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Original Article

Growth variation of tilapia (*Oreochromis niloticus*) with variation of environmental parameters

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A B S T R A C T

With a view to assess the growth variation of mono-sex Tilapia (*Oreochromis niloticus*) an experiment was carried out from 5 May 2016 to 4th December 2016 in two different environmental conditions. Two locations were one in Mymensingh –Bhaluka and the other in Tangail - Modhupur. At each location, there were seven ponds of almost similar size (30 decimal) and water depth (1.5 m). The stocking density was 200 fry per decimal for each location. Pre-stocking and post-stocking management were similar in both locations. There were considerable variations in most of the water and soil qualities between two locations. After six months of rearing, significantly higher ($p<0.05$) mean harvesting weight of *Oreochromis niloticus* (500 ± 50g) was observed in Mymensingh, as compared to that of Tangail (350 ± 30 g).

Introduction

Bangladesh has huge potential for tilapia farming due to its rapid growth rate and high market value, thus become one of the most popular commercial culturable species in Bangladesh (Rahman, 2012).Tilapia is widely cultured and high demandable fish species in Mymensingh as well as whole Bangladesh. It is tasty and low price fish (Mahmuda *et al*., 2020). Tilapia has become the shining star of aquaculture with farms starting and expanding across the globe. Tilapia, now the second maximum farmed fish inside the world, has performed a vital function within the growth of aquaculture and could keep to within the density. Tilapia is the popular fish which is extensively dispensed in many nations of the arena (Nasrin *et al*., 2021). Fish production through aquaculture is rapidly gaining importance due to increasing human population and diminishing natural fisheries resources in Bangladesh. But fish culture on a small scale basis has often been failed due to inadequate knowledge about fish culture technique and feeding regime of fish (Reza, 2013). With the expansion of aquaculture in Bangladesh, there has been an increasing trend in using chemicals in aquatic animal health management (Uddin *et al*., 2020). *Oreochromis niloticus* is considered to be highly nourishing, palatable and tasty and well preferred because of its less spine, less fat and high digestibility in many parts of Indian sub-continent (Khan *et al*., 2003). Tilapia is one of the most-farmed aquaculture fish in Bangladesh and performs 60% better growth (Nasrin *et al*., 2021). The species is very high content of iron 214 mg $100g^{-1}$ and fairly high content of calcium compared to many other freshwater fishes. Due to high nutritive value the fish is recommended in the diet of sick and convalescents. Being a lean fish it is very suitable for people for whom animal fats are undesirable (Rahman, 1999). It is a very hardy fish and can survive for quite a few hours outside the water due to presence of accessory respiratory organs. Fish perform all their bodily functions in water. Water quality in turn mainly depends on soil quality/types. Again, both water and soil quality depends on the location based on ago-climatic conditions.

With the above background and justification, the production trials of *Oreochromis niloticus* culture technology was carried out in two different locations under two different

Zones. There have been large variations in different parameters within each zone such as, Modhupur contain low pH, and low amount of nitrogen, phosphorous, potassium, calcium but iron content was high compare with Bhaluka (BARC, 2012). The present study was carried out with an aim of ascertaining the feasibility of adoption of *Oreochromis niloticus* culture at two different locations with the following specific objectives: To compare the growth variation *Oreochromis niloticus* under monoculture in Mymensingh and Tangail locations.

Materials and Methods

The experiment was conducted at two different locations of Tangail and Mymensingh district. There are large variations in different parameters within each zone.

Description of the ponds: The average area of experimental ponds was 30 decimal with an average water depth of 1.5 m. All ponds possessed almost similar size, shape and bottom type. The ponds were free from aquatic vegetation and well exposed to sunlight. The main sources of water in ponds were rainfall but had facilities to supply water from a big reservoir using water pump whenever needed.

Design of experiment: The experiment was designed to compare the aquaculture production potential of *O. niloticus* in two different zones. There were seven ponds in each location. The stocking density of *O. niloticus* in each pond in each location was 200 fry per decimal. The duration of the experiment was six months. Here the two experimental locations were considered as treatment and the numbers of ponds in each location were as replication.

