Comparison of production performance and economics between mono-sex and mixed-sex tilapia (*Oreochromis niloticus*)

A Thesis
By
ARUNA RANI DEB

Examination Roll No: 1302030204, Registration No: 0753

Session: 2008-2009, Semester: July-December, 2014

Submitted to the
Department of Aquatic Resource Management
Faculty of Fisheries
Sylhet Agricultural University, Sylhet-3100
In partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE
in
Aquatic Resource Management

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DEDICATION

Dedicated

To My

Beloved Parents

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First of all, the author would like to express her deepest sense of gratitude to Almighty God, the supreme authority of the universe for his kind assent to complete the research work successfully for the degree of M.S. in Aquatic Resources Management.

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The Author

ABSTRACT

The study was conducted to assess the production performance and economics between mixed-sex and mono-sex tilapia, *Oreochromis niloticus.* The experiment was carried out with two treatments each with six replicates for a period of 99 days from 7 May to 12 August 2014, in 12 cages in a pond of Sylhet Agricultural University, Sylhet. In the first treatment (T_1), mixed-sex tilapia was stocked with a mean initial weight of 1.74 ± 0.44 g. In the second treatment (T_2), mono-sex male tilapia was stocked with a mean initial weight of 1.76 ± 0.48 g. Fish were fed at the rate of 30% body weight (bw) initially and gradually decreased up to 4% bw until the end of the study. Water parameters, viz. temperature, transparency, DO, pH, CO_2, NH_3, TDS, hardness and nitrite were found within the range of fish farming. After 86 days and 99 days of culture period, mono-sex male tilapia attained a significantly ($P<0.05$) higher mean final weight and specific growth rate than mixed-sex tilapia. However, there was no significant ($P>0.05$) difference of food conversion ratio, specific growth rate and survival values between the treatments at the final harvest of study. The benefit-cost ratio was calculated as 1.47 and 1.59 for mixed-sex and mono-sex tilapia, respectively. However, it was observed that there were no significant differences of individual weight, gross yield and net yield of tilapia at 72 days between two treatments. Thus the study suggest that mixed-sex tilapia can be cultured economically like mono-sex tilapia until 72 days of culture period.

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ACRONYMS

ANOVA = Analysis of varience

BCR = Benefit-cost Ratio

Bw = Body Weight

DoF = Department of Fisheries

FAO = Food and Agriculture Organization

FCR = Food Conversion Ratio

S.D. = Standard Deviation

SGR = Specific Growth Rate

Wt = Weight

BW = Body weight

DO = Dissolved Oxygen

et al. = et alia (L), and others

GIFT = Genetically Improved Fry of Tilapia

Kg = Kilogram

Mg/l = Milligram Per Liter

NGO = Non Government Organization

pH = Hydrogen Ion Concentration

ppm = Parts Per Million

°C = Degree Celsius

CAGES = Cage Aquaculture for Greater Economic Security

DFID = Department for International Development

CHAPTER I
INTRODUCTION

INTRODUCTION

Bangladesh comprises a land area of 147,570 km^2, which is bounded by India on the West, North and North East, by Myanmar on the East and South-East, and by the Bay of Bengal on the South. There are more than about 140 million people has been lived in Bangladesh. Bangladesh has the sub-tropical monsoon climate with temperature range ranging from 11 to 34^0C. Bangladesh is composed of mainly the great combined delta and flood plains criss-crossed by numerous rivers and their tributaries. There are over 250 large rivers in the country. There are three major rivers, the Padma, the Brahmaputra and the Meghna. The area of these river basins are about 1.5 million sq km of which 8% is in Bangladesh. Bangladesh alone has about 4 million hectares of inland open water area and 0.3 million hectares of inland closed waterbed (Banglapedia, 2003). The inland closed water bodies especially the ponds and shrimp-farms are almost on peak of utilization and losing their production potentials day-by-day. But most of the inland open water bodies including extensive floodplains are still left for capturing the natural stocks and unutilized. Increasing pressure of population over the natural resources, siltation, and water pollution by industries and agriculture are causing decline in the natural fish stock critically while the demand is increasing rapidly. Wise use of the potential vast flowing water by promoting culture of fish in cages could assist in fulfilling the demand of national protein intake as in other Asian countries.

The fisheries resource of the Bangladesh is one of the most important in Asia, ranked as the fourth aquaculture producing country in the world (FAO, 2014). Fish constitutes the major protein food in the country; about 60% of the available animal protein in the diet of the people of is contributed by fish, and the rest comes from livestock and poultry (DoF, 2013). Fish contributes about 4.39% of national GDP, 22.76% of agricultural products and 2.46% of country's total export earnings (DoF, 2013). Approximately 11% of the total populations are directly or indirectly dependent on fisheries sectors for their livelihood (DoF, 2013). After the liberation of the country a number of NGOs (e.g. CARE-Bangladesh and others) along with the relevant government department tried for decades but unfortunately due to some factors the technology didn't sustain in the country. However, Department of Fisheries (DoF) collaborating with other governments and NGOs continue to promote cage culture. Cage aquaculture is very popular throughout the world, and a lot of research on the cage culture of fishes has been performed in many countries including Japan, Indonesia, Philippines, USA, India, Australia and Europe which have made significant progress in cage farming of freshwater and brackish-water fishes. In Bangladesh, cage culture was started in 1980s in the Kaptai Lake (Flexy, 1987). But research on cage culture has not been conducted extensively in Bangladesh, especially comparative study on production performance between mono-sex and mixed sex tilapia in cages.. Therefore, literatures in this regard are very scarce.

- **Advantages and disadvantages of cage aquaculture**

  - **Some advantages are:**
  - Regular exchange of water allowing fresh water with oxygen
  - Partial feed supply from natural sources like planktons
  - Easy and economical treatment of diseases
  - Flexibility of management
  - Higher production from higher stocking density
  - Easy and low cost of artificial feed supply and harvesting
  - Close observation of fish feeding response and health status
  - Relatively low capital investment compared to ponds and raceways

  - **Some disadvantages are**
  - Risk of loss from easy poaching or damage to cages from predators or storms
  - Less tolerance of fish to poor water quality due to high stocking density
  - Dependence on nutritionally-complete diets

Tilapia was first introduced in Bangladesh in 1954. About 80 species of tilapia have been described out of which 10 species are reported to be used for culture (Macintosh, and Little, 1995). Tilapia have distributed to so many different types of water, different types of culture systems in the world that they have been even labeled as the “aquatic chicken” (Maclean,1984). Tilapia has received significant research attention in the past 20 years, including those provided by CRSP. Culture of tilapia is being promoted as a poor farmer’s fish as well as fish with export potential in many parts of Asia. Tilapia have been successfully farmed under a wide range of environmental conditions and are important group of cultured fish species in many parts of the world, particularly in developing countries (Bentsen et al., 1998; Gjedrem, 2005; Pillay and Kutty, 2005; El-Sayed, 2006) . Tilapia is highly suitable for cage culture (Coche, 1977) both for monoculture and polyculture. (Balarin and Haller, 1982) stated that tilapias are able to survive in extremely adverse conditions and are frequently found in habitats where no other species could exist. (Khan, 1996) found that GIFT could be easily and profitably cultured in cages with locally available feeding materials. Pond cage culture is the standard method of producing tilapia in the tropics. The feeding rate limit for fed ponds is determined by the ability of the pond's microbial community to assimilate fish waste products such as ammonia and solid waste, which undergoes microbial decomposition. They are considered to be hardy, rapid in growth with high food conversion ratio, easy breeding under captivity, high fecundity and generally resistant to many diseases. These characteristics make tilapia suitable for culture in most developing countries (El-Sayed, 2006). Among the tilapia, *Oreochromis niloticus* was found to be suitable for semi-intensive culture system because of its ability to utilize a wide range of feed stuff originating from plants and/or animals (Liti et al, 2005). The fish is being farmed in about 85 countries worldwide and about 98% of tilapia productions in these countries have grown outside their original habitats (Shelton, 2002). In view of the increasing commercialization and continuing growth of tilapia industry, the commodity is not only the second most important farmed fish globally, next to carps, but is also described as the most important aquaculture species of the 21st century (Shelton, 2002; Hernandez et al., 2013). Moreover, tilapia grows and matures at younger age under captivity, contrasting to the natural system (Balarin and Hatton, 1979; Lowe-McConnel, 1982) and reproduces in a wide range of environmental conditions and tolerates stress induced by handling (Tsadik and Bart, 2007; Chakraborty et al., 2011). Production of tilapia, for home or local consumption and for export, has been raised tremendously in the last few decades. The tonnage of worldwide tilapia production (in 2010, about 3 million tons) is second, among fish, only to carps. Global production of tilapia was estimated to be 2.5 billion US$ in 2010. The present trends indicate a continuous growth of production and expanded penetration of that fish to a variety of markets, from expensive restaurants to local households all around the world.

