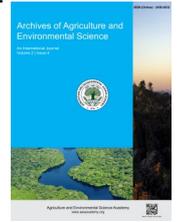This content is available online at AESA

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**ORIGINAL RESEARCH ARTICLE**

# Effects of restricted feeding regimes on greenhouse gas emission, production and economics of tilapia (*Oreochromis mossambicus*) monoculture in pond

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**ABSTRACT**

This study evaluated the effects of different feeding regimes on water quality parameters, fish growth, feed performance, economic returns and greenhouse gas emissions (GHGs) in *Oreochromis mossambicus* monoculture. Three treatments were applied viz. $T_1$: regular feeding (twice daily); $T_2$: feeding off 1 day/week and $T_3$: feeding off 2 days/week, each with two replications. Significant variations (P<0.05) were found in water quality parameters such as dissolved oxygen (4.59±0.24 to 6.31±0.22 mg/L), pH (5.51±0.08 to 6.60±0.01), $CO_2$ (4.59±0.24 to 6.31±0.22 mg/L) and total dissolved solids (520.68±3.74 to 554.57±3.78 mg/L), while temperature remained within the optimal range (29.06 to 29.32$^0$C). Growth performance was highest in $T_1$ (final weight: 249.65 g; SGR: 2.08%) and lowest in $T_3$ (190.63 g, SGR: 1.74%). FCR ranged from 1.67 to 1.87, and survival rate from 80.50% to 87.50%. Net profit was highest in $T_2$ (454322.78 BDT/ha) followed by $T_1$ and $T_3$, indicating 16.7% increase over $T_1$ and 50.2% over $T_3$. Cost-benefit ratio was also highest in $T_2$ (0.70), suggesting economic viability of moderate feed deprivation. Importantly, GHGs emissions were maximum in $T_1$ (8.75 kg/ha/year), and minimum in $T_3$ (6.62 kg/ha/year), showing a 24.3% reduction with intermittent feeding. These findings highlight that moderate feed restrictions ($T_2$) can optimize production performance, enhance profitability, and reduced environmental impact, offering a sustainable strategy for tilapia aquaculture. This dual benefit approach supports economic efficiency and environmental sustainability, aligning with global goals for climate-smart aquaculture.

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## INTRODUCTION

Globally, aquaculture is a rapidly growing sectors, playing a vital role in ensuring food security and making a substantial contribution to overall fish production and in 2022, global aquaculture reached a record 130.9 million tons, up 8.1 million tons from the 122.8 million tons documented in 2020 (FAO, 2024). Aquaculture represents key sectors in Bangladesh, contributing significantly to food security, nutrition, livelihoods, employment opportunities and the generation of foreign exchange earnings (Hossain *et al*., 2014). The fisheries sector contributes 1.24% to total export earnings, 2.53% of GDP and 22.26% of total agricultural output (DoF, 2024). Notably, over 12% of the total population is engaged in fisheries-related livelihoods. Bangladesh is ranked third worldwide for inland fish production and 5th in overall aquaculture production. Additionally, it is the 4th largest tilapia producer globally and the 3rd largest in Asia. (DoF, 2024). In the fiscal year 2022-23, inland culture fisheries accounted for 58.02% of total fish production, while inland capture and marine fisheries contributed 28.15% and 13.82%, respectively. Since 1983-84, inland aquaculture has expanded more than six fold, and total national fish production reached 49.15 lakh M tones in 2022-23. Aquaculture is projected to play a key role in doubling fish production to meet future demand and in achieving the goals of a Smart Bangladesh by 2041 (DoF, 2024). Aquaculture's benefits are closely aligned with achieving SDGs (Sustainable