Pond preparation and stocking: Ponds were prepared by removing weeds and unwanted fish species with repeated netting. Afterwards, the ponds were treated with lime at the rate of 1.0 kg decimal^{-1}. Thereafter the ponds were left out for 7 days to allow the development of plankton community. The fish were stocked with fry of *O. niloticus* collected from fish hatchery, located in Mymensingh. Before stocking all fishes were kept in a hapa for conditioning, and length and weight of fry were recorded. The stocking rate of *O. niloticus* fry was 200/decimal, respectively. The average weight was about 5 g.

Feeding: Commercial fish feed was used for feeding the fish daily. Feeds were applied twice a day, half in the morning and the rest in the afternoon. Feeds were supplied at the rate of 20% for the first month, 15% for the second month, 10% for the third month and 5% for the fourth month. Feeding rates were adjusted according to increase of fish body weight observed after fortnightly sampling.

Analysis of water quality parameters: Water nice parameters are the maximum crucial elements affecting fish fitness and overall performance in aquaculture manufacture structures. Maximum essential environmental parameters are water temperature, dissolved oxygen and pH. There exists dating among feeding strategies and water quality parameters (Nasrin *et al*., 2021). Feeding to be decreased or stopped if water best fall beneath positive degree. Commonly after feeding, dissolved oxygen tiers decline hastily due to decomposition of uneaten feed. Dissolved oxygen ranges should be maintained above 5.0 ppm for exceptional increase of fish. As a hard fish tilapia can endure lower oxygen ranges underneath 3.0 ppm.

Water temperature is an important water quality parameter for proper growth of fish (Nasrin *et al*., 2021). Various water quality parameters were recorded and estimated fortnightly. Water temperature was recorded by a portable digital Celsius thermometer. Transparency of water of the experimental ponds were measured by a Secchi-disc (30 cm in diameter) tied to a rope along with measuring tape. First the Secchi-disk was immersed into the water then the visible and invisible lengths under the water to the naked eye were measured in cm. Dissolved oxygen (mg/l) of water was measured by a portable digital dissolved oxygen (DO) meter (Lutron, PDO-519) on the spot. pH of water samples was measured by a direct reading using digital pH meter (HANNA, HI 8428) on the spot. Total alkalinity of the water samples was determined by titrimetric method using methyl orange indicator. It was calculated by the following formula:

Total alkalinity (mg1^{-1}) as $CaC0_3$ = A × 20 (when amount of sample is 50 ml), A = Total ml of titrant used.

Ammonia-nitrogen was also determined by the HACH device (FF2, CAT. NO. 9262600) with Rochelle salt and Nessler reagent.

Plankton analysis: For qualitative and quantitative study of phytoplankton and zooplankton, ten liters of water sample were randomly collected from five different locations of each of the ponds and passed through a plankton net (mesh size 55 μm) and finally concentrated to 100 ml. Then concentrated samples were preserved in small plastic bottles in 5% buffered formalin for further study. Counting of plankton was done with the help of Sedgwick-Rafter Counting Cell (S-R cell) following Rahman (1992). Identification of plankton (phytoplankton and zooplankton) up to generic level was made according to Belcher and Swale (1978).

Soil analysis: Soil quality is an important factor in fish pond productivity as it controls pond bottom stability, pH and salinity of overlying water and concentrations of plant nutrients required for the growth of phytoplankton, which is the base of food chain of the fish. Soil samples were collected monthly from the surface soil of the pond bottom with the help of an Ekman Dredge which was designed to trap normally a column of soil of 3-4 cm deep from the soil-water interface. Soil color of both wet and dry soil samples were determined by eye estimation.

Total nitrogen was determined by micro Kjeldahl Method (Bremner and Mulvancy, 1982). Phosphorus was determined by Bray and Kurtz' method (Olsen and Sommers, 1982). Potassium was determined by Ammoniun acetate extraction method (Barker and Surh, 1982). This was determined by Ammoniun acetate extraction method (Barker and Surh, 1982). Iron was determined by using the Atomic Absorption Spectrophotometer (AAS) according to their respective wave length (Ullah *et al*. 1993).