Improved growth capacity and high fish production are the major economic aims of the fish farmers. In Bangladesh, culture of Nile tilapia in freshwater ponds is getting popular due to its higher market price and desirable features for aquaculture such as faster growth, higher survival and culture feasibility in both perennial and seasonal ponds (Siddik et al., 2007). Nile Tilapia, *Oreochromis niloticus* is an important culturable species and it is highly accepted by the consumers in Bangladesh. The species have a disadvantage of prolific reproduction under mixed sex culture in ponds. They attain sexual maturity in 2 -3 months from fry stage. They can breed as often as once a month under favorable conditions. This characteristic results in the production of large numbers of stunted fish which cause overcrowding in the pond and does not appeal to consumers when harvested for sale (Sule et al., 1996). It therefore becomes imperative to curb or eliminate completely this unwanted reproduction and its resultant consumers non preference. The existing methods in use to salvage this problem include: Cage culture, mono sex culture etc. Farmers have been well-acquainted with mono sex (all-male) tilapia culture due to faster growth of male than the female. But it is observed that within 3- 4 months of culture period the difference of production between all-male and mixed-sex tilapia is not too much distinct. So it is assumed that in the economic point of view there is no significant difference between mono sex and mixed sex culture of tilapia within short culture period. Moreover, the major marketable size of tilapia in Bangladesh is 100-200 gm per individual which can be grown up by 3 months only. Most of the farmers adopting these technique to get at least three crops in a year which is more economic than a single crop in a year with bigger size tilapia. On the other hand production cost is lower by mixed sex tilapia culture with short duration than that of mono-sex culture with long duration.

There is a perception in the general people that there may have some negative effect of hormone on human health which is used for sex-reversal tilapia production. This is why a large number of consumers do not prefer to use mono-sex tilapia for home consumption. As the tilapia farming is growing rapidly in Bangladesh we should give into account the consumers’ choice as well as farmers’ profitability, especially the marginal and medium category farmers. This study would be able to accelerate the production and consumption of tilapia through the country.

Objectives of the study

The objectives of the study are -

a). To compare the production performance of mono-sex (all-male) and mixed-sex tilapia culture in cages.

b). To compare the economics between mono-sex (all-male) and mixed-sex tilapia culture in cages.

CHAPTER II
REVIEW OF LITERATURE

REVIEW OF LITERATURE

Review of related literature is a necessity in the sense that it provides as scope for reviewing the stock of knowledge and information relevant to the proposed research. These knowledge and information can give a guideline in designing the future research problem and validating new findings. There are some review of literature is given below:

2.1: Cage culture in Bangladesh

Cage aquaculture is relatively a new technology in Bangladesh though it has successful history in many other countries in Asia. It was introduced into Bangladesh in the late 1970s on experimental basis; a series of experiments were conducted at Bangladesh Agricultural University (BAU) Ahmed et al., (1995), and Hasan, (1998) which demonstrated the potential of cage aquaculture.

VOSD, (2005) reported that, CARE, an international NGO, initiated a project at the end of 1995 to 2000 named Cage Aquaculture for Greater Economic Security (CAGES), supported by the Department for International Development (DFID). According to the report, cage culture is yet to become popular among the farmers in spite of its high initial cost and comparatively complex management technology.

Table 1. Chronological history of cage aquaculture in Bangladesh (DoF, 2001)

Duration	Activities	Remarks
1977	Commercial cage culture was included in the National Development Program.	Target was to promote fish production utilizing the vast open water.
1978	Department of Fisheries and Bangladesh Agricultural University introduced cage culture mainly for research of the post-graduate students of Fisheries Faculty.	These experimental cages were mainly as a part of post graduate student's course-curriculum.
1980	Bangladesh Fisheries Development Corporation and Bangladesh Krishi Bank jointly started cage	Poor management and lack of technical know-how resulted ending of project.

	project in Kaptai Lake.	
1986-87	Department of Fisheries introduced cage culture of Indian major carps in Kaptai lake.	Hand-made feed could not bring any good result.
1981-84	Department of Fisheries derived experimental cage culture in different places of the country; the remarkable one was the cages in Dhandmondi lake in Dhaka town.	Survival rate was good but production of *O. niloticus* was not up to the satisfactory level.
1983-84	In the same Dhanmondi lake cage culture of Rohu, Catla, Mirgal, Bighead, Silver and Nile tilapia was trialed. Survival rate was high and production rate was poor.	The survival rate was high.
1987-91	BFRI tried experimental cage culture in Kaptai Lake.	Hand-made feed was used, no good result was obtained.
1992	CARE-Bangladesh and North-west Fishery Extension project introduced cage culture in Kakrul beel (floodplain) in Rangpur.	Leasing complexity of the beel caused stopping of the activities.
1993-95	North-west Fishery Extension project run cage culture with women groups in many places of Chirirbandar and Parbatipur.	Cutting off the nets by crabs finally became a threat.
1995	CARE-Bangladesh undertook the project “Cage Aquaculture for Greater Economic Security” (CAGES) for experimenting in Meghna-Gomti river.	The technology couldn’t be proved economically sound and therefore, was not disseminated.
1996	North-west Fishery Extension project along with RDRS started cage culture at Dimla and	Tilapia was found to be the best species

	Aditmari.	for cage culture followed by Pangasias.

Hussain et. al. (1989) reported that the Department of Fisheries (DoF) conducted a cage culture project in Kaptai Lake during 1985–86 achieving a production of 6900 tons of fish from 1600 cages.

Haque, (1978) suggested that the concept of fish culture in foating pond derived from cage-culture and pen-culture of fishes (tried at BAU) has the potentiality to use in solving most of the problems encountered in farming fish in Bangladesh, besides attaining spectacular increases in the yield of fish from unit areas.

2.2 Cage culture of tilapia

The culture of tilapia in cages has a relatively short history. The first scientific experiment started around 1970 at Auburn University, Alabama with the rearing of *Sarotherodon aureus* in cages placed in fish ponds (Armbrester et. al., 1972). Since then, the technique has spread progressively to several other regions of the world.

Khan, (1996) conducted a preliminary study on cage culture of GIFT tilapia and demonstrated that GIFT tilapia could be easily and profitably cultured in cages with locally available feeding materials.

Ahmed et al., (1995) conducted an experiment to determine the production of tilapia (*O. spirulus*) in sea water cages at two water depths of 2m and 3m. He reported that tilapia production level of 40 kg/m^3 can be achieved in sea cages and increasing the depth from 2 to 3 m has no apparent adverse effect on production parameters.

Norberg and Stenstroem, (1993) studied on the environmental impact of tilapia cage culture and the significance of grazing on the cage net as a contribution to total consumption of feed by the fish. They compiled data from available literature on feed choice and growth. Parameters for the three cultured tilapias, i.e. *O. mortimeri, O. niloticus* and *T. rendalli.* A model of the cage and support system was presented and analyzed for flows of energy and phosphorus. The percentage outflow of facial and unconsumed pellets from the cage of the total input in pellet form was estimated to 53% of phosphorus and 39% of the energy. Grazing contributed only to approximately 0.9% of the total daily amount consumed by the fish. *O. niloticus* was found to be the most productive species in terms of production parameters but has the disadvantage of not being a native species to Lake Kariba, *T. rendalli,* being mainly a grazer on macrophytes, probably contributes to preventing fouling of the cage net.

Chunhua and Meiping, (1992) conducted an experiment on culture of tilapia in the five net cages set up in the cistern in which it was unsuitable to culture tilapia directly because of much muddy and rough bottom of the cistern to make fishing difficult. The average net output of the adult tilapia cultured within 13 days in net cages was 57.2 kg/m^2 and the net output tilapia in the high yield net cage was 75 kg/m^2. The average weight of fish increased 740%. The diet coefficient was 1.58. The output of other fish outside the net cages was 6941 kg, average yield was 259 kg/m^2.

Scog et al. (1992) undertook fish culture in net cage in different kinds of water area. They studied on the type of net cages, the standard of fingerlings, the density of fish culture, the setting of net cage and the feed prescription in two year's experiments. The result of the above studies showed that the output of fish in net cages rose apparently. In 1988, the area of experimental net cage was 4.02 mu in which the area of the carp net cage was 1.40 mu whose average net output per mu was 51, 933 kg and the average weight of the individual carp was 604 g; the area of the tilapia net cage was 2.62 mu whose average net output per mu was 58,588 kg and the average weight of the individual tilapia was 628 g. The feed co-efficient is 2.2 and the ration of input and output was 1:1.62. The result of the experiment was appraised.

