



Influence of Aeration Timings on Growth, Survival and Production of *Labeo rohita* (Hamilton) Fingerlings during High Density Seed Rearing

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Abstract

A 60 day study was conducted to evaluate the impact of different timings of aeration during night hours between 18.00-24.00 h, 21.00-03.00 h and 24.00-06.00 h on growth, survival and production performance of rohu (*Labeo rohita*) fingerlings against a control with no aeration, in 50 m² outdoor concrete tanks (10 m×5 m×1.3 m). *L. rohita* fry were stocked at a density of 0.5 million ha⁻¹. Compared to control, aeration caused significant increase in survival, harvested size, specific growth rate and net biomass production while the feed conversion ratio significantly reduced. However, varied timing of the night aeration could not yield any significant difference in these yield attributes among the aerated treatments. Further, comparison of night aeration between 21.00-03.00 h and 24.00-06.00 h revealed relatively better performances of the fingerlings in the later treatment, indicating effectiveness of aerating the tanks after midnight (24.00-06.00 h).

Keywords: Aeration, growth, survival, *Labeo rohita*, fingerlings

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Introduction

The beneficial effect of aeration on culture system has been demonstrated in different species (Lai-Fa & Boyd, 1988; Thomforde & Boyd, 1991; Hargreaves

et al., 1991; Aravindakshan et al., 1997; Das et al., 2004; Jena et al., 2005). Aeration, as an input in aquaculture systems, has been receiving importance in recent years in the context of greater thrust on intensification of the farming activity along with water quality upkeep. Further, as an effort towards intensive seed production, use of concrete tanks is becoming popular in countries like India due to its low area utilisation, greater environmental control, scope of higher stocking density and better production performance in terms of seed survival, growth and feed utilization (Biswas et al., 2006a; 2006b; Sahu et al., 2007; Pawar et al., 2009; Jena & Das, 2011, Das et al., 2012). Use of aeration in high density seed rearing system of carps has been proved advantageous in terms of higher yield and maintenance of good environmental condition (Pawar et al., 2009; Das et al., 2012). Further, night time aeration has been reported to be more effective than that during day time (Thomforde & Boyd, 1991; Diana et al., 1997; Boyd & Tucker, 1998). Boyd (1998) attributed such higher oxygen diffusion to the greater difference between oxygen content of water and the saturation level during night hours.

In the carp seed rearing system, provision of aeration on a daily basis involves considerable energy use and cost which influence the economics of seed rearing. Therefore, identifying the duration of aeration and appropriate timing is of great relevance. In an earlier study, Pawar et al. (2009) demonstrated eight hours of aeration to be adequate for production of carp fingerlings during high density (0.5 million ha⁻¹) seed rearing in concrete tanks. In the present study, an attempt has been made to identify the suitable part of night hours for aerating the tanks in order to achieve maximum output in terms of survival, growth and other production attributes during fingerlings production of *L. rohita*.

Materials and Methods

The experiment was conducted in outdoor fish seed rearing facility of the Central Institute of Freshwater Aquaculture, Bhubaneswar, India. A unit of twelve concrete tanks of 50 m² (10 m×5 m×1.2 m) each provided with 15 cm soil base and filled up to one-meter mark with filtered water from a pond, 10 days prior to stocking were used for the study. Aeration was provided from an air-blower (7.5 HP, L-15-310/100 WB, Zhejiag Sensen Industry Co. Ltd.) through 2.5 cm perforated PVC pipes, placed 0.5 m above pond bottom along the length at centre of each tank. In order to ensure adequate plankton productivity, the tanks were fertilized eight days prior to seed stocking with 15 kg cowdung (3.0 t ha⁻¹) along with 150 g single super phosphate (10 kg ha⁻¹) (Jena et al., 2005).

Fry of rohu (*Labeo rohita*) were stocked after due acclimatization in the tanks at a density of 50 fry m⁻² (0.5 million ha⁻¹) as per Pawar et al. (2009). The mean length and weight of fry recorded by measuring 25 samples were, 25±0.2 mm and 0.2±0.01 g, respectively. Six hours of aeration was provided in each treatment tank, but at different span of the night, viz., with varied timings, 18.00-24.00 h, 21.00-03.00 h and 24.00-06.00 h and were designated as T-I, T-II and T-III, respectively, and evaluated against (TC) control with no aeration. Each treatment was replicated their times. The experimental fish were fed with supplementary feed comprising powdered mixture of groundnut oil cake and rice bran (1:1 ratio on w/w basis), once daily between 9.00-10.00 h. The mixture was broadcasted on the water surface at 10% of the stocked biomass during the first fortnight, followed by 8% in 2nd and 3rd fortnight and 6% in 4th fortnight. The daily ration was adjusted based on the fish biomass, which was calculated from the sampled body weight data by assuming 80% survival levels (Jena et al., 2005). No water exchange was carried out during experimental period, except the evaporation loss of about 5 cm per week was compensated at the week end to maintain the desired water level. The tanks were covered with nylon nets to avoid predation from birds.

