ISSN: 2224-0616
Int. J. Agril. Res. Innov. & Tech. 7 (2): 49-56, December, 2017 Available online at http://www.ijarit.webs.com

EFFECTS OF POPULATION DENSITY ON GROWTH AND PRODUCTION OF TILAPIA IN MONOCULTURE

T.H. Majumder[1], P. Chowdhury[2]*, M. Shahjahan[3] and M.S. Rahman[4]

Received 30 September 2017, Revised 9 December 2017, Accepted 24 December 2017, Published online 31 December 2017

Abstract

The experiment was conducted to determine the effect of population density on growth and production of Tilapia (monosex GIFT tilapia) in monoculture system for a period of 110 days. The experiment was carried out in six earthen ponds, which were situated in the Bangladesh Agricultural University Campus, Mymensingh. The experiment was carried out under three treatments each with two replications. Fish population density was 200 fish per decimal under treatment-I, 400 fish per decimal under treatment-II and 600 fish per decimal under treatment-III. In the ponds supplementary feed of wheat bran and rice bran mixture were used daily at the rate of 46 g, 92 g and 136 g per decimal under treatment-I, II, and III, respectively. The average initial length and weight of tilapia were 4.63 cm and 2.82 g respectively. The ponds were fertilized fortnightly with urea and TSP at the rates of 60 g and 90 g, respectively. During experimental period, the ranges of water temperature (25.82 to 29.80 ºC), transparency (28.00 to 38.00 cm), dissolved oxygen (5.50 to 8.30 mg/L), pH (7.00 to 7.90), total alkalinity (130.00 to 200.00 mg/L), free CO2 (2.00 to 6.00 mg/L), phosphate-phosphorus (1.20 to 2.30 mg/L), and nitrate-nitrogen (3.20 to 4.00 mg/L) were within the productive range and more or less similar in all the ponds under three treatments. There were 25 genera of phytoplankton under five major groups and 10 genera of zooplankton under three major groups in the experimental ponds. Mean survival rate of fish under treatment-I, treatment-II, and treatment-III were 82.75%, 77.12% and 74.33% respectively. The calculated net fish production under treatment-I was 6.75 ton/ha/yr and that of the ponds under treatment-II was 10.26 ton/ha/yr and that of the ponds under treatment-III was 12.15 ton/ha/yr. The net fish production under treatment-II and treatment-III were 152% and 180% higher than that of treatment-I, taking net fish production under treatment-I for 100%. According to profit-cost analysis, the ratios of net profit under treatments I, II, and III were 1:0.44, 1:0.27, and 1:0.09. According to specific growth rate and survival, treatment-I is the best, and according to profit-cost analysis treatment-I (ratio 1:0.44) also the best. So, the population density of 200 fish per decimal (under treatment-I) might be considered the best among the three treatments.

Keywords: Tilapia, Stocking Density, Production, Water Quality

[1]Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh
[2]Scientific Officer, Bangladesh Fisheries Research Institute, Headquarters, Mymensingh-2201, Bangladesh
[3]Professor, Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh
[4]Professor, Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

*Corresponding author's email: nitoldhk@gmail.com (P. Chowdhury)

Introduction

Bangladesh is situated in a zone where climatic conditions and geographical position are very much favorable to fisheries resources. Fisheries sector plays a major role in the development of socio-economic situation, employment generation, poverty alleviation, nutrition of large number of population, and foreign currency earnings in the economy of Bangladesh. Fish is considered as one of the most delicious and an essential food all over the world including Bangladesh. Capture fisheries, although still the major source of supply of fish are in decline due to over-fishing and environmental degradation, and it is now considered that aquaculture has the greatest potential to meet the growing demand for fish from the increasing population. Currently aquaculture production accounts for about one-third of the total fish production in Bangladesh (DoF, 2011). Aquaculture is rapidly gaining attention with increase in human population and reduced natural fisheries resources. Pond aquaculture is growing fast in many Asian countries. However, fish culture on a small-scale basis has often failed due to inappropriate knowledge regarding optimum stocking density and feeding regime of fish. Stocking density is