Development Goal), especially SDG 2 (zero hunger) and also SDG 3 (good health and wellbeing). Despite its benefits, aquaculture sector is also criticized with emission of greenhouse gases (GHGs) like $CO_2$, $CH_4$ and $N_2O$ (Islam *et al.*, 2020). The Food and Agriculture Organization (FAO) in 2014 reported that greenhouse gas emissions from the fisheries sector almost doubled over the last fifty years and are expected to rise by 30% by the year 2025. Freshwater aquaculture, especially pond-based systems common in Bangladesh, is recognized as a major contributor to methane and nitrous oxide emissions (Kais & Islam, 2018). Hu *et al.* (2012) estimated that global $N_2O$-N emission from aquaculture were $9.30 \times 10^{10}$ g in 2009, with projections indicating a rise to $3.83 \times 10^{11}$ g by 2030 - potentially accounting 5.72 % of anthropogenic $N_2O$ emissions if the industry's current 7.1% annual growth rate is maintained. On the other hand, among all inputs in aquaculture, feed is the costliest, accounting for between 40% and 70% of the variable expenses are depended on the intensity of production (Obirikorang *et al.*, 2015; Gandotra *et al.*, 2015). Feed efficiency directly influences profitability and is a major determinant of the economic success of aquaculture operations (Bolivar *et al.*, 2006). However, improper feeding practices can lead to overfeeding, resulting in feed waste accumulation, increased production costs and degradation of water quality. Conversely, underfeeding can stunt fish growth and increase mortality rates, thus profitability and productivity can be adversely affected (Eroldogan *et al.*, 2006). Simultaneously, restricted feeding regime is found as a proven technique to overcome the problem of feed wastage (Amin *et al.*, 2005; Wang *et al.*, 2005). Limbu & Jumanne (2014) reported that feed costs could be reduced 10 to 20% through the restriction of feeding tilapia to 1 and 2 days, respectively without compromising fish growth, feed efficiency and survival in tilapia. Regular feeding increases production cost and reduces net benefit and also increases greenhouse gas emission. Therefore, implementing restricted feeding strategies is crucial for both economic viability and environmental sustainability in aquaculture. To mitigate GHG emissions from tilapia aquaculture, it is imperative to adopt sustainable practices, including the restricted feeding regimes. Unfortunately, not a single work is found on the development of restricted feeding regimes towards the smooth farming promotion and reducing GHG emission in pond. Based on these evidences, the present study aimed at studying the effects of restricted feeding regimes on greenhouse gas emission, production and economics of tilapia (*Oreochromis mossambicus*) monoculture in pond which helped us provide valuable recommendation to farmers towards profitable and climate smart aquaculture. This study's specific objectives were to monitor important water quality indicators; to evaluate greenhouse gas emission; assess growth, yield and also economics of tilapia culture; to evaluate FCR and finally suggest suitable strategy of restricted feeding regimes to reduce the greenhouse gas emissions from tilapia monoculture pond.

## MATERIALS AND METHODS

### Location and duration

The current experiment was conducted in six farmer-managed ponds over a six month period from July to December, 2024 (mean area of 0.04±0.01 ha and water depth 1.51±0.19m) located at Harian of Paba upazila under Rajshahi district, Bangladesh which spreads from 24°18' N to 24°31' N and 88°28' E to 88°43' E.

### Experimental design

Three different treatments of restricted feeding regimes were used in the experiment: $T_1$, Regular feeding (twice daily), $T_2$ (Feeding off 1 day/week) and $T_3$ (Feeding off 2 days/week), each with two replications. Stocking density (49,400 fish/ha), initial stocking weight (20.75g ± 2.47), dietary protein content (30%) and fish growing period (6 months) were same for all treatments. Experiment layout is shown in Table 1.

### Pond management

The aquatic plants were manually removed from the experimental ponds. Repeated netting was used for eliminating predatory fishes and also unwanted fishes. Then, the ponds were treated with 250 kg of agricultural lime per hectare, and seven days later, all of the research ponds were fertilized with inorganic fertilizer (Urea: 25kg/ha, triple super phosphate: 15 kg per ha for increasing natural productivity of the ponds. After three days of basal fertilization, fish that collected from the nearby nursery pond were stocked at morning. Fish were provided with supplementary feed (30% protein) and feeding was carried out at 5% of fish biomass during the first month of the culture periods and subsequently adjusted to 4%, 3% and finally 2% towards the end of the trial to align with fish growth and ensure optimal production. Divided into two portions, half of the feed was given in the morning and half in afternoon.