Estimation of growth and yield of fish: Fishes were sampled fortnightly by using seine net. Weight and length of about 30 fishes were measured to assess the health condition and growth of fishes. Weight was taken by using a portable balance and length by using a centimeter scale.

The gross and net yield of fish for each treatments were determined by multiplying the average gain in weight of fish both in gross and net by the total number of fish survived in each treatments at the end of the experiments. The growth performance of fish in different treatments was measured by using the following formula (Brown, 1957):

$$\text{Survival Rate} = \frac{\text{Total number of harvest}}{\text{Total number of stock}} \times 100$$

Weight gain: Weight gained refers to as the difference between final weight and initial weight. Initial wt. and final wt. were measured by digital balance and were calculated by using the following formula: Weight gain (g) = Mean final weight (g) – Mean initial weight (g) (Islam *et al.,* 2020)

Percent weight gain: Percent weight gain (%) = (W2 - W1/ W1) x 100 Where, W1 = the mean initial fish weight, W2 = the mean final fish weight (Islam *et al.,* 2020).

Specific growth rate (SGR): The SGR is the immediate change in weight of fish calculated as the percentage increase in body weight per day over given time interval. Growth in terms of weight was calculated by subtracting the initial weight of fish (at the time of release) from final weight of the same after. The SGR was determined by following formula:

Specific growth rate (%/day) = 100 × T - T Ln W - Ln W 12 12 Where, W1= Initial live body weight (g) at time T1 W2= Final live body weight (g) at time T2 T2-T1= No. of days of the experiment (Islam *et al.*, 2020).

$$\text{Gross Production (Kg/decimal/120days)} = \text{Gross weight (Kg) of fish}$$

Statistical analysis: The obtained data were analyzed statistically to observe the water quality parameters, plankton abundance and production performance of fishes in different treatments. T-tests were followed to analyze the mean values of water quality parameters, plankton abundance and growth, survival and yield data, using SPSS (Statistical Packages for Social Science) and MSTAT-C software.

Result and Discussion

Various water quality parameters were recorded and estimated fortnightly in this experiment. Mean ± SD values of different water quality parameters in experimental ponds of two locations have been presented in Table 1.

Table 1. Mean ± SD values of water quality parameters recorded from two different locations.

Water quality parameters	Locations (Treatment)		LSD	Level of significance
	Tangail (T_1)	Mymensingh (T_2)		
Water Temperature (°C)	30.10 ± 1.19^a	30.21 ± 0.94^a	0.0502	NS
Transparency (cm)	26.49 ± 0.30^b	29.21 ± 0.21^a	0.3832	*
DO (mg l^{-1})	5.12 ± 0.14^b	7.77 ± 0.15^a	0.6079	*
pH	7.71 ± 0.09^b	8.18 ± 0.19^a	0.3853	*
Total alkalinity (mg l^{-1})	31.09 ± 0.25^b	54.10 ± 0.34^a	0.9205	*
Ammonia-nitrogen (mg l^{-1})	0.40 ± 0.20^a	0.25 ± 0.13^b	0.0347	*
Phytoplankton (cells l^{-1})	1758 ± 45^b	3908 ± 186^a	73.097	*
Zooplankton (cells l^{-1})	1210 ± 49.93^b	1506 ± 23.01^a	42.261	*

LSD = Least Significant Difference
NS= Means are not significantly different (p>0.05)
* Means values with different superscript letters in the same row indicate significant difference at 5% significance level.

The mean ±SD values of water temperature were 30.10±1.19 and 30.21±0.94°C in the Tangail and Mymensingh region, respectively. There was no significant difference (p>0.05) between temperature values recorded in different locations (Table 1). Water transparency is a gross measure of pond productivity. In the present experiment, the transparency of pond water was found to vary from 26.2 to 28.1 cm and 29 to 30.5 cm in Tangail and Mymensingh region, respectively, which indicate that the ponds in both sites were productive. The DO concentration in pond of Mymensingh location, were within the more suitable range compared to that in ponds of Tangail location. The mean values of pH were 7.71±0.09 and 8.18±0 in Tangail and Mymensingh region, respectively. There was significant (p<0.05) difference in pH variations between two different locations.

