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Effect of Culture Environment on the Production Potential of GIFT Tilapia (*Oreochromis niloticus*) in Integrated Cage Cum Ponds System

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Abstract: The impact of culture environment was assessed for the production of GIFT tilapia over high stocking densities at 20 fish/m^2 and 30 fish/m^2 in ponds and 300 fish/ m^3 and 400 fish /m^3 in cages in the same ponds to ensuring maximum utilization of the pond resources. After 120 days culture period the highest net yield of 3.72 kg/ m^2 was obtained from ponds which were stocked with 20 fish / m^2 and fed with homemade feed consisted of 60% wheat bran + 30% mustard oil cake +10% flour, while the highest net yield of 8.55 kg / m^3 was obtained from cages stocked with 300 fish / m^3 fed with the same feed from the same cultural environment. The lowest net yields of 2.34 kg/ m^2 and 8.48 kg/ m^3 were recorded from fish stocked at 30 fish/ m^2 and 400 fish / m^3 fed with the same feed from ponds and cages respectively. With the high survival rate the growth and yield of tilapia fish were found to be significantly influenced ($p < 0.05$) by the cultural environment, stocking density and their interactions. Therefore the culture environment had a greater exerted effect on the production than the stocking densities.

Keywords: Genetically Improved Famed Tilapia (GIFT); Cage; Homemade feed; Pond; Bangladesh.

INTRODUCTION

Fisheries sector plays an important role in the nation's economy of Bangladesh, where aquaculture stood on top through providing high quality cheap animal protein to the poorer segments in the rural areas [1]. This sector alone contributes about 60% of the nation's animal protein intake, 5% to the GDP and 2% of the total foreign export earnings of the country.

In a developing country like Bangladesh where population increases in the geometrical progression, making the gap between the supply and the demand of protein food. Only the culture fisheries, especially pond aquaculture in the upcoming decades seem to be a dependable means of achieving increased yield of fish that might be an option for minimizing the ever increasing demand of fish and will reduce malnutrition poverty [2]. According to DoF [3] there are 20.7 lakh fish ponds with a total area of 3.71 lakh hectares in Bangladesh of which seasonal ponds accounting in 1.30 lakh hectares.

In rural Bangladesh more or less in every house there are small ditches which are dug for raising ground for the purpose of constructing houses. These ditches/ mini ponds retain water for 5-6 months in a year. These water bodies either remain fallow or used for the purpose of jute retaining and most cases covered with aquatic vegetation. The farmers believe that these waters cannot be utilized for production purpose because of their seasonal nature, but actually they hold tremendous potential for adopting an intensive culture of species having a shorter life cycle. This could be done with tilapias which are very hardy, good converters of organic matter into flesh and resistant to diseases [4]. Among various production inputs, the choice of fast growing species with desirable aquaculture traits is a pre-requisite for augmenting fish production in culture-based fisheries. Natural food based culture of indigenous carp is still in practice in Bangladesh but carp culture could not be widely practiced in the shallow and seasonal ponds. In this regard, tilapia is an excellent fish for growing in the shallow and seasonal ponds in a country like Bangladesh [5-9] because Bangladesh enjoys very suitable climatic and ecological conditions for culture of warm-water species. MAEP Project [10] funded by DANIDA had shown that pond size affects the production of major carps. Smaller ponds under 0.1

acres in size may not be profitable for conventional carp polyculture. Mustafa and Brown [11] reported that the growth rate in smaller ponds was relatively higher for tilapia fishes than in large impounded ponds. They commented that small ponds were more productive and easily manageable for edible fish production per unit area, tilapia especially Nile tilapia are more productive than most farm animals at the same level of intensification. GIFT strain (*Oreochromis niloticus*) is a fast growing popular cultivable fish [12, 13]. It can easily survive in derelict water bodies at the minimum oxygen level and wide range of temperature and consume all types of feed. GIFT tilapia may be cultured with low inputs which are locally available without any negative environmental effects in the homestead mini ponds in rural Bangladesh [14]

Considering the enormous potential of GIFT tilapia as a means of producing chief animal protein with low capital investment with the promise of high financial returns, the present study was undertaken to determine the production potential of GIFT tilapia through semi-intensive culture system in ponds and cages and to assess the effect of cultural environment for the production of GIFT tilapia.