**Table 1.** Experimental layout for tilapia monoculture in ponds under different treatments of restricted feeding regimes.

| Parameters | Treatments | | | F-value | *p*-value |
|---|---|---|---|---|---|
| | $T_1$ | $T_2$ | $T_3$ | | |
| Pond area (ha) | 0.04±0.01[a] | 0.04±0.12[a] | 0.04±0.00[a] | 0.005 | 0.995 |
| Pond depth (m) | 1.51±0.19[a] | 1.52±0.00[a] | 1.51±0.19[a] | .005 | 0.995 |
| Stocked *O. mossambicus* (no./pond) | 2000.00±282.84[a] | 2000.00±565.68[a] | 2000.00±309.83[a] | 0.000 | 1.000 |

Figures bearing common letter(s) in a row as superscript do not differ significantly (p> 0.05).

## Monitoring of water quality parameters

The experimental ponds' water quality parameters were checked every two weeks between 8:30 am to 10:30 am. Water temperature was detected with a centigrade thermometer (range of 0°C to 120°C). A secchi disk was used for recording water's transparency (cm). The water pH and dissolved oxygen (mg/L) were determined with the help of a multimeter (HQ40d, HACH, USA). Ammonia-nitrogen (mg/L), carbon dioxide (mg/L) and alkalinity (mg/L) of pond water were detected with a HACH kit (FF-2, USA).

## Quantitative analysis of $CH_4$ and $N_2O$

$CH_4$ emission was determined after Lesschen *et al.* (2011) as follows:

$$CH_4 \text{ emission from culture system} = S\,EF \times T \times A \times 10^{-6}\,Gg\,CH_4\,year^{-1}$$

EF stands for methane emission factor= $0.351\,kg\,CH_4\,ha^{-1}day^{-1}$

$N_2O\text{-}N$ emission was determined after Hu *et al.* (2012) as follows:

$$N_2O\text{-}N \text{ emission from culture system} = S\,EF \times P \times 10^{-3}\,Gg\,N_2O\text{-}N\,year^{-1}$$

EF stands for $N_2O\text{-}N$ (Nitrous oxide) emission factor = $0.00169\,kg\,N_2O\text{-}N\,metricton^{-1}\,year^{-1}$

All the estimation of greenhouse gases was transformed to $CO_2$ based on the relative global warming potential (GWP). The GWP for $CH_4$ and $N_2O\text{-}N$ were 25 and 265 times of $CO_2$ based on its mass over the 100 year (Pearce *et al.*, 2014).
So,
Total emission $= 25 \times CH_4 + 265 \times N_2O\text{-}N$

## Fish growth monitoring

The fish sampled fortnightly to assess the growth performance and adjustment of the feeding ration. In each sampling, 10% of the stocked fishes were caught from each pond using a cast net for the study of growth performances of fishes. The examined fishes were then immediately released into the pond without any harm. The following parameters were analyzed after Brett & Groves (1979) as follows:

Initial weight (g) = weight of fish at stock

Final weight (g) = weight of fish at harvest

Weight gain (g) = Mean final weight- Mean Initial weight

Specific growth rate (SGR, $\%bwd^{-1}$) = ($L_n$ final weight- $L_n$ initial weight)/culture period $\times 100$

Survival rate (%) = Number of fish harvested/ number of fish stocked $\times 100$

Yield (kg/ha/yr) = Fish biomass at harvest- Fish biomass at stock
Feed performance was also tested through calculating the feed conversion ratio (FCR) as follows:

FCR =Feed fed in dry weight / live weight gain (g).