Jameson, (1991) studied on plankton feeding of *O. mossambicus* by keeping them in webbed nylon cages. Plankton concentrate collected from the vicinity of the cage contained algae 30%, vegetable bits 22%, zooplankton 20%, unidentified miscellaneous items 7.5% and diatoms 5%.

Around 86% of the food of *O. mossambicus* represented phytoplankton and plant derivatives. It satisfied 61% of the daily food requirement during noon hours. Microcystis, blue green algae was found to occur frequently in the stomach of the fish *O. mossambicus.*

Watanabe et al., (1990) studied the growth, survival and feed conversion of juvenile, monosex male Florida red tilapia (*Oreochromis sp.*) of 8.78 g average weight. They found no significant effects of stocking density on these parameters. They reported that a significant effect of stocking density on final size variation is evident, with greater co-efficient of variation of body weights and lengths among fish reared at a density of $100/m^3$ (average = 26.0±8.51%) than among those reared at higher densities (average = 20.8± 6.87%) and in case of dissolved oxygen fell to <3 ppm during the study due to declining ambient levels suggesting that higher biomass densities are attainable, with presence of higher ambient dissolved oxygen.

Balarin and Haller, (1982) stated that tilapias are able to survive in extremely adverse conditions and are frequently found in habitats where no other species could exist.

Pantastico **and Baldia, (1979)** conducted an experiment of supplemental feeding of *T. mossambica* in floating cages at a density of 75 $fishes/m^3$ in Luguna de Bay. They found significantly higher (P<0.05) growth using Feed No. 1 (rice bran-ipilipil leaf: fish meal = 60:20:20) than Feed No. 2 (chopped snails: rice bran = 30:70). They also reported that controls shows slower growth rates as compared to the supplemental feed lots. Laboratory experiments in aquaria indicated the feasibility of improving the growth of tilapia with ipilipil leaf meal alone.

Cruz and Laudencia, (1978) studied the protein requirements of Nile tilapia (*O. niloticus*) fingerlings and concluded that 20-30% crude protein is required in the ration for optimum growth in cages.

Guerrero, (1978) found that supplemental feed containing fish meal and rice bran gave the best result of *O. niloticus* and *O. mossambica* cage culture. He also showed that feeds containing fish meal and rice bran and fish meal, rice bran and copra meal gave the better result with a little bigger fishes.

Ibrahim et al., (1975) conducted an experiment on cage culture of *T. esculenta* and *T. zillii.* They found that tilapia attains a size range of 64.0 to 96.0 mm and an average size of 77.26 mm/10.0 g in two months and a size range of 65.0 mm to 128 mm and an average size of 91.35 mm/15.6 g in three months.

Ramirios and Bayne, (1974) conducted an experiment with *Tilapia aureus* in pens using natural food with supplementary feed of poultry manure or pellets containing 30% coffee pulp. They observed that pellets perform better than poultry manure.

2.3 : Stocking density in cage culture of tilapia and other fishes

In aquaculture, stocking density denotes the concentration at which fish are initially stocked into a system. However, it is generally used to refer to the density of fish at any point of time. It is considered to be one of the important factors that affect fish growth, feed utilization and gross fish yield (Liu and Chang, 1992). A considerable number of studies have been made on the effect of stocking density in cage culture of tilapia and other fishes.

Chakraborty et al., (2010) conducted an experiment to compare the growth potential of control and hormone treated, sex reversed tilapia at various stocking densities and to determine an ideal stocking density for cage culture of monosex fish. He found that the highest growth was observed for the 50 fish/m^3 groups for both the control and hormone treated categories.

Nabil et al., (2009) carried out an experiment on 16 floating cages, each of a total water volume of lm^3 stocked with Nile tilapia fingerlings weighing 30.07 to 30.22 g at the experimental start. The 16 cages represented four stocking densities (80 Dl; 100 D2; 120 D3 and 140 D4 fish/m^3) and four protein levels within each density tested (PI 20; P2 24; P3 28 and P4 32%). The experiment lasted 6 months after start. Results obtained are summarized as, increasing the protein level within each stocking density increased significantly ($P<0.05$) both body weights and length of fish, Within each protein level tested, increasing the stocking density resulted in significant decreases in body weight and length of Nile tilapia, both protein levels and stocking densities released significant effects on gains in live weights, specific growth rate, feed conversion ratio and protein efficiency ratio. The total cage yield differed among the where fish at a density of 120 fish/m^3 fed on the diet with 32% protein gave the highest yield of marketable size fish.

Osofero et al., (2007) conducted a study to evaluate the effect of varying stocking densities on the growth, survival and yield of tilapia (*O. niloticus*) at the freshwater reservoir (average depth, 1.7 m) of the University of Agriculture Abeokuta, Nigeria, for a period of 3 months. He concluded that the stocking density of 150 juvenile/cage with a final weight of 82.74 g per fish, feed conversion ratio of 2.15, survival of 99.35% and fish production of 24.79 kg/cage was the best on the basis of the profit index.

Liti et al., (2005) investigated the effects of open-water and caged fish density on growth, feed utilization, water quality and profitability to assess the feasibility of a small-scale rotational system for production of *O. niloticus* in fertilized ponds. They used hand-sexed male fingerlings averaging 18.6 and 29.9 g in open water and cages, respectively in four treatments with open-pond: caged tilapia ratios of 300:0 (control), 150:150 (L), 300:150 (H1) and 300:300 (H2). The ponds in L and H1 contained one cage, two cages in H2 and the control ponds had no cages, each cages contained 150 fish, which were fed daily at 1.5% body weight for 125 days. They found that, growth of open water tilapia was significantly ($P<0.05$) higher in L than in control. Feed utilization, dawn DO and economic returns were significantly better ($P<0.05$) in caged than control ponds. Growth of tilapia in L was significantly lower ($P<0.05$) in cages than in open water. Fingerling production was significantly lower ($P<0.05$) in L than in other treatments. They conclude that, cage-cum-open-pond integrated treatment (L) was optimal for *O. niloticus* production in fertilized ponds.

Diana et al., (2004) reported that sex reversed Nile tilapia stocked in ponds at a low density showed better growth than at a higher density.

Dikel et al., (2004) reported that larger group (larger fingerlings) resulted in higher final weight and greater total net yield than the small group.

Hashim et al., (2002) investigated the influence of stocking density on the growth, feed utilization and population characteristics of red hybrid tilapia (*O. mossambicus* × *O. niloticus*) raised in portable canvas tanks. They reported that the stocking rate of 79 fish/m^3 resulted in the highest specific growth rate (SGR) and relative growth rate (RGR) but was not significantly different from stocking rates of 119 and 159 fish/m^3. However, feed conversion ratio (FCR), condition factor and survival did not differ significantly (P>0.05) among all stocking densities. Based on these findings, they recommended a maximum stocking rate of 159 fish/m^3 for culture of tilapia with this raceway system.

Glasser and Oswald (2001) conducted an experiment to study the reduction the *O. niloticus* yield in high stocking densities and model building to aid the optimization of production**.** They found that, for a given rearing period (from 30-50 g fingerling to market-size), yield increased with density, but then decreased beyond an optimal density.

Winckler and Leboute, (2000) conducted an experiment to study the Nile tilapia (*O. niloticus*) production in cages, with different stocking densities and initial weights in Southern Brazil. They used two stocking densities (40 and 80 fish/m^3) and two initial weights (18 and 32 g) in a 2x2 factorial design with different replicates. They found that the higher initial weight fishes (32 g) showed the possibility of reaching 450 g in the required time. Stocking density did not influence live weight gain. The 80 fish/m^3 density is more suitable since it can produce twice as much as the 40 fish/m^3 density. The initial weight has influenced live weight gain with a 1.47 and 2 g/day gain for the 18 and 32 g initial weights, respectively. The feed conversion ratio was 3.04:1.

Dambo and Rana, (1992) reported that increasing stocking density of Nile tilapia (*O. niloticus*) fry might have lead to diminishing social dominance, resulting in lower individual growth rates.

Battes et al., (1979) reported that best results were obtained with 5-7 kg fish/m^3 water fed on animal protein fodder. For a daily food rate of 5% weight the conversion factor was 2.6-2.8. The mortality rate during the 120 days experiment was 5% at a density of 5-7 kg/m^3 increasing to 15-20% at higher densities. At 12 kg/m^3 growth was 70-4000 g/fish. Growth rate decreased with increasing ammonia content.