MATERIALS AND METHODS

Study area

The study was conducted in the field research facilities under the Department of aquaculture, Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh-2202 over a period of 4 months from June to September 2016.

Ponds preparation

A total of 4 (11.6 m^2, 16.6 m^2, 13.67 m^2, and 22.26 m^2) earthen ponds was used for this experiment. Prior to initiation of the experiment the ponds were cleaned from vegetation, dried, limed (247 Kg/ ha) and manured with at the rate of 1225 Kg/ ha. Urea and Triple Super Phosphate (TSP) were also applied to the ponds at the rate of 25 Kg and 37.5 Kg/ha respectively, after filling the ponds with water maintained water depth of 1.5 meters.

Construction and installation of cages

Net cages of the same size (1.0 m × 1.0 m × 1.0 m) were used for this experiment. The frame of the cage was made of iron flat plate. Nets made of synthetic twine of mesh size 5.0 mm were tightly fixed with frame by nylon thread. There was a small window on the top of the cage through which the formulated feed could be provided to the fish and the fish could be captured easily for sampling. All the cages were placed in two rows on the bottom of the pond. Each row contained two cages at equal distances.

Numbering and marking of the ponds and cages

The ponds and cages were numbered in view of proper management of feeding, sampling and other related works.

Experimental design for both ponds and cages

The same pond was used for the two types of cultural practices such as pond culture of GIFT tilapia and cage culture of tilapia in the same ponds aimed at developing a suitable and economically viable production system at high stocking density of GIFT tilapia from a unit area of water within a short period of time without any negative environmental effect. Therefore, there were two factors, each factor had two levels. Culture environment and stocking density were the two factors. One type of feed was supplied to fish which contained wheat bran 60%, mustard oil cake 30% and 10% flour. Based on the stocking density and culture environment, the density was designated as:

Pond culture of GIFT Tilapia

- Level I: Fish under stocking density of 20 fish/m^2
- Level II: Fish under stocking density of 30 fish/m^2

Cage culture of GIFT tilapia

- Level I: Fish under stocking density of 300 fish/m^3
- Level II: Fish under stocking density of 400 fish/m^3

Chemical composition of feed

The proximate composition of the feeds was determined as per methods of AOAC [15] with certain modification. The proximate composition on dry matter basis of the formulated feed is presented in Table-1.

Collection of fish fingerlings for stocking in ponds and cages

The fingerling of GIFT tilapia was collected at the age of 60 days both reared in the ponds and cages. The fish were stocked under two stocking densities; viz. 30 fish/ m^2 and 20 fish/ m^2 in the ponds and 400 fish / m^3 and 300 fish / m^3 in the cages.

Stocking management

Careful attention was given in regular feeding of fishes in ponds and cages. During the entire period of the experiment the fishes were fed daily in the morning between 8 and 10 am at 10% of body weight. The feed ration was adjusted on the basis of monthly sampling data. The experimental ponds and cages were inspected every day, especially in the morning to observe the behavior of the fishes. All the ponds and cages were kept clean to provide hygienic conditions. The water level was maintained at a fixed level of 1.0 meters throughout the experimental periods and water exchanged fortnightly.

Fish sampling and harvesting

Length (cm) and weigh (g) of the fishes were properly noted during initiation and harvesting of fishes. After four months of rearing in ponds and cages the total biomass in each pond and cages were determined with a precision weighing balance.

Statistical Analysis

Simple statistical tools such as means, standard deviation, range and percentage were used. Analysis of the variance (ANOVA) was performed according to Gomez and Gomez [16].

