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Optimization of Stocking Density for Cage Farming of Nile Tilapia *(Oreochromis niloticus* L.*)* in the River in Ecosystem of Northern Bangladesh

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ABSTRACT

Water quality, production and economics of small scale cage aquaculture were studied for a period of four months from September, 2009 to December, 2009 at Mahananda River of Chapainawabganj district, Bangladesh under three different treatments of different densities of *Oriochromis niloticus* L. T_1 (200 fingerlings/m^3 cage), T_2 (150 fingerlings/m^3 cage) and T_3 (100 fingerlings/m^3 cage) each with three replications. Water quality parameters (water temperature, transparency, dissolved oxygen, CO_2, pH, hardness, alkalinity and NH_3-N) were monitored fortnightly and the growth parameters were monitored monthly. Mean water temperature (°C), transparency (cm), DO (mg/l), pH, CO_2 (mg/l), alkalinity (mg/l), hardness (mg/l) and NH_3-N (mg/l) varied from 26.18±2.40 (T_1) to 26.29±2.41 (T_3), 33.91±8.59 (T_1) to 33.96 ± 8.58 (T_3), 5.38±0.14 (T_1) to 5.95± 0.16 (T_3), 7.43± 0.08 (T_1) to 7.50± 0.08 (T_2), 5.80±0.16 (T_3) to 6.00±0.16 (T_1), 77.89±1.22 (T_2) to 81.85±1.23 (T_3), 89.02±3.41 (T_2) to 91.08±3.23 (T_3) and 0.27±0.07 (T_3) to 0.49±0.10 (T_1), respectively and all the values were found suitable for fish culture. Water quality parameters only dissolved oxygen and NH_3-N varied significantly ($P<0.05$) within the treatments. Growth parameters only final weight and yield varied significantly ($P<0.05$) within the treatments. The mean total cost (Tk/m^{3}cage/4 months), net benefit (Tk/m^{3}cage/4months) and CBR significantly varied ($P<0.05$) from 1176.67±3.33 (T_3) to 1886.67±3.33 (T_1), 2080.00±0.00 (T_3) to 2520.00±0.00 (T_3) and 1.33±0.00 (T_1) to 1.77±0.01 (T_3), respectively. In spite of having highest yield, CBR (Cost Benefit Ratio) was found lowest in treatment T_1. Both moderate yield and CBR were found with treatment T_2. Based on the environmental factors, production and economics, the optimum stocking density is found in treatment T_2.

Key words: Cage aquaculture, Economics, *Oriochromis niloticus*, Stocking density, Production

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1. INTRODUCTION

Cage aquaculture has gained popularity throughout the world and its contribution to improve the livelihoods in Asia is well documented (IIRR, 2001). Fish farming in low cost small scale cages was piloted and introduced in Bangladesh primarily to landless poor (ADB, 2005) and later on commercial aquaculture operation was also made in large cages (DoF, 2008). It is clear that small-scale cage culture is particularly suited to poverty alleviation in Bangladesh. Perhaps the greatest strength is the lack of requirement for land. In Bangladesh many of the rural poor are landless who can get easy access to lakes, rivers, water canals and seasonal water bodies for their livelihood improvement through cage aquaculture. A second major strength is the flexibility of cage culture-especially in terms of investment requirements. Cage aquaculture can be started using a small cage and/or low stocking densities, with correspondingly low start-up costs. Based on these benefits, cage aquaculture is already found to be considered as one of the important technique to improve the livelihood of the resource poor fishers in Bangladesh (Chowdhury & Yakupitiyage, 2000; DoF, 2015; DoF, 2016; DoF, 2018). Research efforts for the promotion of cage aquaculture in Bangladesh are also made with emphasis on aquaculture species like tilapia (*Oreochromis niloticus*), Chinese carps, catfish (*Pangasius* sp.), silver carb (*Barbonymus gonionotus*), and the freshwater prawn *Macrobrachium rosenbergii* including the socio-economic aspects (Rahmatullah et al., 1997; Hambrey et al., 2001; Rahman et al., 2006). Among them, tilapia (*Oreochromisniloticus* L.) can be raised in cage aquaculture because the fish grows well with diets, can tolerate high stocking densities and can be easily spawned (Khalil & Hussein, 1997). However, the growth and yield characteristics of this fish in cages have not been studied in detail. Bangladesh is characterized by vast aquatic resources including natural depressions and wetlands, rivers and lakes, borrow pits, large impoundments canals and dugout ponds that are potential sites for commercial cage aquaculture. Cages are easy to manage, produce fish of high quality and utilize existing water bodies (Beveridge, 1996); therefore, cage aquaculture offers a viable alternative for the landless farmers in resource-poor areas like Bangladesh. Stocking density is a significant factor that determines production in cages. Understocking results in failure to make the maximum possible utilization of the space, and overstocking may result in stress that may lead to enhanced energy requirements causing reduced growth and feed utilization (Leatherland & Cho, 1985). Both under and overstocking affect farm economics and productivity. Identifying the optimum stocking density for a species is, therefore, a critical factor in designing an efficient cage aquaculture system. Therefore, the present study was aimed at optimizing the stocking density of tilapia in cage culture system in the Mahananda River of Bangladesh. The specific objectives of this study were to monitor the water quality parameters, to determine the effects of stocking density on the growth, survival and yield, to evaluate the economics and to recommend suitable stocking density of tilapia for small scale cage farming in the riverine ecosystem.