Important physico-chemical parameters were monitored by sampling the water at seven day intervals between 06.00 and 07.00 h. Total alkalinity, total hardness, free CO₂ and inorganic nutrients like total ammonia nitrogen (TAN), nitrite-nitrogen, nitrate-nitrogen and phosphate-phosphorus were analyzed

following standard methods (APHA, 1998). Water temperature, dissolved oxygen (Orion 3 star DO portable, Thermo Electronic Corporation, USA) and pH (Orion 2 star pH Benchtop, Thermo Electronic Corporation, USA) were recorded *in situ*. Diel studies commencing from 06.00 h through 06.00 h in the following day were carried out once at the end of every month at 3 h interval to study the dynamics of the dissolved oxygen, pH and temperature. At every 15 days interval 50 l water from the experimental tanks were filtered through bolting silk plankton net (No. 25, mesh size 64 µm) to collect the plankton samples. Plankton concentrates were then immediately preserved in 4% buffered formalin for further qualitative and quantitative analysis following direct census method (Jhingran et al., 1969) using a Sedgewick-Rafter counting cell. Identification of plankton to genus level was performed using keys from Needham & Needham (1962). Chlorophyll pigments in water was also estimated at 15 days interval as per standard methods (APHA, 1998). Important soil parameters were measured at the beginning and end of the experiment *viz.*, soil pH, available nitrogen, available phosphorus and organic carbon.

At every 15 days interval, fishes were sampled for assessment of growth and presence of any infection. From each experimental tank twenty five fish were taken to assess their growth (length and weight). Finally, fingerlings were harvested by repeat netting followed by complete drainage of water from the tanks at the end of the experiment (60th day). Further, individuals were counted to record the survival rates, while 25 fish from each tank were taken to estimate mean length and weight. Standard formulae were used for calculating growth parameters as per Sahu et al. (2007).

Data related to fish growth performance in terms of length and weight, survival, feed conversion ratio, specific growth rate and hydrobiological attributes were subjected to statistical analysis using Microsoft Excel programme. Selected data were also subjected to analysis using PC-SAS programme for Windows, release v6.12 (SAS Institute, Cary, NC, UK). Further, in order to compare the treatment means for different parameters the Duncan's Multiple Range Test was performed at 95% significance level.

Results and Discussion

During the experimental period water temperature was observed to be in the range of 26.5 to 31.1°C

with no marked variation in values among the treatments. However, seasonal variation in water temperature was observed in the tanks with lower values of 26.5-26.9°C recorded in initial days followed by temperature rise in later part. Water pH varied within narrow alkaline range of 7.42 to 8.10 while free CO₂ concentrations ranged between 0.5-8.0 mg l⁻¹ (Fig.1).