RESULTS

The results of the study of the growth performance of GIFT tilapia in ponds and cage environment are presented below:

Data furnished in Table-2 indicates that the average survival rate of GIFT tilapia in the pond and cage environment was 97% and 91% respectively. A notable survival variation was observed due to the variations of raising environment. The lowest ADG was observed under stocking density of 400 fish/m^3 in the cage while the highest was in stocking density under 20 fish/ m^2 in a pond environment. The highest value of SGR was recorded from pond reared tilapia under lower stocking density of 20 fish/m^2. The lowest CF was recorded under density 400 fish/ m^3 in cage comparison with pond condition indicated the higher environmental effect.

Data to gain in weight (g) of the experimental fishes are presented in Table 3. The fishes were averaged (9.9 ± 0) g at the time of initial stocking. After a growing period of 4 (four) months, the fishes attained an average body weight of (205.7 ± 0.4) g and (90.6 ± 0.2) g under density of 20 fish/m^2 and 30 fish/m^2 respectively in pond condition. The body weight gain was found to be significantly higher under density I while the growth rate was comparatively low under density II (30fish/m^2). Over a growing period of four months, the fish reached to an average body weight of (39.75±0.7) g and (34.00 ±2. 3) g respectively in cage condition.

Growth in relation to interaction between culture, environment and stocking density

The effect of stocking density, culture, environment and their interactions on the growth of GIFT tilapia were significant (Table-4). The highest value of F (37.65) suggested that the culture environment had exerted a greater effect on the growth of tilapia than the stocking density. ANOVA tests showed that the mean gain in weight of the experimental fishes at two levels of stocking density and under two selected environments was significantly different among different densities ($p < 0.05$).

Production of GIFT tilapia in ponds and cage environment

Production of the GIFT tilapia raised under two stocking densities both ponds and cages is furnished in Table 5 and 6. The net production of tilapia was highest (3.72 ± 0.07 kg/m^2) in density I where 20 fish/ m^2 were stocked in the pond and fed a mixture of 60% wheat bran + 30% mustard oil cake + 10% flour. Lowest net production (2.34 ± 0.06 kg/m^2) was recorded from stocking density II, where 30 fishes/ m^2 were stocked in ponds and supplied with same feed. It is note worthy to mention here that there were significant difference in net fish production of GIFT tilapia ($(p < 0.05)$ between density I and II. The gross production of tilapia was highest (12.19 ± 2.2 kg /m^3) in density II, where 400 fishes /m^3 were stocked in a cage and fed with same homemade feed. The net production of (8.55 ± 1.98 kg/ m^3) was recorded from density I, where 300fish/m^3 were stocked and supplied with same feed. It is noteworthy to mention here that there was no notable significance difference in net production ($p < 0.05$) of GIFT fishes between the two stocking densities in cage environment.

Table-1: Proximate composition (dry matter basis) of formulated supplemental feed [15].

Dry matter %	Protein %	Lipid %	Crude fibre	Ash	Nitrogen free extract (NFE)
37.27	22.73	6.92	14.81	9.36	46.18

* NFE = 100 - % (protein + lipid +ash + crude fiber)

Table 2: Survival rate, Average daily gain (ADG), Specific growth rate (SGR), Condition factor (CF) and Food conversion ratio (FCR) in GIFT tilapia under different stocking densities in pond and cage environment

Culture environment	Density	Survival rate %	ADG	SGR%	Condition Factor (CF)	FCR
Ponds	20 fish/ m^2	98±0.50	0.35 ± 0.05	1.16± 0.02	1.91± 0.01	4.2 ± 0.6
	30 fish/m^2	96± 1.50	0.26 ± 0.02	1.03± 0.06	1.88± 0.02	4.5± 0.05
Cages	300 fish/m^3	91± 2.50	0.30 ± 1.6	0.87± 0.10	2.13± 0.6	6.1± 0.03
	400 fish/m^3	90± 1.50	0.20 ± 2.6	0.72± 0.30	1.50± 0.40	6.7± 0.01