2. MATERIALS AND METHODS

Study area and experimental design

The experiment was conducted for the period of four months from September 2009 to December 2009 in the Mahananda River in Chapainawabganj district (24° 37′ 48″ N latitude 88° 39′ 13″ E longitude) of Bangladesh. Three different stocking densities of all male tilapia *Oreochromis niloticus* were evaluated under three treatments namely T_1: 200 fingerlings/m^3 cage, T_2: 150 fingerlings/m^3 cage and T_3: 100fingerlings/m^3cageeach having three replications.

Cage description

This study was carried out in the river using cages (1mx1mx1m) made of knotless, high-density polyethylene netting of 0.5mm mesh size. Cage frames were made of bamboo bars. The cages were suspended from a bamboo structure fixed by cotton nylon cords to a walkway from the shore. Plastic bottles were attached along the four corners of each cage to keep them floating.

Stocking of fish fingerlings

The fingerlings of *O. niloticus* (initial stocking weight 41.0 g) were collected from a rearing pond located at Nachole upazila of Chapainawabganj district. Fingerlings were brought to the experimental site through oxygenated polythene bag. Fingerlings were acclimatized by letting the transport bags float in the fish cage for about 30 minutes, after which letting the fingerlings get out freely from the bags. The fishes were randomly released into different replicates of three treatments. Fish were stocked early in the morning to avoid stress when the water was cool.

Feeding

A commercial pellet feed (ACI, Dhaka, Bangladesh) with 28% crude protein content was used. Fish were hand-fed using feeding trays at10% of body weight at the start of the feeding trial. Feeding level was reduced to 5% of body weight by the end of the trial. Fish were fed twice a day at 09:00-10:00 AM and at 05:00-06:00PM with 50% of the ration allocated at each time. Feed quantity was adjusted every month according to fish biomass determined by sub sampling. The cage nets and feeding trays were cleaned in each week.

Water quality monitoring

Some important physico-chemical parameters such as water temperature, transparency, dissolved oxygen (DO), hydrogen ion concentration (pH), free carbon dioxide (CO_2), alkalinity, total hardness and ammonia-nitrogen (NH_3-N) were studied fortnightly between 10 am to 11 am for the present study. Water temperature was recorded by the help of a Celsius thermometer (°C) at 20 to 30 cm water depth.

Transparency of water was measured by a secchi disc (cm), DO (mg/l), pH, CO_2 (mg/l), Alkalinity (mg/l), Total hardness (mg/l), NH_3-N (mg/l) were measured with the help of water quality test kit (HACH kit FF-2, USA).

Growth monitoring

At least 10% (by number) of the fish in each cage were randomly sampled on a monthly basis by partially lifting the cage and removing fish with a dip net. On each sampling day, individual fish from each cage were weighed and measured. The purpose was to determine fish growth in weight and to adjust the ration. The following parameters were used to monitor the growth.

i) Weight gain (g)

Weight gain (g) = Mean final weight (g) – Mean initial weight (g).

ii) Specific growth rate (SGR, % bwd^{-1})

$$SGR = \frac{L_n \text{ (final weight)} - L_n \text{ (initial weight)}}{\text{Culture period}} \times 100$$

(Brown, 1957).

iii) Survival rate (%)

$$\text{Servival rate (\%)} = \frac{\text{No. of fish harvested}}{\text{No. of fish stocked}} \times 100$$

iv) Production / yield of fishes

Yield (Kg /cage/cycle) = Fish biomass at harvest –fish biomass at the stock.