Chaitiamvong, (1977) studied on floating cage culture of *Pangasius sutchi* in Thailand and achieved a production of 65 kg/m^3 with stocking density of 25- 40 fishes/m^3. On the other hand, a production of 30-50 kg/m^3/year with stocking density 110-120 fishes/m^3 was obtained from *O. niloticus.*

Coche, (1977) cultured *O. niloticus* in floating cages at a density of 200-400 fingerlings/m^3 and achieved a production of about 36 to 64 kg/m^3/year in lake Kossuou, Ivory Coast. He reported that 3 crops per year could be possible by stocking only the male fishes and therefore it would be raised to 200 kg/m^3 annual production with proper management.

Sedikin, (1977) reported that fish culture in cages could be developed by improving stocking density, feeding, selection of species and regulating the culture cycle for minimum profitability.

Coche, (1976) received on the growth performance, effect of stocking rate and production of fishes suitable for cage culture in Africa. He reported that in case of intensive cage culture, stocking rate and average maximum yield vary from one species to another.

Shiloh and Hamifraz, (1973) studied on nutritional requirement of carp reared in cages. They observed that the cage of 1 m^3 size with stocking density of 200 fishes/m^3 is highly efficient for the cited experiment. They found that the weight increase of carp had a high correlation with the energy content of the supplemental feed.

2.4 Comparative growth studies of tilapia

Siddik et al., (2014) studied on the over-wintering growth performance of mixed-sex and mono-sex male tilapia, *Oreochromis niloticus* in northeastern Bangladesh. They found that, it is possible to successfully culture tilapia during the winter period in Bangladesh, and the culture of mono-sex tilapia is more profitable due to its higher growth rate.

Dagne, (2013) studied on the Comparative Growth Performance of Mono-Sex and Mixed-Sex Nile Tilapia (*Oreochromis niloticus L*.) in Pond Culture System. He found that male mono-sex tilapia showed significantly higher ($P<0.05$) growth rate (weight, length, DWG, SGR) than mixed-sex group.

Kohinoor et al., (1998) studied on the growth and production performance of red tilapia and Nile Tilapia *(Oreochromis niloticus)* under low input culture system. They found that the gross fish production of 3218 and 3017 kg/ha were obtained from Nile tilapia and red tilapia, respectively.

Sultan et al., (1997) conducted an experiment on comparative growth studies of GIFT Tilapia and existing strain of Nile Tilapia (*0. niloticus*) in nursery system, at the fresh water station, Mymensingh. The nursery trials of GIFT and existing strains were conducted in hapa for 2 months. The initial mean weight of GIFT and existing strains of Tilapia were 1. 03 g and 1.12 g and the mean initial length were 3.75 to 3.79 cm. The stocking density for both the strains was maintained at 150 fish m^{-3}.

CHAPTER III
MATERIALS AND METHODS

MATERIALS AND METHODS

This study was carried out in Sylhet Agricultural University Campus from May to August 2014. Twelve cages were used to carry out the experiment. The detail methodology is given below:

3.1 Study period and area

The study was carried out for a period of 99 days from 7 May to 12 August 2014, in 12 cages which set up in a pond in Sylhet Agricultural University, Sylhet.

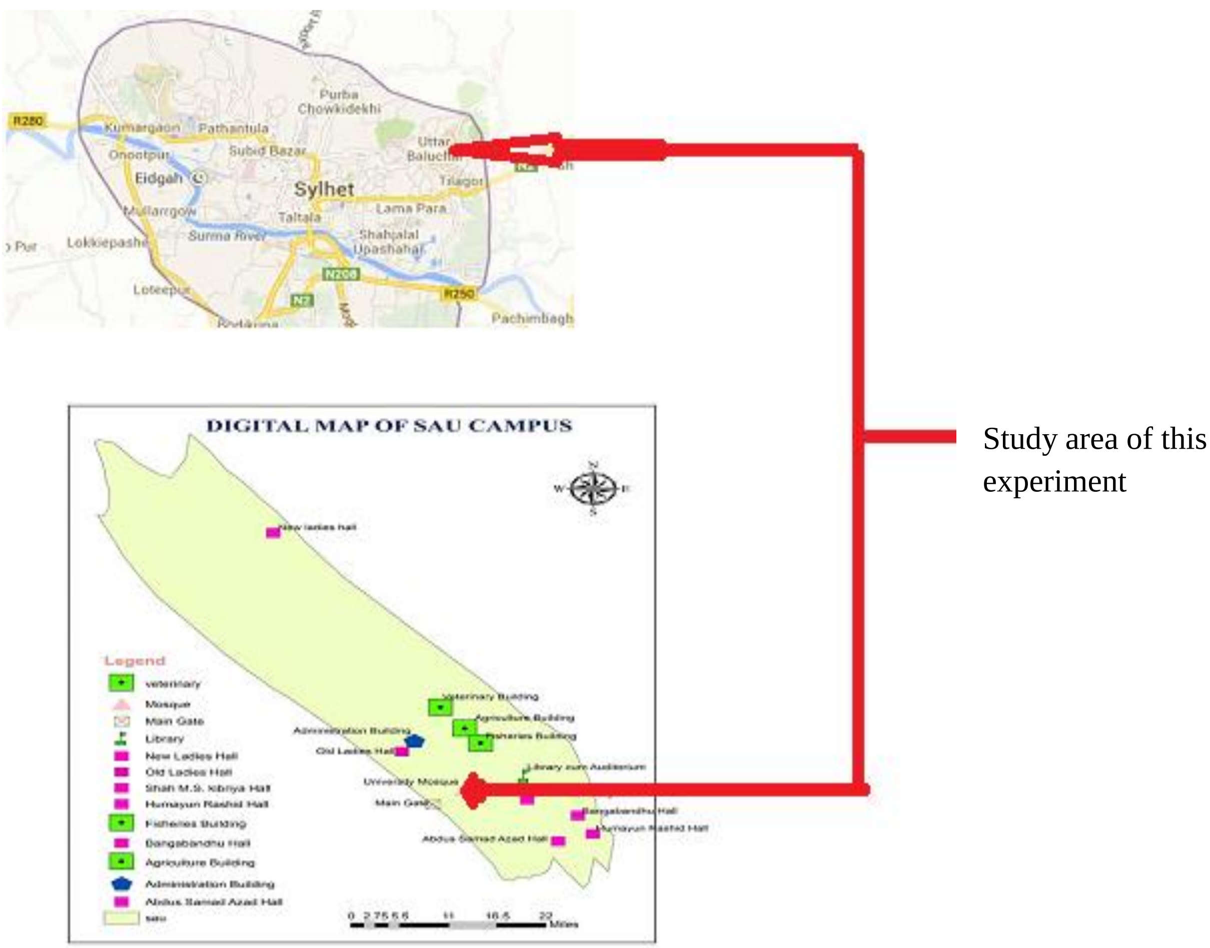

Figure 1 : Map showing the study area

3.2 Materials needed for cage preparation

- Bamboo
- Nylon wire
- Plastic wire
- Net
- Knife and
- Plastic bottle

3.3 Cage preparation and set up

Twelve cages were constructed each with size of 1.5m^3 (1.5m×1m×1m). The cages were made of bamboo frame and covered by black nylon net with tied nylon twine. The mesh size was 0.8 cm sized so that not to allow the experimental fish fry escape and large amount of water can easily pass through the cages. One edge of upper side of each cage was kept open and tied with nylon threads for management as well as supplying feeds, sampling and harvesting of fish. Empty capped plastic bottles of two liter size were fixed at every upper corners of the cage to keep it floating. Each cage was tied up with a rope to fix it on the bank of the water body. Cages were settled into the water with bamboo poles one week prior to stocking of tilapia fry. To prevent floating feeds escaping from the cages by the natural flow of water all the cages were covered with fine meshed net to a length of 15 cm from the water surface to downwards. Bamboo made platforms was set through the pond and cages were set up at both side of the platform for easy feed supply and observation of the cages.

Plate: 1 Cage making activities and setting up

3.4 Study design

The study consisted of two treatments with six replicates. Mixed-sex tilapia was stocked in treatment-I (T_1) and mono-sex (all-male) tilapia were stocked in treatment-II (T_2). Stocking density was same in all the treatments. Individual mean stocking size of the tilapia was 1.74 ± 0.44 g for all the replicates in T_1 and 1.76 ± 0.48 g for all the replicates in T_2. Stocking size of the tilapia was same in all the treatments because all the tilapia fries i.e. mixed-sex or mono-sex tilapia fry were collected from same area and before stocking length and weight of 20 fries were recorded. These recorded values were found almost same and then we randomly selected fry for stocking to every cage. The fish ratios of all the treatments were 1:1. Stocking density was 70 m^{-3}, i.e. 105 fry stocked in each of the cages.