Table-3: Growth in term of gain in body weight in pond and cage environment

Culture environment	Density	Initial (g)	1st month (g)	2nd month (g)	3rd month (g)	4th month (g)
Ponds	20 fish/ m^2	9.9±0	38.2± 1.1	42.8±0.2	84.6±0.4	205.7±0.4
	30 fish/m^2	9.9±0	32.4±0.4	38.5±1.6	49.7±0.2	90.6± 0.2
Cages	300 fish/m^3	9.9±0	13.07± 0.1	16.6±0.3	32.4± 0.5	39.75±0.7
	400 fish/m^3	9.9±0	12.58±0.5	16.05±0.2	26.2±1.2	34.0±2.3

Table-4: ANOVA Table for gain in weight in ponds and cages environment under different stocking densities

Source of variation	Degree of freedom	Sum of square	Mean Square	F
Treatment	1	28.24	28.24	37.65 **
Stocking density	1	12.82	12.82	17.09 **
Interaction (T × D)	1	4.89	4.89	6.52 *
Replication	1	0.4	0.4	0.53^{NS}
Error	3	0.27	0.75	-
Total	7	48.62	-	-

Significant at 5% level
NS = Not-significant

Table-5: Production of GIFT tilapia in ponds and cages environment over a period of 4 months

Culture environment	Density	Initial weight (g)	Final weight (g)	Gross production (Kg/ m^2 or $m^{3)}$	Net production (Kg/ m^2 or m^3)
Ponds	20/ m^2	9.9±0	205.7±0.4	3.91 ± 0.09	3.72 ± 0.07
Ponds	30/ m^2	9.9±0	90.6± 0.2	2.62 ± 0.06	2.34 ± 0.06
Cages	300/m^3	9.9±0	39.75±0.7	10.97 ± 2.6	8.55 ± 1.98
Cages	400/m^3	9.9±0	34.0±2.3	12.19 ± 2.2	8.48 ± 1.93

Table-6: ANOVA Table for net production of GIFT tilapia under treatment and stocking densities

Source of variation	Degree of freedom	Sum of square	Mean Square	F
Treatment	1	18.24	18.24	28.06 **
Stocking density	1	5.27	5.27	8.10 *
Interaction (T × SD)	1	3.77	3.77	5.80 *
Replication	1	0.3	0.3	0.46^{NS}
Error	3	1.96	0.65	-
Total	7	29.54	-	-

**Significant at 1% level, *Significant at 5% level,
NS = Not-Significant

DISCUSSIONS

Fish growth and production in relation to stocking density in ponds and cage environment

The results of the present study indicated that the growth rate of the fishes was different in different stocking densities and culture environment. The stocking densities were found to have significant (p (0.05) effect on the monthly growth rate of the fishes in term of gain in weight among all the densities. Highest growth rate as observed in density I, appeared to be related to the low stocking density and less competition among the fishes. On the other hand, higher stocking density and lower growth rate were founded in density II, which seems to be due to more competition among the fishes and shortage of a nutritionally balanced diet probably the cardinal causes for giving a minimum net yield in density II. The accessibility of the fish to the naturally occurring fish food organisms in the pond might be a counting factor for enhanced growth of the fish in the density I [3].

Relatively, lower growth rate was found among the fishes under stocking density of 30 fish/ m^2, perhaps due to overcrowding and severe competition. The present study are in agreement with the observation of Hasan *et al*., [17] who demonstrated the pronounced effect of stocking densities on the growth of Nile tilapia and found that the growth rate was lower where the stocking rate was the highest resulting in shortage of food. The present observation supports the findings of Hepher, and Pruginin [18] and Diana *et al*., [19] who mentioned that the mean weight gain of tilapia decreased with the increased in stocking density.

The net and gross production was highest among the fishes under density I (20 fish /m^2) within the culture period of 4 months. The net production was 3.72 ± 0.07 kg/m^2/4 months, depending on natural pond productivity and supplemental feeding. This production kept similarity with Huet [20] who stated that yields of tilapias with supplementary feeding could be increased

2 to 10 fold over yields from non-fed ponds. Siddiqui *et al*., [21] and Ling [22] stated that a yield of 5000 kg/ha/year is often given as the maximum pond productivity achieved in Africa.