generally defined how many fishes are released per unit area of the pond. It is considered one of the main reasons that affect fish growth, feed utilization and gross fish yield. The full utilization of space for maximum fish production through intensive culture system can increase the profitability of the fish farm. Projections from the Food and Agriculture Organization (FAO) of the United Nations, estimate the animal protein requirement of 2050 to be about 889 million metric tons per year or 3 times the consumption in 2010 in China (FAO/UNDP, 2011). Other estimates show that we may need up to six times the levels produced in 2010. This means that all sectors of agriculture will require expanding to meet the increased demand. If aquaculture is to fulfill its potential and contribute to the improvement of world protein production then we must improve culture technologies, feed formulations and genetics of our culture species. Tilapias are an integral component of subsistence fisheries for thousands of years but have gained popularity in recent years in areas where they are not endemic. Introductions of better performing tilapia species/strains and development of techniques to manage unwanted reproduction have spurred significant developments that became a huge success in tilapia farming. Tilapia is a important food fish in many tropical and sub-tropical countries and one of the first fish species that was cultured in the world. It is considered suitable for culture because of high tolerance to hostile environmental conditions, relatively fast growth and the ease with which they can be bred. It provides one of the most important sources of animal protein and income throughout the world .Tilapia can tolerate dissolved oxygen concentration of 1 mg/L and can survive by using atmospheric oxygen when at dawn DO concentration dropped to less than 1 mg/L. It has also the ability to survive under extremely low dissolved oxygenated surface water layer by reducing activity .Tilapia is the common name applied to three genera of fish in the family Cichlidae: *Oreochromis, Sarotherodon,* and *Tilapia* which are widely distributed in many countries of the world. Now it can be found in more than 100 countries (Ballarin and Haller, 1982). The development of Genetically Improved Farmed Tilapia (GIFT) technology that is based on traditional selective breeding and is meant to improve commercially important traits of tropical farmed fish is a big milestone in the history of tilapia culture. Modern fish culture is usually improvement of culture practices through adopting different measures such as proper doses of fertilizer application, regular feeding, optimum stocking density, maintenance of physicochemical factors, disease prevention and various control measures (Ballarin and Haller, 1982). The stocking density is the major concern for mono-culture. Sometimes excellent fish fry do not perform satisfactory growth unless correct stocking practices (Sanches and Hayashi, 1999). So considering the importance the present experiment has been undertaken to find out the effects of three different population densities on the growth and production of Tilapia in monoculture.

Materials and Methods

Experimental duration and location

The duration of the experiment was 4months from 29 June to 29 October in six ponds. The ponds were situated at the southeast corner of the Faculty of Fisheries Buildings, Bangladesh Agricultural University, Mymensingh.

Experimental ponds

Six earthen ponds of similar size about 40 m^2 (1 decimal) area each and rectangular in shape, were used for the experiment. All ponds were situated side by side. Each pond have an average depth of 0.90 m. All ponds were free from aquatic animals, unwanted fishes and aquatic higher vegetation. The source of water of these ponds was rainfall and provision for water supply from a deep tube-well using flexible plastic pipes whenever needed. The embankment was well protected and covered with grass. All the experimental ponds were arbitrarily numbered as pond no. 1 (P_1), pond no. 2 (P_2).....and pond no. 6 (P_6). For the convenience of the research work pond 1 and 6 were considered as treatment no. I, pond 3 and 4 as treatment no. II and pond 2 and 5 as treatment no. III.

Experimental design

The experimental layout has been given in the Table 1 below:

Table 1. The layout of the experiment.