## Economic analysis

Simple cost-benefit analysis was followed to study the economics of tilapia monoculture under different treatments of restricted feeding regimes in this study. Both the fixed and variable expenses data were collected for calculating the total production cost (BDT/ha). According to the Asaduzzaman *et al.* (2010), the net return was determined using the following equation:

$$R = I\text{-}(FC + VC + Ii)$$

Where, R = net return, I = income from fish sale, FC = fixed/common cost, VC = variable costs and Ii= interest on inputs. The benefit-cost ratio was determined as:

Cost Benefit Ratio (CBR= Net benefit/ total investment) was also calculated for the current study.

## Statistical analysis

SPSS (Statistical Package for Social Science) version-21 was used for statistically analyzing all of the data gathered during the experiment using by one-way analysis of variance (ANOVA). Significant difference between mean values was analyzed by Duncan's Multiple Ranges Test (Duncan, 1995) at the 0.05 significance level (Gomez & Gomez, 1984).

## RESULTS AND DISCUSSION

### Environmental parameters

The differences in the average measurements of environmental parameters under different treatments are presented in Table 2. Statistical analysis revealed no significant variations in temperature among the treatments, and all are measured parameters remained within the optimum range for tilapia monoculture, are previously reported by Sharmin *et al.* (2019). However, significant variations ($p<0.05$) were recorded in transparency, DO (dissolved oxygen), $CO_2$ (free carbon dioxide), pH, $NH_3\text{-}N$ and total dissolved solids (TDS) across treatments. The recorded average temperature varied between 29.06±0.07°C to 29.32±0.12°C in the $T_2$ and $T_1$ treatment, respectively which was quite different from Islam *et al.* (2021) who recorded temperature from 26.84 to 27.11°C in monosex tilapia culture. Water transparency was higher in $T_3$, indicating favorable light penetration for primary productivity, which supports optimal tilapia production (Wahab *et al.*, 1995). DO levels, crucial for fish metabolism and health, ranged from 4.59±0.24 to 6.31±0.22 mg/L in the treatment $T_1$ and $T_3$, respectively which is consisted with previous observations of Islam *et al.* (2021) who recorded DO range from 5.65±1.07 to 7.36±0.32 mg/L. $CO_2$ concentrations varied between 4.61±0.13 to 5.73±0.00 mg/L in the $T_3$ and $T_1$

**Table 2.** Water quality in tilapia monoculture ponds under different treatments of restricted feeding regimes.

| Water quality | Treatments | | | F-value | *p*-value |
|---|---|---|---|---|---|
| | $T_1$ | $T_2$ | $T_3$ | | |
| Temperature (°C) | 29.32±0.12[a] | 29.07±0.14[a] | 29.06±0.07[a] | 3.275 | 0.176 |
| Transparency (cm) | 29.16±1.06[a] | 33.80±.98[b] | 36.41±.94[b] | 26.921 | 0.012 |
| DO (mg/L) | 4.59±0.24[a] | 5.83±0.04[b] | 6.31±0.22[b] | 41.110 | 0.007 |
| $CO_2$ (mg/L) | 5.73±0.00[b] | 4.72±0.04[a] | 4.61±0.13[a] | 111.270 | 0.002 |
| pH | 5.51±0.08[a] | 6.28±0.02[b] | 6.60±0.00[c] | 247.019 | 0.000 |
| Alkalinity (mg/L) | 93.79±1.47[b] | 91.32±.60[b] | 86.45±1.35[a] | 19.224 | 0.019 |
| $NH_3$-N (mg/L) | 0.35±0.07[b] | 0.20±0.00[a] | 0.15±0.02[a] | 11.207 | 0.041 |
| TDS (mg/L) | 554.57±3.78[c] | 532.70±2.41[b] | 520.68±3.74[a] | 51.851 | 0.005 |

Figures bearing common letter(s) in a row as superscript do not differ significantly (p> 0.05).