Plate 2: Overview of the study area

3.5 Stocking of tilapia

Tilapia fry (both mono-sex and mixed-sex) were collected from Delta Agro Fisheries, Chotokhurma, Kamal Bazar, Bisshonath, Sylhet. The fries were transported by Pick-up Van with large plastic drums and stocked early in the morning. During transportation water in the plastic containers were agitated manually to add oxygen from the air. Before stocking length and weight of 20 fries were recorded.

Plate 3: Stocking of tilapia in cage

3.6 Management of tilapia

In this study starter feed which name Misha Floating Fish Feed and grow out feed which name Paragon Floated Feed were used for feeding purposes. Composition of those feed were not tested. Feeding was started with commercial feed at 30% of body weight of fish initially and gradually decreased up to 4% bw until the end of the study. Feeds were spreaded over the cages through the upper opening. Total feed for a day were divided into two equal half and supplied in the morning between 8.00-9.00 am and in evening at 5.00-6.00 pm. Feeding rates were adjusted every 7 days interval depending on the mean body weight of tilapia. Net of the cages were cleaned and checked every 15 days interval.

Plate 4: Feeding of tilapia

3.7 Experimental diet

In this study starter feed which name Misha Floating Fish Feed and grow out feed which name Paragon Floated Feed were used for feeding purposes. To know the acceptability of the experimental feed, we need close observation of feeding responses of the fry. Generally, in all treatments the fish become habituated to the experimental diet within 2- 3 days of feeding.

Table. 2 - The major composition status of Misha Floating Fish Feed were given below-

Name of the major composition	**Amount of composition**
Improved protin % (lowest)	28%
Moisture % (highest)	11%
Crude Lipid % (lowest)	4%
Crude fibre % (highest)	8%

Table. 3 - The major composition status of paragon floated feed were given below-

Name of the major composition	**Amount of composition**
Moisture	12.00%
Crude protin	30 ± 1%
Crude fibre	5.00%
Crude fat	8.00%
Lysine	1.70%
Mithionin	0.55%
Calcium	2.00%
Phosphorus	1.00%

Plate 5: Sample of floating Fish Feed

3.8 Sampling of tilapia

Feeding status was monitored regularly on daily basis. However, health conditions of fishes were checked fortnightly and condition of cage were checked fortnightly during sampling whether getting damage or not. Length and weight of randomly selected 20 individuals were measured and recorded from each of the cages at fortnightly throughout the study period. Length of fish was measured by wooden scale and weight of fish was measured by digital weight machine. Initial individual body weights of fishes were recorded at the time of initiation of the experiment. At the end of the study all fishes were captured and bulk weight were taken.

Plate 6: Sampling of tilapia

3.9 Water quality monitoring

Water samples were collected in small plastic bottles from the experimental pond on the sampling days. Monitoring of water quality parameters such as temperature, transparency, DO, pH, CO_2, NH_3, TDS, Hardness and Nitrite were recorded fortnightly during sampling. Temperature was taken by an thermometer. Dissolved oxygen of water was measured by a digital dissolved oxygen meter. Transparency was measured by using a secchi disc and pH with a pH meter. TDS of water was measured by a digital TDS meter. Total alkalinity and others parameters were determined titrimetrically in the laboratory.

3.10 Estimation of growth, yield and survival of tilapia

At the end of the study period all fishes were harvested. During harvesting, lengths and weights of 20 individuals of each cages were measured.

Plate 7: Measurement of length and weight of tilapia

Then, the bulk weight of tilapia were measured separately for each of the cages and recorded. The following parameters were used to evaluate the growth of fishes:

3.10.1 Individual weight gain (g)= Average final weight (g) - average initial weight (g)

3.10.2 Survival = $\dfrac{\text{No. of fish harvested}}{\text{Initial no. of fishes}} \times 100$

3.10.3 Yield of fish:

i. Gross Yield = No. of fish caught × Average final weight
ii. Net Yield = No. of fish caught × Average weight gained

3.10.4 Specific growth rate (SGR) is the instantaneous change in weight of fish calculated as the percent of increase body weight per day over the experimental period. SGR was calculated by using following formula

$$\text{Specific growth rate (SGR \% per day)} = \frac{\text{Loge W2} - \text{Loge W1}}{\text{T2} - \text{T1}} \times 100$$

In which

W_1= the initial live body weight (g) at time T_1 (day)

W_2= the final live body weight (g) at time T_2 (day)

T_1 = Time at the commencement of experiment

T_2 = Time at the end of the experiment

3.10.5 The food conversion ratio is expressed by the amount of food consumed to the weight gain was determined for each of the two treatments. It was calculated as:

$$\text{Food conversion ratio (FCR)} = \frac{\text{Food fed (dry weight)}}{\text{Live weight gain}} \times 100$$

3.11 Benefit-cost analysis

Benefit-cost analysis of the different treatments was calculated on the basis of the prices of fertilizer, fish seed (including transport) and feed and the revenue from the sale of tilapia. At the end of the study, all fish were sold in the university campus. The analysis was based on market prices in Bangladesh for fish and all other items expressed in Bangladeshi Taka (BDT) (1 USD = 80 BDT). The net benefit and benefit-cost ratio (BCR) were calculated using the following formula:

Net benefit = Total revenue – Total cost

$$\text{BCR} = \frac{\textit{Total revenue}}{\textit{Total}\cos t}$$

3.12 Statistical analysis

All the data collected during the experiment were recorded in a note book and regularly inputted in a computer. At the end of the experiment all data were analyzed statistically using one way analysis of variance (ANOVA). The mean values were compared to Independent Sample T-test. SPSS statistical software (18.0 version) was used for all the analysis. Standard deviation (SD) of treatment means were calculated from the residual mean square in the analysis of variance. Probabilities of $P<0.05$ were considered to test significance level.

CHAPTER IV
RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

Throughout the experimental period weight gains of fishes at different treatments in different sampling dates have been recorded and growth performances in different stocking densities were calculated by using standard formula.

4.1 Monthly growth increment

Tilapia were sampled fortnightly until the end of the research to compare the monthly growth increment for both the treatments and showed in Figure 2 and Figure 3. According to the line graph until 72 days of study period growth increment was almost same in both the treatments, which is gradually increased to a maximum increment rate by the next month with significant changes among the treatments. The growth significantly increase in T_2 (189.67 ± 19.142) compared to T_1 (167.15 ± 13.297) at the end of the research. In case of length of fish both the treatment were almost same until 72 days of study period and after that showed the significant differences.