Treatment	Replication	Pond no.	Fish species	Fish Population Density	Fertilization	Feeding (Wheat bran and rice bran mix)
T-I	2 (2 ponds)	P_1, P_6	Tilapia (*Oreochromis niloticus*)	200 fish per decimal	Urea 60 g,	46 g, 92 g and 136 g in
T-II	do	P_3, P_4	do	400 fish per decimal	TSP 90 g per decimal per	treatment I, II and III
T-III	do	P_2, P_5	do	600 fish per decimal	2 weeks	respectively

Pond preparation

Pond drying, dyke repairing and liming

Before starting the experiment, the ponds were dried, aquatic higher vegetation's and unwanted aquatic animals were removed manually. Pond dykes were repaired and renovated. Liming (CaO) was done in all the ponds at rate of 1 kg/decimal before 7 days of fertilization.

Water supply

Ponds were supplied with water after 7 days of liming from a deep tube-well water supply system; rainfall was also a source of water supply to the ponds.

Fertilization of the ponds

Fertilization of ponds was done fortnightly with the application of urea (60 g/decimal) and TSP (90 g/decimal). TSP was dissolved in water for 24 hours in a plastic bucket and then applied by spreading over the pond surface by a mug. Urea was also dissolved in the same plastic bucket before spreading on the water surface of the ponds.

Stocking of fish

Fingerlings of monosex GIFT tilapia (*O. niloticus*) was stocked in the ponds. All the fish fry were collected from BFRI, Freshwater station, Mymensingh. Transportation of fry was done in well oxygenated polythene bags. Stocking was done in the morning and care was taken to acclimatize the fish gradually to pond condition. The initial average weight of *O. niloticus* was 2.82 g and initial average length of *O. niloticus* was 4.63 cm.

Study of water quality parameters

Different types of water quality parameters were estimated and recorded fortnightly throughout the experimental period. Water quality measurement and sample collection were made between 8.00 am to 12.00 noon. Physical parameter such as water temperature (ºC), air temperature (ºC), transparency (cm), and water depth (m) were measured at the pond site on every sampling day. Chemical parameters such as pH, dissolved oxygen (mg/L), free carbon dioxide (mg/L), PO_4-P (mg/L), NO_3-N (mg/L) and biological parameters such as phytoplankton density (cells/L), zooplankton density (cells/L) were determined in the Limnology Laboratory of the Department of Fisheries Management. Water samples were collected and transported in black plastic bottles having a volume of 250 ml each marked with pond number to the laboratory for chemical analysis and for biological analysis, plankton samples were collected using plankton net of 55 µ mesh-size. Plankton samples were preserved in 5% formalin and plankton samples were studied under a compound microscope.

Methods for study of physical and chemical parameters

The physical and chemical factors of experimental ponds were studied followings standard methods and using different digital meters.

Methods for study of biological parameters

Collection and preservation of plankton sample

Water samples in a 500 ml bottle were randomly collected for quantitative and qualitative study of phytoplankton and zooplankton of water from different locations of each of the ponds and passed through a plankton net (mesh-size 55 µ) and finally concentrated to 100 ml. Then concentrated samples were preserved in small plastic bottles in 5% formalin for study under a compound microscope.

Counting of plankton

Counting of both phytoplankton and zooplankton were done with the help of Sedgwick-Rafter Counting Cell (S-R cell). The S-R cell is 500 mm long and 20 mm wide and 1 mm deep. The volume of the chamber is equally divided into 1000 fields of 0.001 ml each. From the concentrated plankton samples, 1 ml was taken by a dropper and then put in the S-R cell. Before counting plankton sample was left to stand for about 10 minutes to allow the plankton settle down and then it was studied under a compound microscope and planktons were counted in 10 squares of the S-R cell chosen randomly.