Economics

In order to assess the financial viability of cage culture, economic data were collected and a simple economic analysis was conducted to determine economic returns of different treatments based on market prices in Bangladesh for harvested fishes and are expressed in Bangladesh Taka (BDT) (1 USD=79 BDT). The total cost (variable cost and fixed cost) was calculated and total return was determined from the current market prices of harvested fish. CBR was also calculated by the following equation:

CBR= Total return / Total cost

Statistical analysis

All the collected data during the experiment were recorded and preserved on a computer spreadsheet. Data of water quality, yield parameters (growth, yield, SGR and survival) and economic performance were analyzed statistically by one-way analysis of variance (ANOVA) using the SPSS (Statistical Package for Social Science, version-15.0). Significance was assigned at the 0.05% level. The mean values were also compared to see the significant difference through DMRT (Duncan Multiple Range Test).

3. RESULTS

Water quality parameters

The mean values of different water quality parameters in different treatments by the total of all fortnights are presented in Table 1. There were no significant differences for water temperature, transparency, pH, free carbon dioxide, total alkalinity and total hardness among the treatments.

The mean value of water temperature during the study period was found to be ranged from 26.18±2.40 to 26.29±2.41°C. The minimum value was recorded in treatment T_1 whereas the maximum value was recorded in treatment T_3. The mean value of water transparency varied from 33.91±8.59 to 33.96 ±8.58cm. The minimum value was recorded in treatment T_1whereas the maximum value was recorded in treatment T_3. The mean value of DO varied from 5.38±0.14 to 5.95± 0.16mg/l. The minimum value was recorded in treatment T_1 whereas the maximum value was recorded in treatment T_3. The mean value of water pH varied from 7.43± 0.08 to 7.50± 0.08. The minimum value was recorded in treatment T_1whereas the maximum value was recorded in treatment T_2. The mean value of free carbon dioxide varied from 5.80±0.16 to 6.00±0.16mg/l. The minimum value was recorded in treatment T_3 whereas the maximum value was recorded in treatment T_1. The mean value of total alkalinity varied from 77.89±1.22 to 81.85±1.23mg/l. The minimum value was recorded in treatment T_2 whereas the maximum value was recorded in treatment T_3. The mean value of water hardness varied from 89.02±3.41 to 91.08±3.23mg/l. The minimum value was recorded in treatment T_2 whereas the maximum value was recorded in treatment T_3. The mean value of ammonia-nitrogen varied from 0.27±0.07 to 0.49±0.10mg/l. The minimum value was recorded in treatment T_3 whereas the maximum value was recorded in treatment T_1. Only the mean values of DO and ammonia-nitrogen varied significantly with the treatments.

Fish growth

The variation in the mean values of different growth parameters under the different treatments during the study period are presented in Table 2.

Weight gain (g/month)

The mean weight gain (g/month) of tilapia at different treatments was found as 18.59±2.48 in treatment T_1, 23.63±4.06in treatment T_2 and 31.97±5.11 in treatment T_3.

Specific growth rate (%, bwd^{-1})

The mean specific growth rate (%, bwd^{-1}) of tilapia at different treatments were found as 0.86±0.21 in treatment T_1, 0.99±0.33 in treatment $T_2$and 1.18±0.41 in treatment T_3.

Final weight (g)

The mean final weight of tilapia at different treatments were found as 115.60±0.21g in treatment T_1, 135.70±0.06g in

Table 1 Variations of the mean values of water quality parameters under different treatments during study period.

	Treatments				
Variables	T_1	T_2	T_3	*F*-value	*P*-value
Water temperature (°C)	26.18±2.40^a	26.25±2.40^a	26.29±2.41^a	0.001	0.999
Transparency (cm)	33.91±8.59^a	33.93±8.60^a	33.96±8.58^a	0.213	0.798
DO (mg/l)	5.38±0.14^b	5.75±0.15^{ab}	5.95±0.16^a	2.936	0.075
pH	7.43±0.08^a	7.50±0.08^a	7.49±0.09^a	0.221	0.803
CO_2 (mg/l)	6.00±0.16^a	5.91±0.16^a	5.80±0.16^a	0.410	0.669
Alkalinity (mg/l)	79.55±1.21^a	77.89±1.22^a	81.85±1.23^a	0.579	0.569
Hardness (mg/l)	90.13±3.48^a	89.02±3.41^a	91.08±3.23^a	0.250	0.781
NH_3-N (mg/l)	0.49±0.10^a	0.33±0.07^{ab}	0.27±0.07^b	1.849	0.182