**Table 3.** GHG emission in tilapia monoculture ponds under different treatments of restricted feeding regimes.

| Items | Treatment | | | F-value | P-value |
|---|---|---|---|---|---|
| GHGs (Gg/ year) | $T_1$ | $T_2$ | $T_3$ | | |
| $CH_4$ | 0.000029±0.00004[a] | 0.000029±0.000028[a] | 0.000029±0.00004[a] | 0.034 | 0.966 |
| $N_2O$-N | 0.0165±0.0007[b] | 0.0150±0.0000[b] | 0.0125±0.0007[a] | 9.333 | 0.014 |
| Total emission ($CO_2$e, Kg/ha/6months) | 4.37±0.190[b] | 3.97±0.007[b] | 3.31±0.183[a] | 27.12 | 0.012 |
| Total emission ($CO_2$e, Kg/ha/year) | 8.75±0.381[b] | 7.95±0.014[b] | 6.62±0.367[a] | 24.70 | 0.014 |

Figures bearing common letter(s) in a row as superscript do not differ significantly (p> 0.05).

treatment respectively, which are in close line with values stated by Uddin *et al.* (2007) and Majumder *et al.* (2017), who observed the levels of $CO_2$ 3.09±0.46 to 3.25±0.42 mg/L and 2.00 to 4.00 mg/L, respectively. The pH values ranged from 5.17± 0.04 to 7.88± 0.04 in the treatment $T_1$ and treatment $T_3$, respectively partially aligning with findings by Ogola *et al.* (2020) and Hossain *et al.* (2020). Alkalinity, an important parameter for buffering capacity and pH stability, varied between 86.45±2.05 mg/L in $T_1$ and 93.79±1.47 mg/Lin $T_3$ which is different from Rahman *et al.* (2021) who found alkalinity values ranging from 31.09±0.25 to 54.10±0.34 mg/L in tilapia culture. The current study was found that the alkalinity was within a productive range. The concentration of $NH_3$-N in this study varied between 0.15±0.02 mg/L in $T_3$ and 0.35±0.07 mg/L in $T_1$ treatment. These findings are comparable to the observations of Nabi *et al.* (2017) and Milstein *et al.* (2009) who also evaluated ammonia levels in fish culture ponds. TDS values, representing the total concentration of dissolved salts and minerals, ranged from 506.50±2.12 to 583.50±3.53 mg/L in $T_3$ and $T_1$, respectively. These values supporting the findings of Kumar *et al.* (2023) who noted TDS levels of 319.12 to 468.00 mg/L and 400 mg/L for diverse aquaculture systems.