Calculation of plankton

The plankton population was determined by Sedgwick Rafter Counting Cell (S-R Cell) using the following formula (Rahman, 1992).

$$N = \frac{A \times 1000 \times C}{V \times F \times L}$$

Where,
N = No. of plankton cells per liter of original water
A = Total no. of plankton counted
C = Volume of final concentrate of the sample in ml
V = Volume of a field = 1 mm^3
F = No. of the fields counted
L = Volume of original water in liter
The number of phytoplankton and zooplankton were expressed as cells/L

Harvesting of fish

At the end of the experiment the water of the ponds were pumped out and all the fish were harvested. Then the final growth gained by the fish was recorded by measuring the length (cm) and weight (g) of the harvested fish by using a measuring scale and a balance respectively.

Estimation of survival rate, growth and production of fish

(i) The survival rate was estimated by the following formula

$$\text{Survival rate (\%)} = \frac{\text{No. of harvested fishes}}{\text{Initial no. of fishes}} \times 100$$

(ii) Specific growth rate (SGR %) was estimated by the following formula:

$$\text{SGR (\% per day)} = \frac{\log_e W_2 - \log_e W_1}{T_2 - T_1} \times 100$$

Where,

W_1= Initial live body weight (g) at time T_1

W_2= Final live body weight (g) at time T_2

(iii) Calculation of gross fish production (ton/ha/yr)

$$= \frac{\text{Gross weight (kg) of fish per decimal per month} \times 250 \times 12}{1000}$$

(iv) Calculation of net fish production (ton/ha/yr)

$$= \frac{\text{Net weight (kg) of fish per decimal per month} \times 250 \times 12}{1000}$$

Statistical analysis

T-test of net fish production of the ponds under three treatments was done by a computer using SPSS package programme.

Results

Physico-chemical parameters

The results of the different physico-chemical parameters of the experimental ponds have been presented in the Table 2. All physico-chemical parameters were found to be within the acceptable ranges for fish culture in all treatments.

Table 2. Physico-chemical parameters (Mean±SD, n=3) of the ponds during the experimental period.

Parameters	Treatment-I	Treatment-II	Treatment-III
Average water depth (m)	0.92±0.01	0.88±0.03	0.91±0.02
Water temperature (°C)	28.01±1.73	28.13±1.28	28.15±1.17
Air temperature (°C)	28.69±0.81	28.69±0.81	28.69±0.81
Transparency (cm)	34.35±1.38	31.93±0.84	31.32±1.63
Dissolved oxygen (mg/L)	6.94±0.51	7.37±0.15	7.41±0.44
Free CO_2	3.07±0.45	4.07±0.53	4.40±0.53
pH	7.36±0.15	7.48±0.09	7.40±0.08
PO4-P (mg/L)	1.75±0.09	1.84±0.06	1.53±0.25
NO3-N (mg/L)	3.50±0.11	3.51±0.13	3.58±0.16
Total Alkalinity (mg/L)	166.71±14.49	167.14±10.68	164.04±11.79

Biological parameters

The results of biological parameters such as phytoplankton density (cells/L) and zooplankton density (cells/L), generic status of phytoplankton and zooplankton, and growth and production of fish have been presented in Tables 3 to 5 and Figs. 1 to 2.

Phytoplankton (cells/L)

During the experimental period, 25 genera of phytoplankton belonging to 5 different groups of Bacillariophyceae, Chlorophyceae, Cyanophyceae, Dinophyceae, and Euglenophyceae were found in the experimental ponds (Table 3). The mean values of phytoplankton density of the pond nos. 1 and 6 under treatment-I were 75.86±5.21, and 75.00±6.95 (×10^3) cells/L, respectively and those of the pond nos. 3 and 4 under treatment-II were 71.00±6.32, and 74.57±3.74 (×10^3) cells/L, respectively and those of the pond nos. 2 and 5 under treatment-III were 74.71±8.73, and 74.43±5.34 (×10^3) cells/L, respectively. The average density of phytoplankton of the pond under treatment-I was 75.43±3.10 (×10^3) cells/L and that of the pond under treatment-II was 72.79±1.35 (×10^3) cells/L and that of the pond under treatment-III was 74.57±7.02 (×10^3) cells/L.