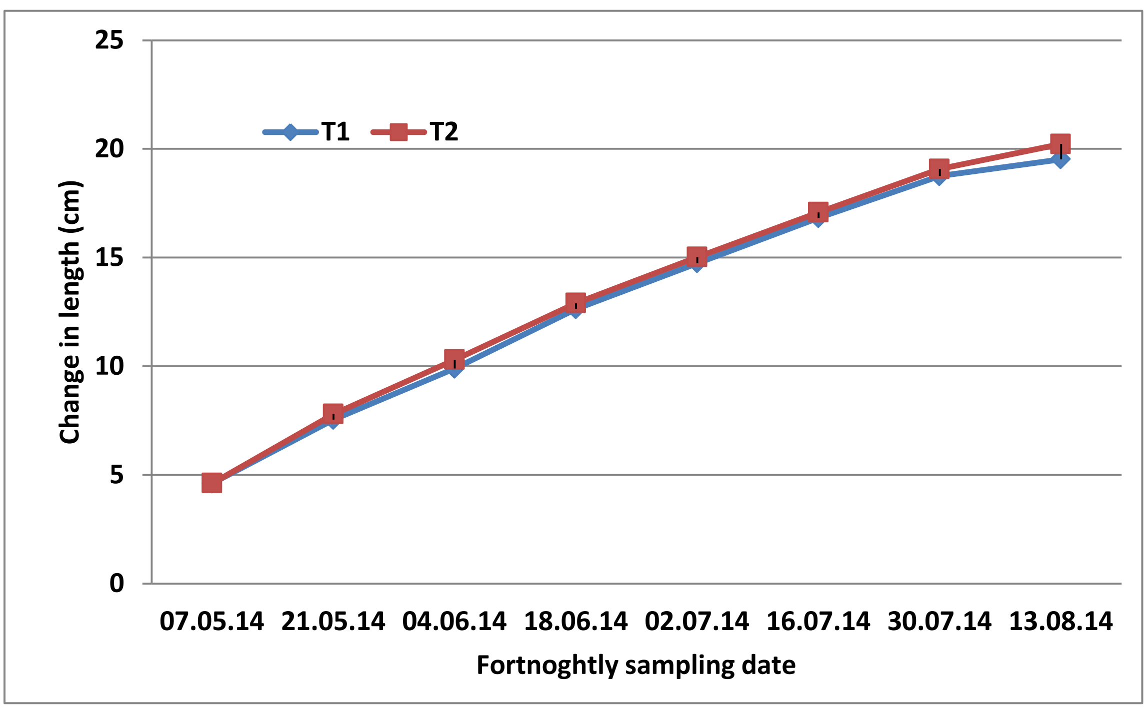

Figure. 2 : Fortnightly changes in length of tilapia in different treatments

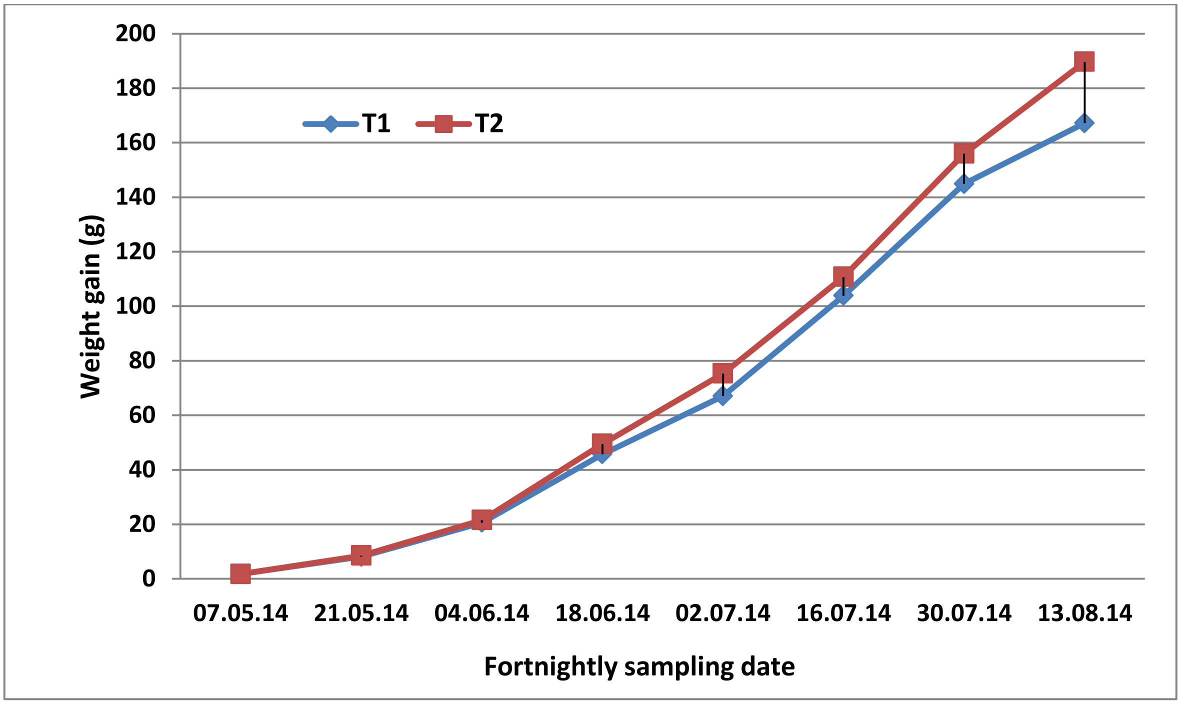

Figure 3: Fortnightly average weight gain of tilapia in different treatments

4.2 Survival of tilapia

In this study or experiment the survival were found very well in all of the treatments. There was no significant difference ($P<0.05$) in case of survival both the treatments. As the oxygen availability with good water quality, proper feeding and stocking of large size fingerling resulted good survival in all the treatments. The survivals of tilapia were 95.397 and 95.873 in T_1 and $T_{2,}$ respectively. The survival of fish in the present study is almost similar than the survival of 94 to 100% for over-wintering brood tilapia and higher than that of 33-54% survival for mono-sex over-wintered fry as reported by (Dan and Little, 2000a).

Table. 4: Replication wise survival of tilapia is given below

Replication	$\mathbf{T_1}$	$\mathbf{T_2}$
R_1	97.14	94.29
R_2	95.24	96.19
R_3	92.38	98.10
R_4	97.14	92.38
R_5	93.33	98.10
R_6	97.14	96.19
Average	**95.40**	**95.87**

4.3 Production and growth performances of tilapia in different treatments

Production and growth performances of tilapia (*O. niloticus)* in terms of mean final individual body weight, mean individual weight gain (g), percent (%) weight gain, specific growth rate (SGR % per day) were analyzed using standard formula and have been shown in Table. 5:

Table. 5: Comparisons of means (±SD) of yield parameters of tilapia in different treatments during the experiment period

Parameters	$\mathbf{T_1}$	$\mathbf{T_2}$
Individual stocking weight (g)	1.743 ±SD 0.44	1.756 ±SD 0.48
Individual harvesting weight (g)	167.15 ±SD 13.297[a]	189.67 ±SD 19.142[b]
Survival	95.397 ±SD 2.122[a]	95.873 ±SD 2.227[a]
FCR	1.252 ±SD 0.094[a]	1.188 ±SD 0.121[a]
SGR (% bw per day)	4.607 ±SD 0.080[a]	4.725 ±SD 0.104[a]
Gross yield (kg m^{-3})	11.157 ±SD 0.835[a]	12.724 ±SD 1.272[b]
Net yield (kg m^{-3})	11.035 ±SD 0.835[a]	12.601 ±SD 1.272[b]

4.3.1 Individual stocking and harvesting weight

Individual stocking weight of fish in T_1 was 1.743±0.44 g and in T_2 was 1.756±0.48 g. At 58 days individual weight of fish was found 67.019 ± 2.255 g in T_1 and 75.652 ± 10.255 g in T_2, at 72 days individual weight of fish was found 103.82 ± 5.135 g in T_1 and 110.76 ± 4.701 g in T_2, at 86 days individual weight of fish was found 144.88 ± 5.860 g in T_1 and 155.95 ± 5.257 g in T_2 and at 99 days individual harvesting weight was found 167.15 ± 13.297 g in T_1 and 189.67 ± 19.142 g in T_2. In case of mono-sex tilapia individual weight at 86 days and 99 days found significantly higher than mixed-sex tilapia, but no significant differences were observed between the treatments until 72 days of growth period. Dagne, (2013) found after the 240 days of a research, the fish attained an average weight of 176.20 ± 18.01 g and 108.20 ± 15.40 g for mono-sex tilapia and mixed-sex tilapia, respectively. Chakraborty et al., (2011) documented the faster growth of all male tilapia than females and mixed-sex. This might be attributed to sex-specific growth ability, female mouth brooding behavior or the efficient feeding habits of males. But within the early stage of growing period i.e. within two and half month age tilapia did not attained the maturity and thus growth does not hamper in case of mono-sex and mixed tilapia. In a mouth brooding fish like *O. niloticus* females fast during the early stages and probably throughout the brooding period which causes inconsistent feeding and subsequently affects the body condition (Tadesse, 1988 and Demeke, 1994). Pandian and Sheela, (1995) and Green et al., (1997) reported similar result, where all male tilapia showed faster growth rate over the females and mixed-sex which is in agreement with the results of the present study.