### Greenhouse gas emission

Greenhouse gas emissions (GHGs) emissions ranged from 6.62±0.367 to 8.75±0.381 Kg/ha/year, where the minimal and maximal value recorded in the treatment $T_3$ and $T_1$, respectively (Table 3 and Figure 3). In this study, the highest GHGs emission identified in $T_1$ which were involved regular feeding. This is likely due to the higher feed input contributing to increase organic matter accumulation and subsequent microbial decomposition in pond sediments. In contrast, the lowest GHG emissions were recorded $T_3$ where feeding was off for 2 days/week, resulting in reduced feed input and organic load. These result aligned with (Robb *et al.*, 2017) who reported that poor feed management
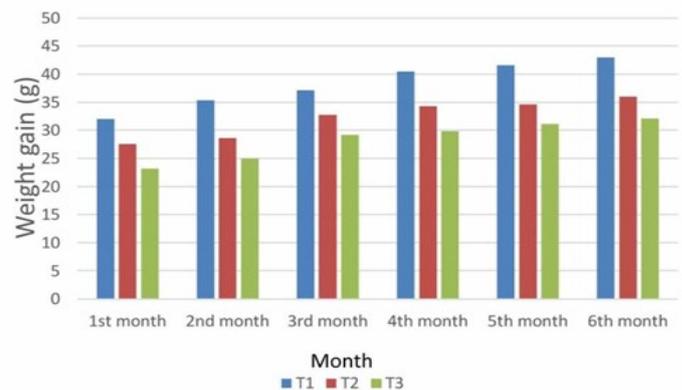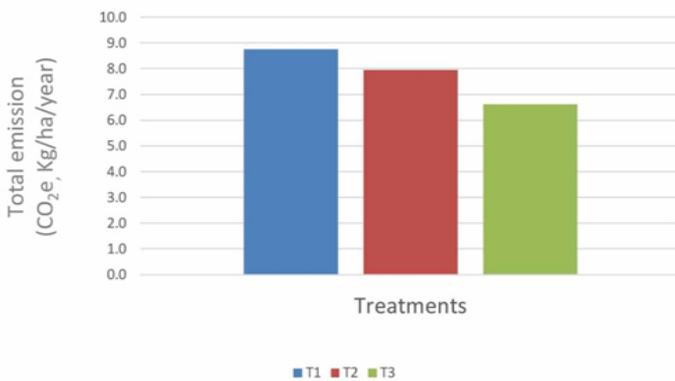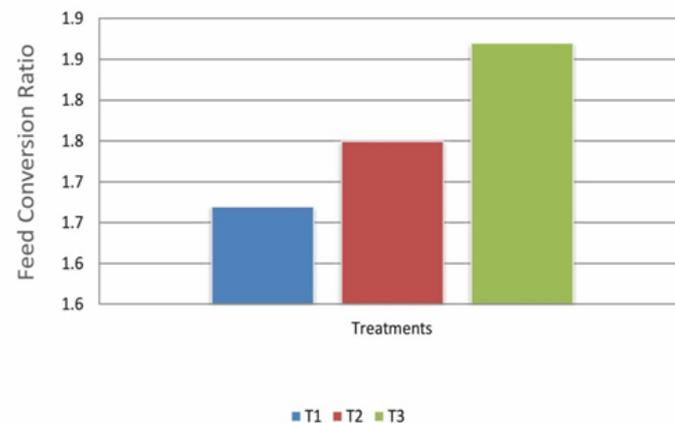


**Figure 1.** *Monthly variation in weight gain.*
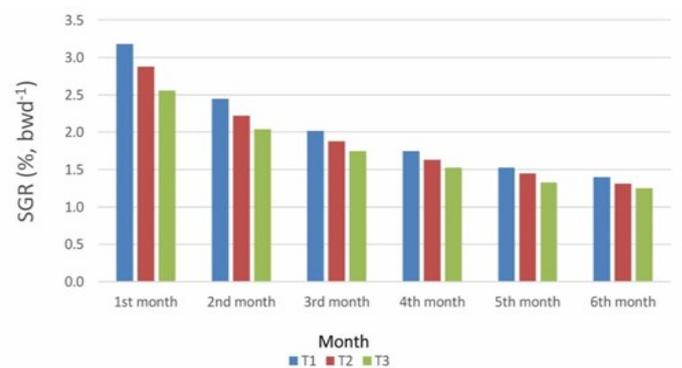


**Figure 2.** *Monthly variation in SGR.*

and degraded water quality contribute to increased GHG emissions in aquaculture systems. Islam *et al.* (2020) suggested that emissions from the aquaculture sector could be mitigated through improved feed management, optimized feed conversion ratios, and reduced nitrous oxide levels in pond water. Improvement of culture system can be an effective alternative to reduce the GHGs emission from aquaculture sector (Nobre *et al.*, 2010 and Liu *et al.*, 2014). The outcomes of this study were thus consistent with these reports to reinforce the need for sustainable aquaculture practices in terms of feed management.

**Table 4.** Fish growth and yield under different treatments of restricted feeding regimes.

| Parameters | Treatments | | | F-value | *p*-value |
|---|---|---|---|---|---|
| | $T_1$ | $T_2$ | $T_3$ | | |
| Initial weight (g) | 20.50±1.41[a] | 20.00±2.28[a] | 20.00±2.12[a] | 0.034 | .966 |
| Final weight (g) | 249.65±.94[c] | 213.94±.47[b] | 190.63±1.49[a] | 1589.805 | 0.000 |
| Weight gain (g) | 229.65±.94[c] | 193.94±.47[b] | 170.63±1.49[a] | 1589.805 | 0.000 |
| SGR (%, bwd$^{-1}$) | 2.08±0.02[c] | 1.92±0.02[b] | 1.74±0.02[a] | 99.206 | 0.002 |
| Survival rate (%) | 80.50±2.12[a] | 87.50±.70[b] | 81.00±1.41[a] | 13.071 | 0.033 |
| Yield (kg/ha/6 months) | 9927.53±114.22[c] | 9247.68±54.25[b] | 7627.54±73.48[a] | 142.905 | 0.001 |

Figures bearing common letter(s) in a row as superscript do not differ significantly (p> 0.05).



