to different stocking rate as reported by those of Pandit *et al*., (2004) [21]. Rahman, (1992) [23] has reported the range of pH for pond water would be 6.5 to 8.5. The pH value in the experimental ponds varied from 7.6 to 8.9 which was closer to the finding of Swingle (1967) [29] ranged from 6.5-9 indicating the suitable condition for fish culture. The transparency was observed in the range of 20 cm to 41 cm. Wahab *et al*., (1994) [30] have reported that the transparency of productive water should be up to 40 cm. which was within the productive range. James (2000) [15] has reported the maximum permissible limit of total dissolved solids for fish culture was 400mg/l. The total dissolved solids in the present study ranged from 110 mg/l to 144 mg/l which was lower than the standard value and nearer to the finding of Munni (2013) [20] reported as 85mg/l to 165 mg/l. James (2000) [15] has reported that electric conductivity (EC) of freshwater aquaculture had a range of 150-500 µs/cm. The EC in the present experiment ranged from 270 µs/cm to 446.3 µs/cm which was within desirable range for fish culture.

The extrapolated gross fish yield in the present study ranged from 2.39 to 3.41 t/ha/yr which was higher than those of fish yield obtained by Prabaharan and Murugan (2012) [22], Awal *et al*., (1995) [4] and Haque *et al*., (2015) [13] from carp polyculture system. Prabaharan and Murugan (2012) [22] have obtained the fish yield of 3t/ha/year in 25% organic, 25% inorganic and 50% supplementary feed condition when cultured for one year. Awal *et al*., (1995) [4] have obtained yield of 982 kg/ha in 6 months (equivalent to 1.96 t/ha/year) in mixed carp polyculture. Haque *et al*., (2015) [13] have obtained the highest fish yield of 2.74 t/ha/year in fertilization and supplementary feed condition for a culture period of three months. The fish yield in the present study was nearer to those of the production of Lakshmanan *et al*., (1971) [18] of 2.23t/ha/year to 4.20 t/ha/year in polyculture of Chinese and Indian major carps stocked at varying proportions. The gross fish yield in the present study was lower than those of Chughtai *et al*., (2015) [5] reported as 6.70 t/ha/year in a carp polyculture feeding with supplementary feed alternated with para grass. Lower fish production in the present study might be due to fact that prevailing of lower temperature in half of the total experiment period, which hinders the growth rate of fish supported by those of Yadava and Garg (1992) [32], Hajek and Boyd (1994) [12], Kolar *et al*., (2005) [17] and Afzal *et al*., (2008) [1].

FCR value did not show significant differences between the treatments (*p*>0.05). The inclusion of grass carp reduced FCR of common carp and mrigal (1.59±0.11) in T3 as compared to T1 (2.07±0.48), which indicated that the excreta of grass carp acted as a source of feed for bottom feeders too which was in accordance with the finding those of Grygierek (1973) [9] and Majhi *et al*., (2006) [19]. The FCR ranged from 1.52 to 1.92 in grass carp added treatments which was lower than those reported by Jeena *et al*., (2001) [16] of 2.69 to 2.82 in carp polyculture with supplementary feeding condition.

The production cost was comparatively greatest in T5 than rest all of the treatments because of increase in cost of fingerlings. The gross revenue and net profit were found highest in T5 among grass carp added treatments and lowest was obtained from carp polyculture excluding grass carp (T1). However economic analysis showed that the benefit cost ratio (B/C) was obtained the highest in T3 (where grass carp was stocked @ 0.2 fish/m$^2$) than T1, T2, T4 and T5. In spite of highest fish production in T5, production cost was also higher. It shows that T3 is better option for carp polyculture which is more economical as compared with other treatments.

## 5. Conclusion

Therefore it can be concluded that of 0.2 fish/m$^2$ is the most suitable stocking density of grass carp in freshwater carp polyculture for better production as well as higher profit. Taking into account the results obtained further research will be carried on complete excluding of supplementary feed and fertilizer with optimal stocking rate of grass carp fed with para grass.

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