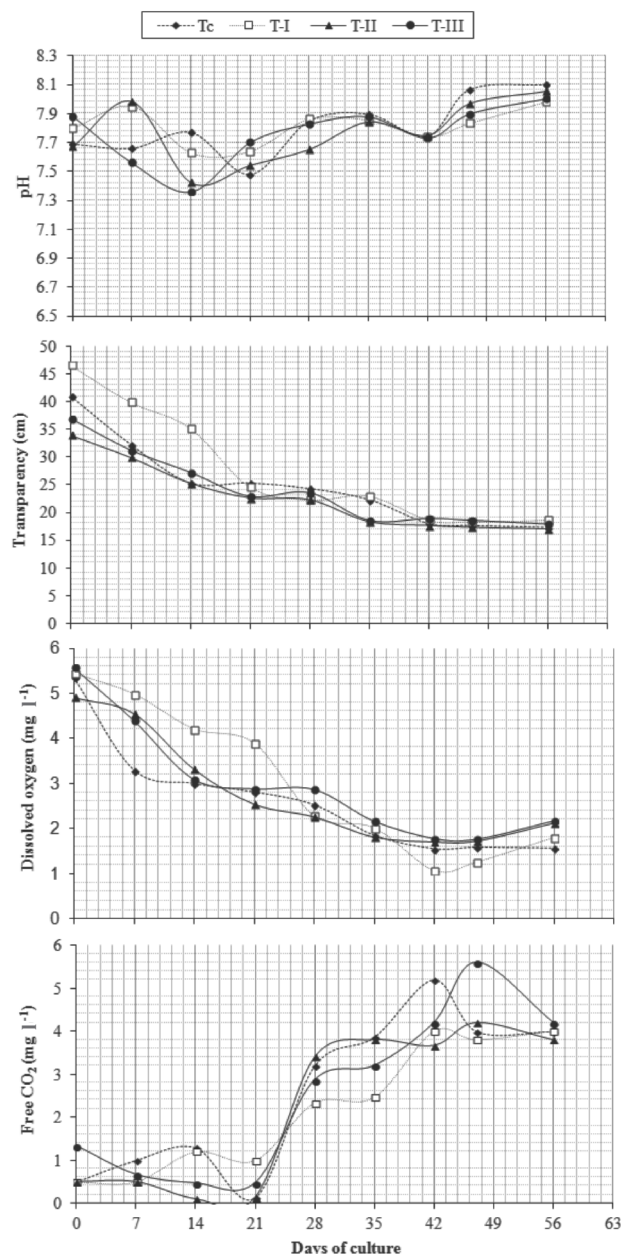


Fig. 1. Changes in water quality parameters in the treatment tanks during rearing of *Labeo rohita* fingerlings

Mean dissolved oxygen concentration varied between 1.08-5.57 mg l⁻¹ and showed decreasing trend with progress of culture (Fig.1), but no significant difference ($p>0.05$) was observed among the treatments. The mean water transparency in T-I was similar to T-C ($p>0.05$) and both were significantly higher than the other two aerated treatments T-II and T-III (Fig. 1). Total alkalinity varied from 69.3 to 94.7 mg CaCO₃ l⁻¹, whereas the total hardness varied from 61.3 to 84 mg CaCO₃ l⁻¹ throughout culture period with no significant difference among the treatments. Similarly, no significant differences were observed in concentrations of inorganic nutrients such as TAN, nitrate and phosphorus among the treatments while, the mean nitrite-nitrogen value was higher in the control (0.047 mg l⁻¹) (Fig. 2).

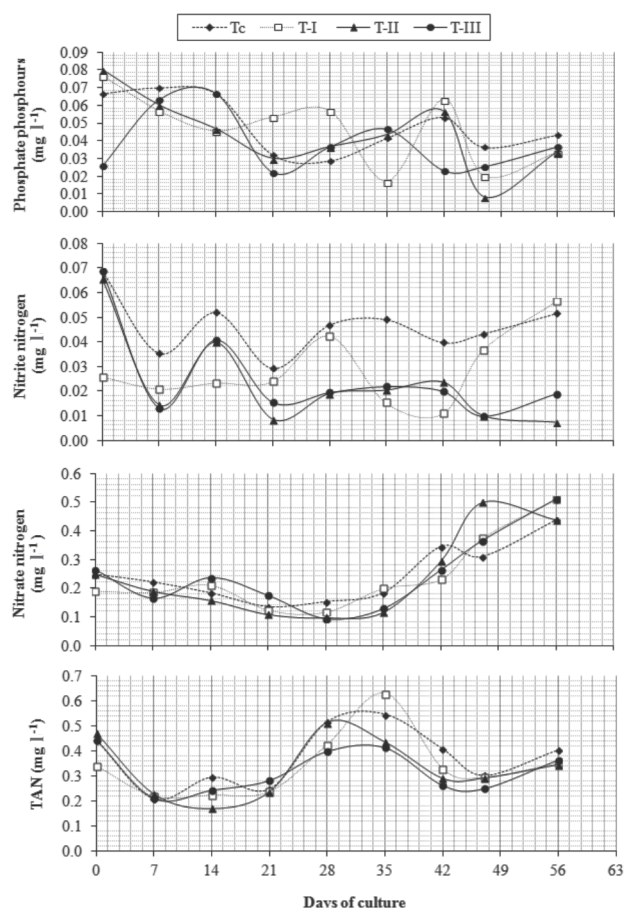


Fig. 2. Changes in inorganic nutrients of water in the treatment tanks during rearing of *Labeo rohita* fingerlings

Total plankton population during experimental period was observed to be varied widely among the treatments with phytoplankton and zooplankton constituting in the range of 91.6-97.5 and 2.5-8.4%, respectively (Fig. 3). Altogether 25 plankton genera were identified of which 19 were phytoplankton and 6 belonged to zooplankton group. In all the treatments, Chlorophyll-*a* was the dominant constituent of total chlorophyll (Fig. 4). While the mean total chlorophyll concentrations were almost similar among the treatments ($p>0.05$), the peak concentrations of chlorophyll '*a*' as well as total chlorophyll were recorded on the 45th day in all the treatments except T-III, where the maximum concentrations were on the 30th day.