Table.6. Comparison of (mean ± SD) production performance between two treatments at different date of growth period

Parameters	T_1	T_2
Individual weight(g) at stocking	1.743 ±SD 0.44	1.756 ±SD 0.48
Individual weight(g) at 58 days	67.019 ± SD 2.255[a]	75.652 ± SD 10.255[a]
Individual weight(g) at 72 days	103.82 ± SD 5.135[a]	110.76 ± SD 4.701[a]
Individual weight (g) at 86 days	144.88 ±SD 5.860[a]	155.95 ±SD 5.257[b]
Individual weight(g) at 99 days	167.15 ±SD 13.297[a]	189.67 ±SD 19.142[b]
Biomass at 58 days (kg m^{-3})	4.476 ±SD 0.194[a]	5.082 ±SD 0.749[a]
Biomass at 72 days (kg m^{-3})	6.936 ±SD 0.428[a]	7.431 ±SD 0.285[a]
Biomass at 86 days (kg m^{-3})	9.677 ±SD 0.488[a]	10.467 ±SD 0.434[b]
Biomass at 99 days (kg m^{-3})	11.157 ±SD 0.835[a]	12.724±SD 1.272[b]

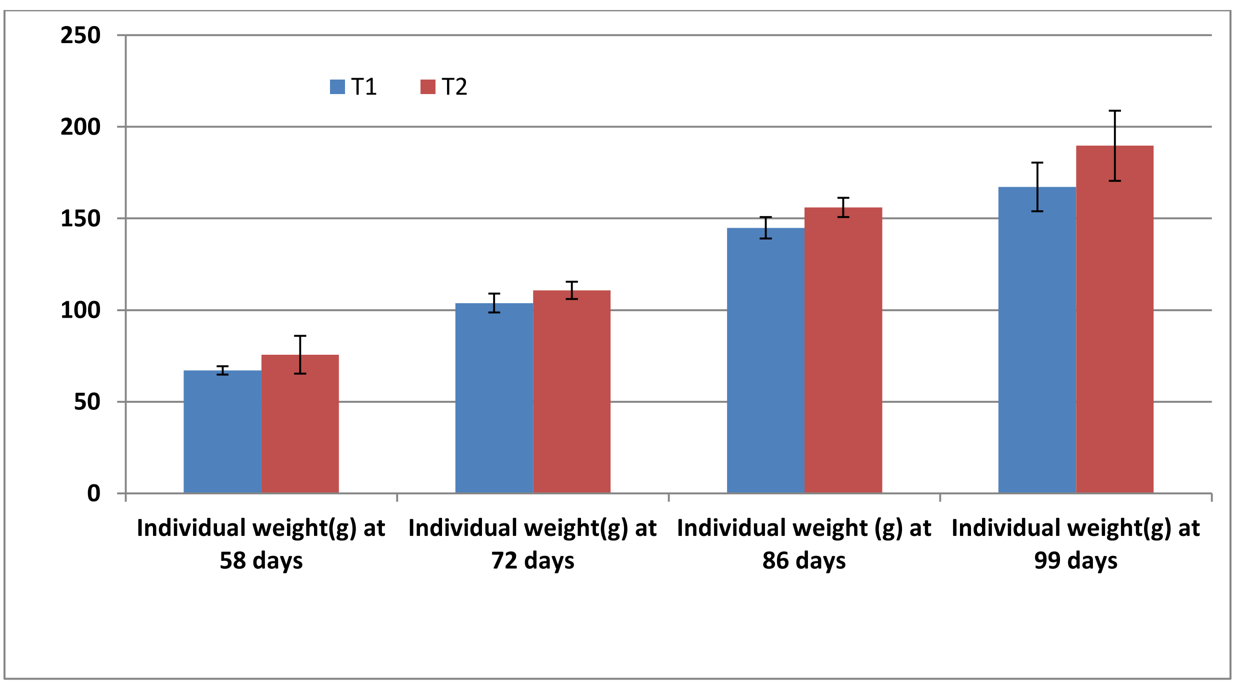

Figure 4: Comparison of (mean ± SD) individual weight (g) between two treatments

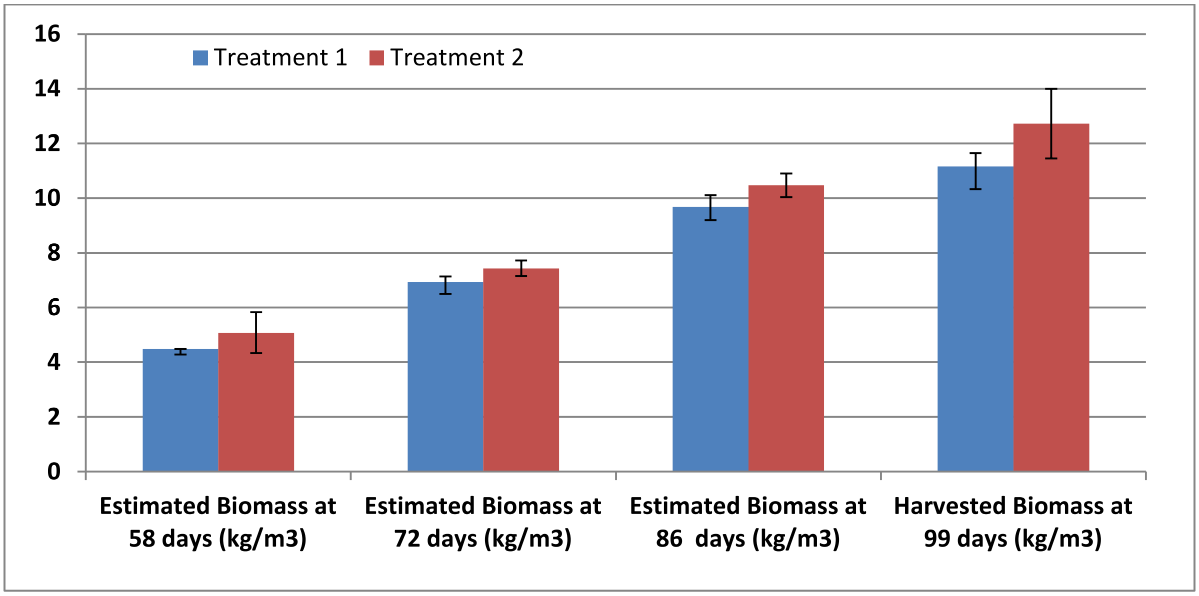

Figure 5: Comparison of (mean ± SD) biomass between two treatments

4.3.2 Food conversion ratio (FCR)

The Food conversion ratio (FCR) in T_1 was 1.252 ± 0.094 and in T_2 was 1.188 ± 0.121 respectively. There was no significant (P>0.05) difference between the FCR values of mixed-sex and mono-sex tilapia. The FCR value of the present study indicated very good utilization of food and might be another cause of availability of natural food in the pond where the cages were set up. The FCR for both mixed-sex and mono-sex tilapia in the present study was comparatively low compared to the study of (Dan and Little, 2000b) which recorded were 1.78 ± 0.07 and 1.71 ± 0.03 for mixed-sex and mono-sex tilapia, respectively. (Hossain et al., 2005) found the FCR values of 1.64 ± 02 and 1.58 ± 0.04 for mixed-sex and mono-sex tilapia, respectively, fed on formulated diet, which is in accordance to this result. Mensah and Attipoe, (2013) cultured tilapia (*Oreochromis niloticus*) through two commercial aquaculture feed diets available on the Ghanaian market (Diet I: Nicoluzzi and Diet II: Rannan) in a 66.67 m^3 cages to evaluate the growth parameters and economics of tilapia cage culture. After 12 week trial performed using 16,000 fish with mean weight recorded 102.17 ± 3.1 g. The best FCR of 1.47 was obtained from that study which is higher than the present study.

4.3.3 Specific growth rate SGR (% bw per day)

Although, the growth performance of *Oreochromis niloticus* is highly influenced by genetic status, quality and quantity of food, post-stocking management and environmental factors (Gjedrem, 1997; El-Sayed, 1999), sex-specific differences in the growth of *O.niloticus* is apparent (Green et al., 1997; Schreiber et al., 1998; Bwanika et al., 2007). Dan and Little. (2000b) reported that growth difference between sex-reversed and mixed-sex Thai strain of Nile tilapia (new-season seed) was significant when cultured in ponds but not significant when cultured in cages. Specific growth rate (SGR) in T_1 and T_2 were 4.607 ± 0.080 and 4.725 ± 0.104, respectively. There were no significant differences of SGR between two treatments. The SGR values obtained in the present study are much higher than those (1.40-1.81) reported by Dan and Little, (2000b) for over-wintering mono-sex tilapia fry. The lower SGR reported by Dan and Little, (2000b) might be due to a higher stocking density (4 fingerlings per m^2), lower temperature used (11.0 to 23.0°C) compared to the present study. The other reason of higher SGR in the present study might be due to the natural productivity of the ponds.