Figures bearing common letter(s) in a row as superscript do not differ significantly ($P < 0.05$)

Table 2. Variations of the mean values of growth parameters under different treatments during the study period

	Treatments				
Variables	**T_1**	**T_2**	**T_3**	***F*-value**	***P*-value**
Weight gain (g/month)	18.59±2.48^a	23.63±4.06^a	31.97±5.11^a	2.810	0.113
SGR (%, bwd^{-1})	0.86±0.21^a	0.99±0.33^a	1.18±0.41^a	0.240	0.792
Final weight (g)	115.60±0.21^c	135.70±0.06^b	169.07±0.22^a	6419.68	0.000
Survival rate (%)	94.67±0.33^a	95.13±0.43^a	96.00±0.58^a	4.571	.062
Total yield (kg/cage/cycle)	21.96±0.67^a	19.41±0.67^b	16.22±0.58^c	64.079	0.000

Figures bearing common letter (s) in a row as superscript do not differ significantly ($P < 0.05$)

treatment T_2 and 169.07±0.22g in treatment T_3. All the treatments varied significantly for the mean values of final weight.

Survival rate (%)

The survival rate (%) of tilapia at different treatments were found as 94.67±0.33 in treatment T_1,95.13±0.43 in treatment T_2 and 96.00±0.58in treatment T_3. No significant difference was found among the treatments for the mean values of survival rate.

Yield (kg/cage/cycle)

The mean yield (kg/cage/cycle) of tilapia at different treatments were found as 21.96±0.0.67 in treatment T_1, 19.41±0.67 in treatment T_2 and 16.22±0.58in treatment T_3. All the treatments varied significantly for the mean values of yield (kg/cage/cycle).

Economics

The economics of different treatments are presented in Table 3. The total cost (Tk/cage/cycle) of tilapia at different treatments (i.e. 200, 150 and 100) were found as Tk. 1886.67±3.33 in treatment T_1, Tk. 1563.33±3.33 in treatment T_2 and Tk. 1176.67±3.3 in treatment T_3. Among the different treatments, the highest total cost (Tk/cage/cycle) was recorded in treatment T_1 whereas the lowest cost (Tk/cage/cycle) was obtained in treatment T_3. Total cost varied significantly under the different treatments.

The total return (Tk/cage/cycle) of tilapia at different treatments of stocking densities (i.e. 200, 150 and 100) was found as Tk. 2520.00±0.00 (in treatment $T_{1)}$, Tk. 2470.00±0.00 (in treatment T_2) and Tk. 2080.00±0.00 (in treatment T_3). Among the different treatments, the highest return (Tk/cage/cycle) was found in treatment T_1 whereas the lowest return (Tk/cage/cycle) was foundin treatment T_3. Total return (Tk/cage/cycle) varied significantly under the different treatments.

The CBR of tilapia at different treatments of stocking densities (i.e. 200, 150 and 100) were found as 1.33±0.003 in treatment T_1, 1.58±0.003in treatment T_2 and 1.77±0.01 in treatment T_3. Among the different treatments, the highest CBR was found in treatment T_3 whereas the lowest was

Table 3. Variations of the mean values of different parameters of economics under different treatments.

Parameters \ Treatments	T_1	T_2	T_3
Fixed/common cost (Tk.)			
Net	500±0.00^a	500±0.00^a	500±0.00^a
Bamboo	30±0.00^a	30±0.00^a	30±0.00^a
Rope	10±0.00^a	10±0.00^a	10±0.00^a
Labour	60±0.00^a	60±0.00^a	60±0.00^a
Subtotal (Tk.)	600±0.00^a	600±0.00^a	600±0.00^a
Cost/cycle (Tk.)	100±0.00^a	100±0.00^a	100±0.00^a
Variable cost (Tk.)			
Fish seed	1000.00±0.00^a	750.00±0.00^b	500.00±0.00^c
Feed	786.67±3.33^a	713.33±3.33^b	576.67±3.33^c
Subtotal (Tk.)	1786.67±3.33^a	1463.33±3.33^b	1076.67±3.33^c
Total cost (Tk.)	1886.67±3.33^a	1563.33±3.33^b	1176.67±3.33^c
Return/cage/cycle (Tk.)	2520.00±0.00^a	2470.00±0.00^b	2080.00±0.00^c
Return/cage/year (Tk.)	7560.00±0.00^a	7410.00±0.00^b	6240.00±0.00^c
CBR	1.33±0.003^c	1.58±0.003^b	1.77±0.01^a

Figures bearing common letter(s) in a row as superscript do not differ significantly ($P <0.05$)

found in treatment T_1. CBR varied significantly under the different treatments.