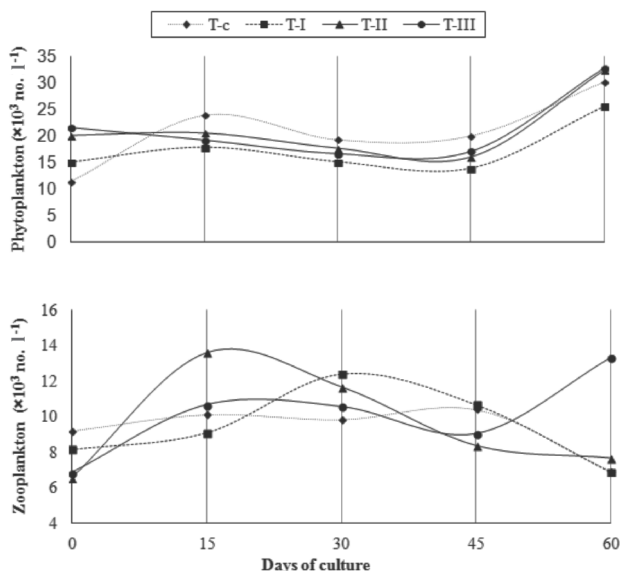


Fig. 3. Changes in plankton count in treatment tanks during rearing of *Labeo rohita* fingerlings

Diel fluctuation of dissolved oxygen concentrations (minimum–maximum) was comparatively narrower in first month (1.62-11.08 mg l⁻¹) compared to that in the second month (0.82-14.07 mg l⁻¹). The temperature within this sampling period ranged between 30.0-32.5°C (Fig. 5).

Sediment characteristics did not reveal any significant variation between the initial and final values of the pH, organic carbon, available phosphorus and nitrogen in any of the treatments. However, the pH and organic carbon values were relatively higher at the end of the study period, while available phosphorus and nitrogen content showed reverse

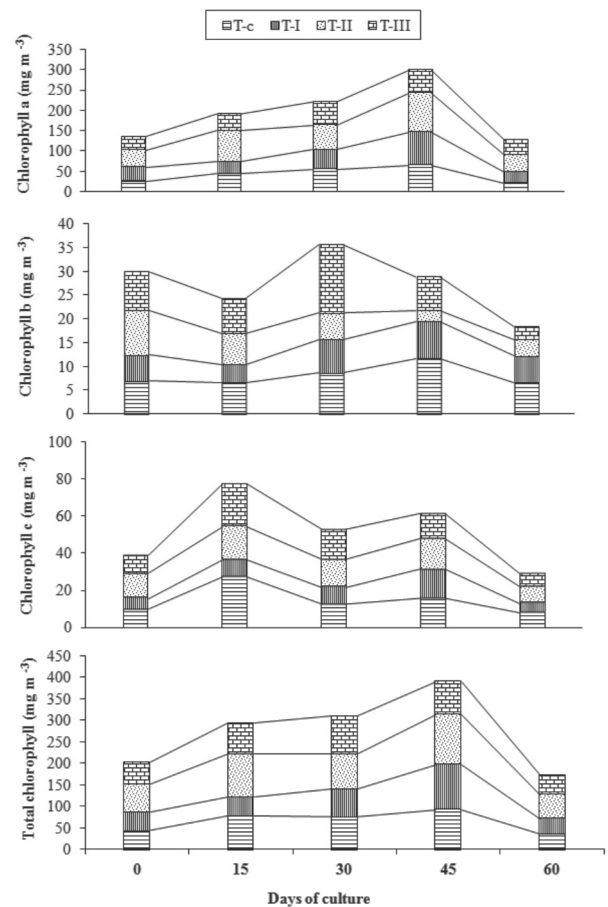


Fig. 4. Variations in chlorophyll concentrations during rearing of *Labeo rohita* fingerlings