Zooplankton (cells/L)

During the experimental period a total of 10 genera of zooplankton belonging to 3 group of Crustacea (Cladocera and Copepoda) and Rotifera were found in the experimental ponds (Table 3). Fortnightly means of zooplankton density of the experimental ponds under treatments I, II, and III have been presented in Table 8. The mean values of zooplankton density of the pond nos. 1 and 6 under treatment-I were 10.71±1.80 and 10.50±0.95 (×10^3) cells/L, respectively and those of the pond nos. 3 and 4 under treatment-II were 10.00±1.41 and 11.00±1.73 (× 10^3) cells/L, respectively and those

of the pond nos. 2 and 5 under treatment-III were 10.57±1.51 and 11.14±1.68 (×10³) cells/L, respectively .The average density of zooplankton of the pond under treatment-I was 10.61±0.99 (×10³) cells/L and that of the ponds under treatment-II was 10.50±1.44 (×10³) cells/L and that of the ponds under treatment-III was 10.85±0.90 (×10³) cells/L (Table 3). Generic status of phytoplankton and zooplankton found in the culture pond.

Table 3. Generic status of plankton found in the culture ponds under treatments-I,II and III.

Phytoplankton				
Chlorophyceae	**Cyanophyceae**	**Bacillariophyceae**	**Dinophyceae**	**Euglenophyceae**
Actinastrum *Chlorella* *Closterium* *Oocystis* *Pediastrum* *Scenedesmus* *Ulothrix*	*Anabaena* *Aphanocapsa* *Gomphospaeria* *Microsystis* *Oscillatoria* *Aphanizomenon*	*Asterionella* *Cyclotella* *Diatoma* *Fragilaria* *Navicula* *Synedra* *Tabellaria*	*Ceratium*	*Euglena* *Phacus*
Zooplankton				
Crustacea				**Rotifera**
Cladocera		**Copepoda**		*Asplanchna* *Brachionus* *Filinia* *Keratella* *Polyarthra*
Daphnia *Diaphanosoma* *Nauplius (Crustacean Larvae)*		*Cyclops*		

Survival rate, growth and production of fish

Survival rate

The survival rates (%) of fish were different in different treatments. The survival rates in treatment-I was 82.75% and in treatment-II was 77.1% and in treatment-III was 74.33%. The survival rate in treatment-I is significantly higher than those in treatment-II and treatment-III (Table 5).

Specific growth rate (% per day)

The specific growth rates (SGR % per day) of fish in different treatments were different. In treatment-I SGR value recorded was 2.0% per day and in treatment-II SGR value recorded was 1.94% per day and in treatment-III SGR value recorded was 1.80% per day. SGR value in treatment-I was higher than those in treatment-II and III (Table 4).

Production of fish

The productions of fish were different in different treatments. The gross and net productions of fish of the ponds under treatment I, II, and III have been presented in the Tables 4 and 5 and Figs. 1 and 2. The calculated gross production of fish of the ponds under treatments I, II, and III were 7.68, 12.06, and 14.94 ton/ha/yr respectively (Table 4). The net productions of fish of the ponds under treatments I, II, and III were 6.75, 10.26, and 12.15 ton/ha/yr respectively (Table 4). The gross and net productions of treatment-III were higher than those of other two treatments.

Table 4. Gross and net production of fish of the ponds under treatments I, II, and III.

Treatment	Production				*Percent increase of net production
	Kg/decimal/year		Ton/ha/year		
	Gross	Net	Gross	Net	
T-I	30.82	27.04	7.68	6.75	100%
T-II	48.39	41.00	12.06	10.26	152%
T-III	59.73	48.56	14.94	12.15	180%

**Percent increase of net productions of treatment-II and treatment-III, over treatment-I which has been taken for 100%.*

Table 5. Total survival rate, growth and production (gross and net) of fishes under treatments I, II, and III.