The mean ± SD values of total alkalinity were 31.09±0.25and 54.10±0.34 mgl^{-1} in Tangail and Mymensingh region, respectively. There was significant (p<0.05) difference in alkalinity values between two different locations. The plankton production higher in Tangail than Mymensingh. According to the values of alkalinity in the present experiment and those have been reported by others researchers, ponds in Mymensingh region were more productive than Tangail region.

Throughout the present study period, the soil colour of treatment 1 (ponds of Tangail) was reddish browny and the soil of treatment 2 (ponds of Mymensingh) remained dark gray before drying, and gray after drying. The general gray colour might be due to the presence of organic matter while the brownish red tinge provided an indication of deposition of ferric oxide. As per textural classification the bottom soil of ponds of Treatment 2 (Mymensingh) was found to be silt loam and that of Ponds of Treatment 1 (Tangail) ingeneral clay loam throughout the present investigation. The mean ± SD values of soils total nitrogen were 0.0884±0.0052% and 0.1604±0.0065% in the Tangail and Mymensingh region, respectively. There was significant difference (p<0.05) among nitrogen values recorded in two different locations (Table 2). The highest value of total nitrogen in Mymensingh region was observed (0.1604%) and the lowest value was recorded in Tangail region (0.0884%) as has been shown in Table 2.

Table 2. Mean ± SD values of different soil parameters recorded from two different locations.

Soils Parameters	Treatments		LSD	Level of significance
	Tangail (T_1)	Mymensingh (T_2)		
Total N (%)	0.0884 ± 0.0052^b	0.1604 ± 0.0065^a	0.0048	*
Total P(mg/100 g)	3.0692 ± 0.24^b	7.2880 ± 0.37^a	0.1532	*
Total K(mg/100g)	0.2424 ± 0.024^b	0.4304 ± 0.034^a	0.012	*
Ca(mg/100g)	11.156 ± 0.36^b	16.640 ± 0.25^a	0.1296	*
Fe (µg/g)	80.652 ± 0.38^a	14.660 ± 0.30^b	0.3379	*
pH	5.5 ± 0.41^b	6.4 ± 0.05^a	0.38	*

LSD = Least Significant Difference
* Means values with different superscript letters in the same row indicate significant difference at 5% significance level.

Total phosphorus of soil was found to vary from 2.80 and 3.6 mg/100g to 6.6 and 7.9 mg/100g in the Tangail (T_1) and Mymensingh (T_2) region, respectively. The mean ± SD values of soils total phosphorus were 3.0692±0.24 mg/100g and 7.2880±0.37mg/100g in the Tangail (T_1) and Mymensingh (T_2) region, respectively. There was significant difference (p<0.05) among phosphorus values recorded in two different regions (Table 2). Therefore, considering the P content, pond soil in Mymensingh was more suitable for maintaining high productivity.

Total potassium of soil was found to vary from 0.20 and 0.28 mg/100g to 0.37 and 0.47 mg/100g in the Tangail (T_1) and Mymensingh (T_2) region, respectively. The mean ±SD values of soils total potassium were 0.2424±0.024 mg/100g and 0.4304±0.034 mg/100g in the Tangail (T_1) and Mymensingh (T_2) region, respectively. There was significant difference ($p<0.05$) among potassium values recorded in two different region (Table 2). Fish can absorb calcium either from the water or from food. The mean ± SD values of soils total calcium were 11.156±0.36 mg/100g and 16.640±0.25mg/100g in the Tangail (T_1) and Mymensingh (T_2) region, respectively. There was significant difference ($p<0.05$) among calcium values recorded in two different locations (Table 2). Iron is an important soil quality variable in aquaculture. It is a dissolved nutrient required in small quantities by both aquatic plants and animals. But chemical reactions of iron in sediment and water can have negative impacts on aquatic life.