**Figure 3.** *Total emission (CO$_2$e, Kg/ha/year).*



**Figure 4.** *Feed conversion ratio.*

### Fish growth and yield

The mean variability in fish growth and yield among the treatments are presented in Table 4, while monthly variations in weight (g) and specific growth rate (SGR) are presented in Figures 1 and 2, respectively. The final mean weight of *Oreochromis mossambicus* ranged from 190.63±1.49 to 249.65±.94 g, whereas the lowest value recorded in $T_3$ and highest in treatment $T_1$. The outcomes are in close line with those noted by Begum *et al.* (2014). The weight gains of tilapia ranged from 170.63 ± 1.49 to 229.65±.94 g under different feeding regimes which was comparatively lower than the observation of Afram *et al.* (2021) who recorded weight gain ranged from 172.2 g to 349.0 gin Nile tilapia farming systems. The minimal weight gain was observed in the treatment $T_3$, whereas the maximal was recorded in treatment $T_1$. The SGR ranged between 1.74±0.02 to 2.08±0.02 %, bwd$^{-1}$in this study, with the lowest SGR observed in treatment $T_3$ and highest in treatment $T_1$. These findings align with those of previous studies by Caldini *et al.* (2011) and Mensah *et al.* (2014). The survival rate ranged from 80.50±2.12

% in treatment $T_1$ to 87.50±.70% in treatment $T_2$, which was quietly different from Islam *et al.* (2021) who found mortality 93% to 97% in monosex tilapia culture in pond. The mean fish yield ranged from 15255.08±146.96 to 19855.06±448.44 kg/ha/year, with the lowest yield recorded in treatment $T_3$ because of low feed inputs and the highest in treatment $T_1$ for regular feeding. These findings exhibit similarity to those observed by Satter *et al.* (2019).

### FCR

Feed performance is presented in Figure 4. FCR in this study varied between 1.67±0.02 to 1.87±0.01, which was lower than that of 2.84 to 3.46 for catfish, tilapia and sharpunti polyculture as noted by Ali *et al.* (2018) and quite different with Islam *et al.* (2021) who recorded the average value of FCR 1.26±0.03 to 1.47±0.05 in monosex tilapia culture. These outcomes exhibit close similarity with Ogola *et al.* (2020) who noted FCR value 0.62 to 1.92 for Nile tilapia (*Oreochromis niloticus*) culture.

### Economics

Variation in the average cost, net benefit and CBR values among different feeding regimes is presented in Table 5. The mean total cost recorded from the present study was 612700.00±2828.42 to 765000.00±12162.23 BDT/ha where the minimal and maximal value was observed with the treatment $T_3$ and $T_1$, respectively. Seed and feed costs, which are variable cost items, were found to differ significantly among the treatments. Feed cost was the largest cost in this study that are in agreement with Gandotra *et al.* (2015) who reported that feed cost represents (40-60%) of total cost in semi-intensive system of Nile tilapia. The mean net profit of the present study varied from 302605.73±4977.22 to 454322.78±5944.90 Tk/ha where the minimal and maximal value was noted in the treatment $T_3$ and $T_2$ respectively and the finding coincided with Nabi *et al.* (2017) who estimated that net benefit ranged from 3845.79 to 318069.31 Tk/ha. Finally, the cost benefit ratio (CBR) also varied across treatments. The maximal cost benefit ratio was noted in $T_2$ (0.70±0.01), followed by $T_3$ (0.48±0.00) and 0.55±0.01 at $T_1$. These results suggest that intermittent feeding, particularly skipping feed once or twice per week, can substantially reduce feeding cost without significantly compromising fish growth. These outcomes align with the findings of Bolivar *et al.* (2006), who notes greater profit margins with alternate-day feeding strategies compared to regular feeding. Importantly, reduced feeding application was also associated