Treatment	Total survival rate (%)	Final total weight (kg/decimal/3.67 months)	Initial total weight (kg/decimal)	Specific growth rate (SGR % per day)	Production (kg/decimal/year)	
					Gross	Net
T-I	82.75	9.43	1.128	2.09	30.82	27.04
T-II	77.12	14.8	2.256	1.94	48.39	41.00
T-III	74.33	18.27	3.384	1.80	59.73	48.56

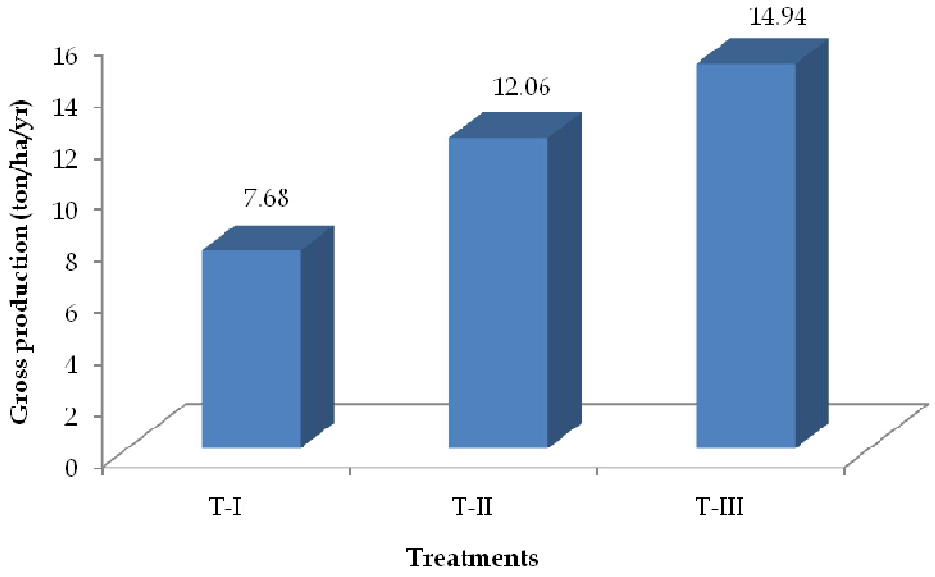

Fig. 1. Gross production of fish under treatments I, II, and III.

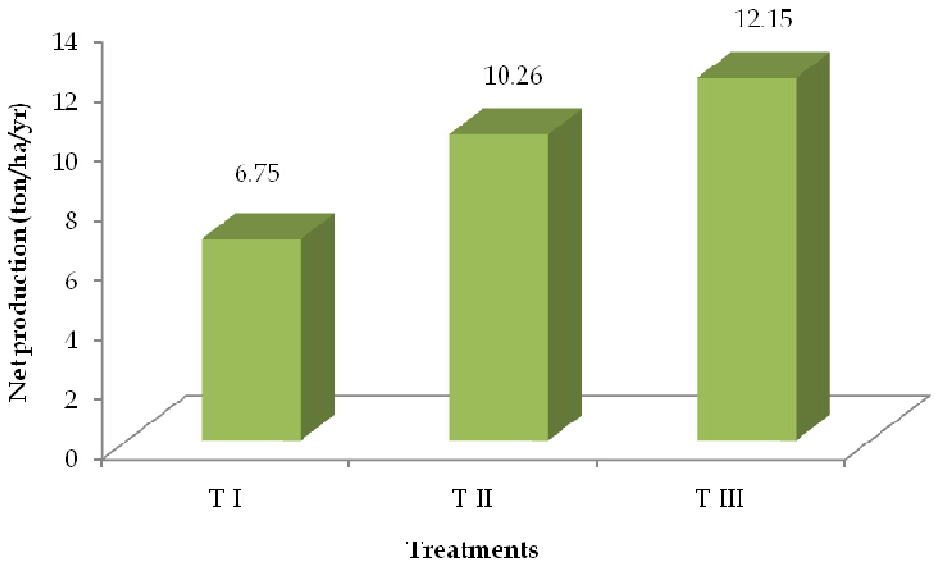

Fig. 2. Net production of fish under treatments I, II, and III.