4. DISCUSSION

Water quality

In the present study, the mean value of water temperature varied from 26.18±2.40 to 26.29±2.41°C. The average water temperature as 29.4°C was found in the Padma River observed by Ashfaque (2004), as 27.52°C in Buriganga River by Islam et al. (1974) and as 27.6±6.68 °C in Meghna River by Ahmed et al. (2005). Shafi et al. (1978) observed average temperature as 25.8 °C of the Meghna River near Daudkaudi. Boyd (1998) reported the suitable water temperature of 25-32°C for warm water aquaculture species. The optimum temperature for tilapia culture is 20-30°C or above reported by El-Sayed (2002). The temperatures in all the different treatments were within the optimum ranges. The mean value of water transparency in this study varied from 33.91±8.59cm to 34.07±8.61cm in 2009. Ahmed et al. (2005) found the transparency value of 34.2±1.18cm in Meghna River. Boyd (1998) reported the secchi disc reading between 30 to 45 cm as suitable for fish farming. In the present investigation, the transparency of the river water for all the stocking density are around the ideal value limits. Mean value of dissolved oxygen content varied from 5.38±0.14 to 5.95±0.16mg/l in 2009.Ahmed et al. (2005) reported the mean DO value as 6.7±0.8 mg/l. Banerjee (1967) and Bhuiyan (1970) reported 5.0 to 7.0 mg/l of DO content of water as fair or good in respect of productivity and water having DO less than 5 mg/l to be unproductive.

The ideal DO level for tilapia culture is 4-5 mg/l and the present study showed higher DO values for all the density cages attributing good environment for tilapia culture. The mean value of pH varied from 7.43 ±0.08 to 7.50±0.08. Average pH value recorded as pH 7.6 by Abo-State et al. (2009) was suitable for tilapia culture. It was also supported by Khalfalla et al. (2008). Ahmed et al. (2005) recorded the mean value of pH in Meghna River as 7.8±0.18. In the present study mean values of free CO_2 varied from 5.80±0.16 to 6.00±0.16mg/l. Result of the present study has more or less similarity with the findings of Ahmed et al. (2005) who obtained the CO_2 value of 4.8±0.74 mg/l in Meghna River. Nile tilapia can tolerate freeCO_2 concentration above 20 mg/l and unlikely to have an adverse effect on fish in intensive culture systems unless freeCO_2 concentration reaches 100 mg/l stated by Tran-Duy et al. (2008). The recorded mean total alkalinity varied from 77.89±1.22 to 81.85±1.23mg/l which has similarity with Ahmed et al. (2005), who obtained the alkalinity value of 80.3±6.78 mg/l in MegnaRiver. However, the finding also agreed with Rahman et al. (2006) who reported 78.5 mg /l of total alkalinity. Boyd (1998) recommended alkalinity level >20 mg/l as suitable for aquaculture. The recorded mean total hardness varied from 89.02±3.41 to 91.08±3.23mg/l. This value in more or less similar to the findings of Ali et al. (2011) who got the mean value of 83.29±3.44 to 91.08±3.23 mg/l.The recorded mean value of ammonia-nitrogen varied from 0.27±0.07 to 0.49±0.10mg/l. Ahmed et al. (2005) got the mean value of 0.35±0.08mg/l in Meghna river. Alam and Thomson (2001), Ali et al. (2011) and Asaduzzaman et al. (2006) who recorded ammonia nitrogen value ranged from

0.2 to 0.4, 0.29 to 0.38, and 0.203 to 0.569 mg/l, respectively.