Precise information about production potential of GIFT tilapia in mini ponds or seasonal ponds is still in infancy, though the present study confirms high production by using a low cost feed. Gupta *et al*., [9] reported that production of Nile tilapia to be 3554 kg/ha/ 6 months through providing supplementary feed consisting of rice bran; mustard oil cake could be achieved. They noted that in fertilized ponds, it was only 1510 kg/ha/ 6 months, while it was 2738 kg/ha/ 6 months in ponds fed with rice bran only without fertilizers.

On the other hand, in cage condition higher stocking rate might be responsible for giving maximum gross yields in density II (400 fish/m^3). On the contrary, the highest growth rate as observed in density I, appeared to be related to low stocking density and less competition among the fishes (Table-4). The present finding agrees well with the observation of Alikunhi [23], Vass-Van Oven [24], Shelton *et al*., [25] and Haque *et al*., [26] who observed that fishes stocked at higher densities had always lower growth rate. Lower growth rate as observed in the present study under the stocking density of 400 fish/ m^3 also seem to be due to the accumulation of metabolic wastage of fishes originating from the increased number of fishes, causing growth suppression under cage culture environment that had a pronounced effect on the production [3, 27, 28]. Kohinoor *et al*., [7] and Chaitiamvong [29] found that the stocking density of 110 –120 fishes /m^3 for *Oreochromis nilotica* was suitable for cage culture and a production of 30-50 kg/m^3/year could be achieved. On the contrary, DoF [3], Azad *et al*., [1] and Coche [30] recommended the stocking density of 200-400 fishes /m^3 for the same species for cage culture in the pond environment and achieved a production of about 36 to 64 kg/m^3/year. Production of GIFT tilapia (12.19 ± 2.2 kg /m^3 / 4 months) in the present investigation is more or less similar with the yield obtained by Chaitiamvong [29] and Coche [30]. Watanabe *et al.*, [31] stocked Red tilapia (*Oreochromis niloticus)* with an initial size of 8.78 g at the density of 100, 200 and 300/m^3 for a period of 84 days with variable amount of dietary protein. Biomass increased with increasing stocking density. They indicated that higher biomass from higher densities are attainable if the dissolved oxygen content of water does not become a limiting factor. Thus, it would appear from the results of the present study that 300 fishes/m^3 and 400 fishes/m^3 could be raised successfully if water quality remain good for the survival and growth of fishes and that results in high production without any negative effect on the culture environment [32, 7].

Growth in relation to interaction between stocking density and culture environment in ponds and cages

The effect of stocking density, culture, environment and their interactions were found to play a significant (p (0.05) role on the growth performance of pond and cage reared GIFT tilapia. Comparison and growth patterns obtained from different stocking densities are shown in (Table-4).

Availability of supplemental diet cannot be the factor of variation in the growth rate because the feed was supplied according to the total body weight of the fishes in each condition. The better growth performance and variation of growth of fishes under density I in a pond could obviously be ascribed to use the relatively low density II in the pond because the daily weight gain of tilapia decreased when the stocking density was increased [18]. Higher values of F (37.65) indicated that the culture, environment had a greater effect on the growth performance of fishes over the stocking densities. The present observation is in good agreement with Ahmed *et al*., [14; Brummet and Alon [33] and Yi-Yang *et al*., [34].

The differences of the net yield of GIFT tilapia among the two cultural environments (pond v's cage) seem to be due to the differences in rearing conditions, i.e. one was free from any kind of pressure and another one was under captivity with high environmental pressure.

CONCLUSION

The study revealed that it is possible to attain higher production of GIFT tilapia in four months of rearing, using available homemade feeds (Wheat bran, mustard oil cake and fertilizers) in the homestead seasonal ponds. This research also confirmed that it is possible to raise Tilapia fishes through integrated cage cum pond system at the same cultural environment for higher economic return where the natural capital like seasonal ponds are available in any part of the world.

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Highlights

- The pond environment was used for two culture practices as a pond and cage culture at a time
- Higher production of GIFT tilapia in four months only
- ANOVA analysis showed significant variation among the two culture environment
- An integrated culture system was developed
- Seasonal ponds can be used in an economic way