Discussion

The present experiment was conducted to determine the suitable fish population density using supplementary feed in monoculture of tilapia (monosex GIFT tilapia). The results of the study on various water quality parameters, impacts of fish population density on the growth and production of tilapia in monoculture system and cost-return relationship have been discussed below.

Rahman (1992) quoted that pond should not be shallower than 1 m and deeper than 5 m and optimum depth should be 2 m. Jhingram (1975) stated that a depth of about 2 m of a pond is appropriate from the view point of biological productivity. The mean values of water depth under treatments-I, II and III were 0.92±0.01 m, 0.88±0.03 m and 0.91±0.02 m, respectively.

The mean values of water transparency of the ponds under treatment-I, treatment-II and treatment-III were 34.35±1.38 cm, 31.93±0.84 cm and 31.32±1.62 cm, respectively.

Rahman (1992) stated that the transparency of productive water bodies should be 40 cm or less (turbidity resulting from plankton).

In the present experiment, the water temperature fluctuated from 25.82 to 29.80 ºC. Ali (1998) stated that water temperature of ponds remain 20.20 to 36.50 ºC which was favorable to fish culture. In the present experiment water temperature was favorable for fish culture.

The range of air temperature was 27 to 30º C. Kadir and Hossain (2007) described that the water temperature is always less than the surrounding air temperature and varied with 3 ºC. The present study shows similar results.

Ellis and Westfall (1946) reported that the dissolved oxygen content at levels of 3 ppm or less should be regarded as hazardous to lethal and that of 5 ppm or more is suitable for fish production. In the present experiment, the mean dissolved oxygen values were within suitable range.

The mean values of free CO_2 content recorded in the present experiment under treatment-I, treatment-II and treatment-III were 3.07±0.45, 4.07±0.53, and 4.40±0.53 mg/L, respectively.

According to Lagler (1992), free CO2 more than 20 mg/L may be harmful to fishes and even lower concentrations may be equally harmful when dissolved oxygen content is less than 3 mg/L.

The mean values of pH recorded in the present experiment under treatment-I, treatment-II and treatment-III were 7.36±0.15, 7.48±0.09, and 7.42±0.08, respectively. Swingle (1967) stated that pH 6.5 to 9.0 is suitable for pond fish culture.

The mean values of total alkalinity in the present experiment under treatment-I, treatment-II and treatment-III were 166.71±14.49, 167.14±10.68 and 166.04±11.79, respectively.

Boyd (1990) stated that total alkalinity of productive ponds should be 20 ppm or more and fish production increases with the increase of total alkalinity.

The average values of PO_4-P in the present experiment under treatment-I, treatment-II and treatment-III were 1.75±0.09, 1.84±0.06, and 1.53±0.25 mg/L, respectively.

The mean values of NO_3-N in the present experiment under treatment-I, treatment-II and treatment-III were 3.50±0.11, 3.51±0.13, and 3.58±0.16 mg/L, respectively. Das (2002) recorded the range of nitrate-nitrogen values from 1.60 to 3.22 mg/L, which is more or less close to the values obtained in the present experiment.

The average density of phytoplankton of the ponds under treatment-I was 75.43±3.10 (x 10^3) cells/L and that of the ponds under treatment-II was 72.79±1.35 (x 10^3) cells/L and that of the ponds under treatment-III was 74.57±7.02 (x 10^3) cells/L. Kabir (2003), Chowdhury (2005), and Sarker (2000) found more or less similar results. During the present experiment the mean values of zooplankton in the experimental ponds under treatment-I, treatment-II and treatment-III were 10.61±0.99 (× 10^3), 10.50±1.44 (× 10^3), and 10.85±0.90 (× 10^3) cells/L, respectively. Kabir (2003), Chowdhury (2005), and Sarker (2007) found more or less similar results.