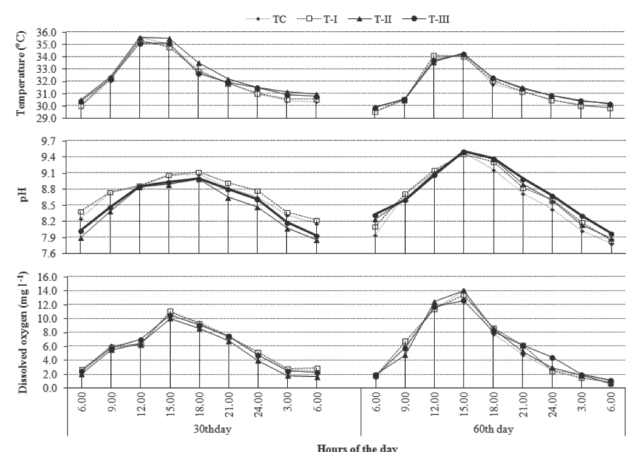


Fig. 5. Diel variations of water quality parameters during rearing of *Labeo rohita* fingerlings

Table 1. Sediment characteristics of rearing tanks under various aeration frequencies

Treatments		pH	Organic carbon (%)	Available phosphorus (mg P ₂ O ₅ -P 100 g ⁻¹ soil)	Available nitrogen (mg N 100 g ⁻¹ soil)
T-C	Initial	6.81-6.99 (6.92±0.10)	0.36-0.39 (0.35±0.05)	1.1-1.2 (1.16±0.08)	25.2-32.2 (29.0±3.7)
	Final	6.75-7.05 (6.92±0.15) ^a	0.54-0.69 (0.62±0.08) ^a	0.8-1.1 (0.93±0.15) ^a	11.9-12.6 (12.4±0.40) ^{ab}
T-I	Initial	6.66-6.75 (6.72±0.05)	0.39-0.4 (0.41±0.02)	0.90-1.2 (1.10±0.20)	18.2-20.1 (19.1±0.95)
	Final	6.84-6.96 (6.91±0.06) ^a	0.54-0.63 (0.60±0.05) ^a	0.5-0.6 (0.53±0.06) ^b	8.4-11.2 (9.56±1.46) ^b
T-II	Initial	6.34-6.55 (6.47±0.12)	0.45-0.48 (0.46±0.02)	0.8-1.2 (1.05±0.22)	21.4-23.8 (23.0 ±1.39)
	Final	6.77-7.10 (6.98±1.89) ^a	0.63-0.79 (0.70±0.08) ^a	0.8-0.9 (0.87±0.06) ^a	9.1-11.7 (11.6±2.45) ^{ab}
T-III	Initial	6.81-6.93 (6.85±0.07)	0.36-0.45 (0.41±0.05)	0.8-1.1 (0.96±0.14)	22.4-27.3 (25.0±2.46)
	Final	6.61-6.98 (6.87±0.19) ^a	0.65-0.79 (0.73±0.07) ^a	0.9-1.2 (1.03±0.15) ^a	13.1-15.9 (13.8±1.89) ^a

Figures in parentheses indicate mean ± SD (n=3)

Values with same superscript in a row do not differ significantly (p>0.05)

trend (Table 1). The recorded water and sediment characteristics of the aerated treatments were within the optimum range for carp culture (Tripathi et al., 2000; Das et al., 2004, 2012).

Gradual reduction in transparency and increased chlorophyll concentration in the experimental tanks during the initial month indicated an increase in plankton population (Fig. 1, 3). Further, fluctuation of oxygen content from around 2.0 mg l⁻¹ at dawn to 10.0 mg l⁻¹ at dusk, as observed through the weekly measurement of night time oxygen, indicated the presence of higher phytoplankton concentration in the tanks since it is the primary *in situ* oxygen producer during day time and the major variable oxygen consumer during night. Greater fluctuation of the diel dissolved oxygen level was also discernible during this period which corroborated the increased phytoplankton population and higher photosynthetic activity in the aerated groups. But, declining phytoplankton population in the aerated treatments during this period, probably attributed to greater grazing by zooplankton, which was also evident from the latter's increasing population in these tanks (Fig. 3). These phenomena clearly indicated higher photosynthetic activity in the aerated treatments which might have ensured

better growing environment for the fry. Sengupta & Jana (1987) reported that aeration induces net photosynthetic activity resulting in increased net primary productivity. Thus, provision of additional aeration in the aerated group ensured a better environment in the treatments than that of control, thus leading to higher survival, better growth, low FCR and higher net biomass production (Table 2).