The data for iron have been presented in Table 2. Soil iron was found to vary from 80.00 and 81.30 µg/g to 14 and 15.3 µg/g in the Tangail (T_1) and Mymensingh (T_2) region, respectively. The mean ± SD values of soils total iron were 80.652±0.38µg/g and 14.660±0.30µg/g in the Tangail (T_1) and Mymensingh (T_2) region, respectively.

But in ponds with acidic sediment, iron deposits on fish can damage gills and cause unsightly blotches on scale. Liming can reduce high iron concentrations in sediment (Boyd, 1992).

Growth and production of fish: For the evaluation of proper growth performance of (*O. niloticus*) in two different locations during experimental period, initial length and weight of fry, final length and weight of fish, % weight gain, SGR (% per day), survival (%) and total fish production (kg $dec^{-1}180\ days^{-1}$) were calculated and are shown in Table 3.

Table 3. Stocking and harvesting size, survival, SGR and gross production of *O. niloticus* in two different locations during the 180 days culture period.

Growth and production parameters	Locations		LSD	Level of significance
	Tangail (T_1)	Mymensingh (T_2)		
Initial mean weight (g)	5±0.07	5±0.03	0.00	NS
Final mean weight (g)	350±6.24^b	500±7.12^a	3.48	*
Mean weight gain (g)	345±6.51^b	495±7.13^a	3.48	*
Survival (%)	70.8±4.21^b	75±5.32^a	3.45	*
Gross Production ($Kgdec^{-1}$ 4 $month^{-1}$)	52±5.61^b	75±6.13^a	1.75	*
FCR	2.13	1.81	0.34	*

LSD = Least Significant Difference, NS= Means are not significantly different ($p>0.05$),* Means values with different superscript letters in the same row indicate significant difference at 5% significance level.

Mean food conversion ratio (FCR) in two locations ranged from 2.13 and 1.81 (Table 3). The highest FCR was obtained in Tangail regionand lowest FCR was obtained in Mymensingh region. The survival rate of *O. niloticus* was 70.8±4.21% and 75±5.32% in the Tangail (T_1) and Mymensingh (T_2) region, respectively. The survival rate was higher in Mymensingh region whereas the survivability rate was low in Tangail region (Table 3).

The final weight of fish was 350±6.24 g in Tangail region and 500±7.12g in Mymensingh region. There was significant ($p<0.01$) difference in final weight of *O. niloticus*in different locations (Table 3). The maximum final weight was observed in Mymensingh region. The minimum final weight was observed in Tangail region. In a study, Thakur and Das (1986) reported production range was 1642 to 7,300 kg ha^{-1} in four to eleven months culture period of *O. niloticus*. Ali *et al.*, (2013) observed that the highest total production of *O. niloticus* 56.47 kg/ decimal/110 days was recorded in T_1. In T_2 and T_3 the production was 45.94 kg/ decimal/110 days and 55.47 kg/ decimal/110 days, respectively. Khan *et al.*, (2003) evaluated that the production of *O. niloticus* in different stocking densities and got the gross production range 48.42 and 53.62 $Kgdec^{-1}$.The pond productivity was significantly higher in Mymensingh region (T_2) than the Tangail region (T_1) and subsequently the growth of fishes was better in Mymensingh region (T_2) than Tangail region (T_1).

Conclusion

Tilapia farming is very beneficial because of market price and demand. The culture technique is also very easy. All parameters of water and soil remained within more productive range for *O. niloticus* culture in Mymensingh region but less productive range for *O. niloticus* culture in Tangail region. The reasons might be due to variation in water and soil quality parameters between Tangail and Mymensingh region. The study indicated that Mymensingh region is more suitable than Tangail for tilapia culture. Farmers can utilize this knowledge for their tilapia farming in that region before starting the farm. This research will be very helpful before site selection for commercial fish farming in that area. Further research needs to be done to ensure all over the Bangladesh to identify the suitable region for tilapia fish farming.

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