The survival rates of the fish in treatment-I was 82.75%, in treatment-II was 77.1% and in treatment-III was 74.33%.

The specific growth rate in treatment-I, II and III were 2.0%, 1.94% and 1.80%, respectively. SGR progressively decreased with the increase in stocking density.

In the present experiment the calculated gross and net fish productions of the ponds under treatment-I were 7.68 ton/ha/yr and 6.75 ton/ha/yr and those of the ponds under treatment-II were 12.06 ton/ha/yr and 10.26 ton/ha/yr and those of the ponds under treatment-III were 14.94 ton/ha/yr and 12.15 ton/ha/yr, respectively.

Considering the above discussion, it is evident that treatment-I (fish population density 200 per decimal) is the best in respect of survival of fish

and specific growth rate. Therefore, it might be suggested that the population density of 200 fish per decimal is the best for monoculture of monosex GIFT tilapia.

References

Ali, M.H. 1998. The potential of periphyton-based monoculture-based of major carp, Calbasu *Labeo calbasu* (Hamilton). MS thesis. Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh, Bangladesh. pp. 55-58.

Ballarin, J.D. and Haller, R.D. 1982. The intensive culture of tilapia in tanks, raceway & cages. Recent Advancement in Aquaculture. West view press, Boulder, Colorado, USA. pp. 265-355.

Boyd, C.E. 1990. Water quality in ponds for Aquaculture, Birminghum publishing co. Alabama, USA. p. 477.

Chowdhury, M.M.R. 2005. Use of duck weed (*Lemna minor*) as supplementary in monoculture of Tilapia (*Oreochromis niloticus*). MS Thesis. Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh, Bangladesh. pp. 34-38.

Das, B.C. 2002. Studies on the effects of stocking density on growth, survival and yield of *Amblypharyng odonmola* and performance of Rohtecotio in combination with *Barbodesgo nionotus* and *Cyprinus carpio* in rice fields.MS Thesis. Department of Aquaculture, Bangladesh Agricultural University, Mymensingh, Bangladesh. pp. 34-38.

DoF. 2011. Fisheries Statistical Yearbook of Bangladesh, Department of Fisheries, Ministry of Fisheries and Livestock, Bangladesh. pp. 23-26.

Ellis, A.E. and Westfall, B.A. 1946. Determination of water quality, Fish and wild life service. New York. p. 182.

FAO/UNDP. 2011. Twenty years fishery development plan for Bangladesh, USA. p. 40.

Jhingram, V.G. 1975. Aquaculture lecture, Summer Int. Intensive fresh water fish culture, Inland fish. Res. Ins. Barackpor (ICAR), India. p. 12.

Kabir, A.N.M.A. 2003. Use of duck weed (*Lemna minor*) as feed for fishes in polyculture. MS Thesis. Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh, Bangladesh. pp. 17-23.

Kadir, A. and Hossain, M.A. 2007. Effect of silver carp and the small indigenous fish mola *Amblypharyng odonmola* and punti, *Punti ussophore* on fish polyculture production. *Aquaculture*. 273: 520-532.

Lagler, K.F. 1992. Freshwater Fisheries Biology, 2nd W.M.C. Brown Company Publisher, Dubuque, IOWA. p. 421.

Rahman, M.S. 1992. Water Quality Management in Aquaculture. BARC Prokashana, Dhaka 1212. p. 84.

Sanches, L.E.F. and Hayashi, C. 1999. Stocking density effect on Nile Tilapia fry performance during sex reversal. *J. Appl. Ichty*. 21: 619-625.

Sarker, M.N. 2000. Effects of periphyton on monoculture of GIF tilapia. MS Thesis. Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh, Bangladesh. pp. 53-57.

Swingle, H.S. 1967. Standardizations of chemical analyses for waters and pond muds, FAO Fish Rep. 4: 397-421.