Growth of fish

Results indicated that only yield was found highest in thetreatment T_1. Other parameters like SGR, weight gain, final weight and survival rate were highest in the treatment T_3. A moderate value of almost all the growth parameters was found in treatment T_2. These variations in growth parameters might be due to the variation in stocking densities with treatments. The mean final weight of fish were inversely proportional to stocking density, i.e. fish grown at the highest density had the lowest final mean weight. Leboute et al. (1994) conducted a trial with all male Nile tilapia fry, (*O. niloticus)*to evaluate their performance in cages, stocking with 4 different stocking densities (fish/m^3): 40, 60, 80 and 100 fish/m^3. After 5 months, mean body weight gain were 140.50, 84.10, 79.80 and 71.00 at densities of 40, 60, 80 and 100 fish/m^3, respectively. The relationships between stocking density and the growth and yield parameters obtained in the present study closely agreed with Chakraborty & Banerjee (2010); Daungsawasdi et al. (1986) and Cruz & Ridha (1989) who worked on tilapia farming. Similar growth and production scenarios were also observed with cat fishes (Rahman et al., 2006; Chowdhury, et al. 2007; Teng & Chua 1979; Hogendoom & Koops 1983; Storck & Newman 1988; Engle & Valderrama 2001) and with silver perch (Rowland, et al. 2004). Significantly highest ($P<0.05$) SGR value was recorded at treatment T_3 while the lowest was obtained at $T_{1.}$ Diana et al. (1994) reported that Nile tilapia stocked at a low density showed better SGR than at a higher density. Survival rates were not significantly affected by stocking density, which is consistent with other reports on tilapia as well as other species. Leboute et al. (1994), reported that mean survival rate was 93% of Nile tilapia. Chakraborty & Banerjee (2010); El-Sayed (1999); Islam et al. (2006) and Daungsawasdi et al. (1986) reported that the mortality of Nile tilapia raised in cages was not dependent upon stocking density. Lower weight gain and final weight as achieved in the present study under the treatment T_1 also seemed to be due to accumulation of metabolic wastage of fishes originating from increased number of fishes causing growth suppression under cage culture condition. Hepher and Pruginin (1982) reported the daily weight gain of tilapia decreased when the stocking density was increased.

Economics

Production estimates that are based on biomass estimates adjusted for mortality and corrected for growth gain are the basis for estimating the economic revenue from fish culture operations. There was an obvious increase in the feed and fingerling costs with increasing stocking density, which resulted in the total production cost becoming higher with higher stocking density. However, as the yield increased with increasing stocking densities,the return also increased (Table 3). These two parameters apparently indicate that higher stocking densities are more profit yielding than lower density for the fish.

While the final harvest and production values were directly related to stocking density, there must be some density at which the mortality is higher and the growth rate is lower; when this occurs, production will be reduced. This critical level was not reached in this experiment even at the highest stocking density of 200 fish/m^3. This suggests that the fish is able to maintain high production levels when cultured at high densities, provided that suitable physical environment and nutritional conditions are met. The performance of tilapia in this study, and the costs and revenue suggest that it may be practical and commercially viable to use cages for the production of the fish. A similar opinion based on cage culture of *O. niloticus*was given by Leboute et al. (1994).Raising fingerling and feed costs with increasing density resulted in the higher total cost per cage. As fish are sold at different set of price per kilogram according to the fish size, the costs per kilogram are the most important determinants in farm profitability. However, as the market size of fish is sometimes an important concern, higher stocking densities may not always be suitable because individual growth rates of fish are reduced after a threshold limit of stocking density, and smaller individuals are produced after that limit. Thus, even though higher yields are produced at higher densities, farm profitability may be higher at density that produces the largest individuals, determined by the consumers choice on fish size. In the present study, the growth rate was maximum at 100 fish/m^3 cage and then reduced consistently with stocking density. However, farm return was maximum and CBR was minimum at 200 fish/m^3 cage, but moderate return was found at 150 fish/m^3 cage. This study clearly documents moderate yields, moderate production costs and moderate CBR/profitability with tilapia culture at moderate stocking densities in cages; this finding indicates that the density of 150 fingerling/m^3 (treatment T_2) produces the suitable farm output and is the moderately profitable among the densities tested. These findings more or less agreed with Rahman et al. (2006) who reported highest economic performance while working with *Pangasiussutchi* at a density of 150 individuals/m^3 cages. However, it does not indicate the upper limit of stocking densities for tilapia cultured in a cage system. Additional experiments could be conducted to determine the dietary protein level feed of tilapia in cages and resulting in the best possible farm economics.

Recommendations

Based on the present findings, it is recommended to conduct further research to optimize the dietary protein level for cage farming of *O. niloticus* in the Riverine ecosystem

5. CONCLUSION

It can be concluded that among the different parameters significant variation specially with DO was found in the treatments with almost all fortnights. Comparatively less value of DO was obtained in the treatment T_1 (i.e., Higher stocking density). Comparatively higher value of NH_3-N and CO_2 was also found in the treatment T_1. Moderate yield and

CBR was found in treatment T_2. In spite of having highest yield, CBR was found lowest with treatment T_1 (i.e., Highest stocking density). Based on the environmental factors, production and economics, the optimum stocking density was found in treatment T_2.

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