**Table 5.** Economics of tilapia monoculture in ponds under different treatments of restricted feeding regimes.

| Items | Treatment | | | F-value | P-value |
|---|---|---|---|---|---|
| Variable cost (BDT/ha) | $T_1$ | $T_2$ | $T_3$ | | |
| Seed (including transportation) | $98250.00\pm909.18^a$ | $98450.00\pm343.50^a$ | $98300.00\pm221.32^a$ | 0.007 | 0.994 |
| Feed | $624900.00\pm656.85^c$ | $514450.00\pm596.19^b$ | $467900.00\pm828.42^a$ | 376.760 | 0.000 |
| Fixed cost (BDT/ha) | | | | | |
| Lime | $10000.00\pm555.63^a$ | $10500.00\pm414.21^a$ | $10000.00\pm414.21^a$ | 0.078 | 0.927 |
| Fertilizer | $5000.00\pm989.94^a$ | $5000.00\pm282.84^a$ | $5000.00\pm707.10^a$ | 0.000 | 1.000 |
| Labor | $12000.00\pm424.26^a$ | $12000.00\pm707.10^a$ | $12000.00\pm414.21^a$ | 0.000 | 1.000 |
| Sampling & harvesting | $15000.00\pm1414.21^a$ | $15000.00\pm1282.84^a$ | $15000.00\pm707.10^a$ | 0.000 | 1.000 |
| Total cost (BDT/ha) | $765000.00\pm1162.23^c$ | $655400.00\pm965.68^b$ | $612700.00\pm828.42^a$ | 183.193 | 0.001 |
| Total return (BDT/ha) | $1191303.60\pm906.82^c$ | $1109722.55\pm2510.26^b$ | $915305.32\pm817.16^a$ | 16.559 | 0.001 |
| Net benefit (BDT/ha) | $426303.60\pm1744.59^b$ | $454322.78\pm944.90^b$ | $302605.73\pm977.22^a$ | 27.93 | 0.012 |
| CBR | $0.55\pm0.01^b$ | $0.70\pm0.01^c$ | $0.48\pm0.00^a$ | 231.16 | 0.001 |

Figures bearing common letter(s) in a row as superscript do not differ significantly (p> 0.05).

with the lower GHGs emissions. In treatment $T_3$ which received feed five days per week, demonstrated the lowest GHGs emissions (6.62±0.367 Kg/ha/year), while the highest emissions were recorded in treatment $T_1$ (8.75±0.381 Kg/ha/year) with regular feeding. These results highlight a dual benefit of moderate feed restriction, enhanced economic efficiency and reduced environmental impact. Overall, the findings suggest that strategic feed deprivation, when approximately managed, not only improve economic returns by reducing feed costs by approximately 10-20% but also mitigates GHG emissions up to 24%, thereby contributing to more sustainable aquaculture practices.

### Conclusion and recommendation

This study investigated that restricted feeding regimes significantly influence water quality, fish growth, profitability and also greenhouse gas emissions in tilapia (*Oreochromis mossambicus*) monoculture in pond. Significantly (*p<0.05*) highest net profit and CBR were found with treatment $T_2$ (i.e., feeding off 1 day/week) in terms of suitable water quality, satisfy growth, moderate yield and especially the highest CBR and lower GHG emission than $T_1$ (Regular feeding). Severe restriction ($T_3$) minimized greenhouse gas emissions but compromised growth and economic returns. So, adopting a moderate restricted feeding strategy ($T_2$) balances production efficiency, profitability and environment sustainability which is also a climate smart approach for tilapia aquaculture.

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### DECLARATIONS

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