Higher survival of the fingerlings in the aerated groups was likely to contribute for relatively greater deterioration of the water quality owing to the use of more feed and release of faecal matter. In contrast, almost all the recorded water parameters in the aerated treatments were within the acceptable limits for carps (Tripathi et al., 2000; Das et al., 2004; Jena et al., 2002; Biswas et al., 2006a; Sahu et al., 2007) and followed the same course of change as that of control, indicating the benevolent effect of aeration in maintaining the water quality in the tanks throughout the culture period.

Experimental aeration treatments led to significant increase in survival, growth rate, harvest size of the fingerlings and net biomass production in all the treatments compared to the control (p<0.05)

Table 2. Stocking and harvesting attributes of rohu fingerling rearing under varied aeration frequencies

Treatments	Stocking size Length (mm) Weight (g)	Harvested Size Length (mm) Weight (g)	Survival (%)	Net biomass (kg 50 m ⁻²)	SGR (% day ⁻¹)	FCR	% Weight gain
T-C	25±0.2 0.2±0.01	68±11 2.97±0.15 ^b	49.90±3.27 ^b	3.40±0.40 ^c	4.12±0.09 ^b	5.78±0.33 ^a	91.74±0.43 ^b
T-I	25±0.2 0.2±0.01	77±12 3.97±0.39 ^a	55.83±5.90 ^{ab}	5.15±0.10 ^b	4.60±0.16 ^a	4.25±0.41 ^b	93.80±0.56 ^a
T-II	25±0.2 0.2±0.01	78±10 4.10±0.20 ^a	63.66±5.65 ^a	6.12±0.50 ^a	4.66±0.08 ^a	4.08±0.22 ^b	94.03±0.29 ^a
T-III	25±0.2 0.2±0.01	77±09 4.17±0.04 ^a	67.96±10.40 ^a	6.59±0.51 ^a	4.68±0.16 ^a	4.03±0.41 ^b	94.10±0.56 ^a

Values are expressed as mean ± SD (n=3)

Values with same superscript in a coloumn do not differ significantly (p>0.05)

(Table 2). Similarly, positive impact of aeration during fingerling rearing has also been reported (George et al., 1990; Rout, 1995; Jena et al., 2005). Higher survival of rohu with provision of aeration has earlier been reported in seed rearing (Rout, 1995; Jena et al., 2005) and grow-out culture (Vijayan & Varghese, 1986; Jana & Sengupta, 1992; Jena, 1998; Das et al., 2004). The FCR achieved in the study were 4.03-4.25 in the aerated treatments which might be considered good in the context of carp fingerling rearing with rice bran and groundnut oil cake as the supplementary feed. But the FCR in aerated treatments was lower than in control (5.78) which indicated better feed utilization by the fingerlings with additional provision of aeration (Thomforde & Boyd, 1991; Aravindakshan et al., 1997; Das et al., 2004; Jena et al., 2005).

Treatments with aeration after mid night (T-III, 24.00-6.00 h) recorded maximum harvested size (4.17±0.04 g and 7.73±0.10 cm) followed by T-II, T-I and T-C. The SGR (% day⁻¹) and percentage weight gain followed the same trend as that of harvest size. However, these attributes, except the net biomass yield, did not appear to be influenced significantly by the timing of aeration as there was no significant difference in their values (p>0.05) among the aerated treatments. The net biomass productions were similar in T-II (6.12 ± 0.50 kg tank⁻¹) and T-III (6.59±0.51 kg tank⁻¹), while both were significantly higher (p<0.05) than that of T-I (5.15 ± 0.10 kg tank⁻¹). Similarly, there was significant improvement in the FCR in the aerated groups than that of non-aerated control, showing

lowest value (4.03 ± 0.41) in T-III and highest in T-C (5.78 ± 0.33) (Table 2).

Though advantage of aeration in the fingerling performance was clearly discernible in the present study, varied timing of the night aeration could not yield significant difference in survival, weight gain, SGR or FCR in the aerated treatments. However, some advantages were evident with relatively higher values of these attributes in treatments provided with aeration towards later part of the night (T-II and T-III). The net biomass production in T-I was significantly lower than that of T-II and T-III, which favoured aeration in the later part of night. Further, between fingerlings of T-II and T-III, though all these yield attributes did not differ significantly, their relatively better performances in T-III over T-II indicated effectiveness of aerating the tanks after midnight (24.00-06.00 h).

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