4.3.4 Yield of fish

In this study, yield of tilapia under the two treatments were estimated on the basis of survival and average final weight gained by the tilapia at the end of the study period, and the results obtained have been shown in table 6 and Figure 4 and 5. In this study, the gross yield of tilapia, at 58 days estimated in T_1 and T_2, were 4.476 ± 0.194 kg m^{-3} and 5.082 ± 0.749 kg m^{-3}, at 72 days estimated in T_1 and T_2, were 6.936 ± 0.428 kg m^{-3} and 7.431 ± 0.285 kg m^{-3}, respectively. There was no significant difference between two treatment until 72 days of culture period. But at 86 days gross yield observed in T_1 and T_2, were 9.677 ± 0.488 kg m^{-3} and 10.467 ± 0.434 kg m^{-3}, and at the end of study period i.e. 99 days, the gross yield of tilapia were 11.157 ± 0.835 kg m^{-3} and 12.724 ± 1.272 kg m^{-3} which is significantly higher in case of mono-sex tilapia than mixed-sex tilapia. Azaza et al., (2008) reported that increasing the male sex ratio at stocking significantly affected the marketable yield by increasing weight of stocked fish. Evidence from the study of Lovshin et al., (1990) suggested that significant additional increases in yield could be gained from the absence of recruitment into the all-male population. According to the present study within Two &

Half month period like the monosex tilapia culture, mixed sex tilapia is the same profitable for the fish farmer.

4.4 Benefit cost analysis in different treatment

The cost and income calculated in different treatments at per meter cube volume presented in Table 7. At the end of the study, the gross incomes obtained were significantly higher in treatment II, but there were no significant differences of economics between two treatments until 72 days.

Table. 7: Comparisons of economics (mean ± SD) among different treatments based on 1 m^3 area of cage

Variables	**T_1**	**T_2**
Financial inputs		
Cage cost (making, setting)	157	157
Tilapia fry (Tk. 2.00 per fry)	140	140
Feed	687	742
Total costs	984	1039
Financial returns		
Total returns (Aveg. Sale value Tk. 2.00 per fry)	1450.4 ±SD 108.508^{a}	1654.2 ±SD 165.391^{b}
Net benefit	466.36 ±SD 108.508^{a}	615.16 ±SD 165.391^{a}
Benefit cost ratio (BCR)	1.47:1	1.59:1

*Different superscript letter in the same row indicated significant differences (P<0.05) based on one sample T-test. **Currencies are given in Bangladeshi Taka, BDT (1 USD = 80 BDT).

Table.8 Comparison of (mean ±SD) economics between two treatments at different date of growth period

Parameters	T_1	T_2
Gross Return at 58 days (Tk.)	581.86 ± SD 25.159[a]	660.62 ± SD 97.473[a]
Gross Return at 72 days (Tk.)	901.61 ±SD 55.604[a]	966.01 ±SD 37.093[a]
Gross Return at 86 days (Tk.)	1257.9 ±SD 63.448[a]	1360.7 ±SD 56.442[b]
Gross Return at 99 days (Tk.)	1450.4 ±SD 108.508[a]	1654.2 ±SD 165.391[b]

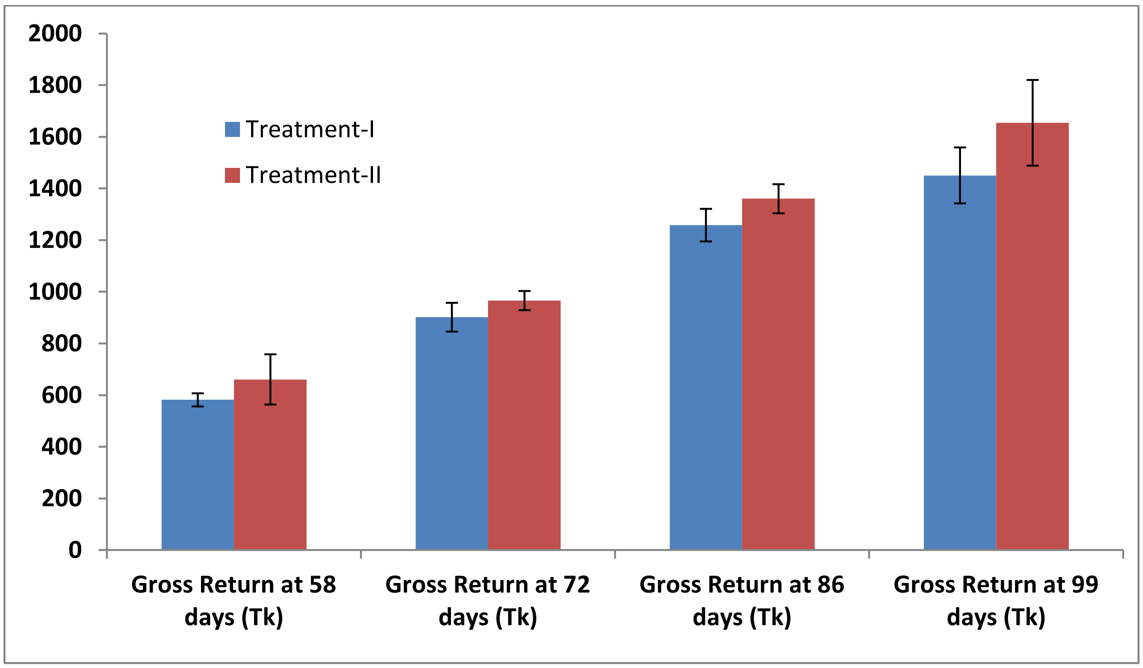

Figure.6 : Comparison of (mean ± SD) gross return between two treatments

4.4.1 Total cost

Cost of cage making i.e. Net, rope, bamboo, float and labor cost (TK. 157 per cage), tilapia fry cost (Tk. 2.00 per fry) and feed are taken into consideration to calculate total cost which measured 984 and 1039, taka in T_1 and T_2, respectively. This variation was due to amount of feed used in different treatments. Ofori et al., (2009) cultured tilapia using a 48 m^3 aquaculture cage in Stratum II of the Volta Lake with a stocking density of 125 fish m^{-3}, for a period of 147 days and achieving a survival rate of 77.32%, the total cost of their research was 2,809.50 Ghanaian cedi (¢1 = US$0.89). According on the basis of cost benefit this experiment was very much successful.

4.4.2 Net benefit

Net benefit in T_1 and T_2 was found 466.36 ± 108.51 m^{-3} and 615.16 ± 165.39 m^{-3}, respectively. There was no significant difference between two treatments. Ofori et al., (2009) cultured tilapia using a 48 m^3 aquaculture cage in Stratum II of the Volta Lake with a stocking density of 125 fish m^{-3}, for a period of 147 days and achieving net income was 718.54 Ghanaian cedi. So according to this study, we can say that our experiment was very much successful.

4.4.3 Gross benefit

At 58 days gross return in T_1 and T_2 was found 581.86 ± 25.159 m^{-3} and 660.62 ± 97.473 m^{-3}, respectively, at 72 days gross return found 901.61 ± 55.604 m^{-3} and 966.01 ± 37.093 m^{-3}, respectively. There were no significant differences between two treatments. But at 86 days gross return in T_1 was found 1257.9 ± 63.448 m^{-3} and in T_2 was found 1360.7 ± 56.442 m^{-3}, at 99 days gross return in T_1 we found 1450.4 ± 108.508 m^{-3} and in T_2 was found 1654.2 ± 165.391 m^{-3}. The best gross return of tilapia observed significantly higher in T_2 than T_1 at 86 days and 99 days which is shown in table 8. A study conducted by Rahman et al., (2012) demonstrated a 78.11% profit from mono-sex tilapia over mixed-sex tilapia in watershed ponds during the summer season in Bangladesh. But it is observed that within 3- 4 months of culture period the difference of production between all-male and mixed-sex tilapia is not too much distinct. So it is assumed that in the economic point of view there is no significant difference between mono sex and mixed sex culture of tilapia within short culture period. Moreover, the major marketable size of tilapia in Bangladesh is 100-200 g per individual which can be grown up by 3 months only. So that the culture of mixed-sex tilapia is not only profitable in economic point of view also safe for human consumption as it is not hormone treated like mono-sex tilapia.

4.4.4 Benefit cost ratio

Benefit cost ratios (BCR) finally at 99 days were estimated as 1.47:1 and 1.59:1, respectively in T_1 and T_2. The benefit-cost ratio shows that T_2 is most favorable than T_1. But no significant differences were observed between two treatments at 72 days. So it is possible to culture mixed-sex tilapia economically as like as mono-sex tilapia during the short time of period.

4.5 Water quality parameters

The water quality parameters like water temperature, transparency, DO, pH, CO_2, NH_3, TDS, Hardness and Nitrite, were within the suitable ranges during the experiment. Both the treatments set up in a same pond so there were no treatment differences in water quality parameters. The water quality parameters are given below in table. 9 - :

Table 9: Water quality parameters of study area in each sampling day is given below -

Parameters	**Sampling**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Temperature	28.5^0c	29^0c	27^0c	30.5^0c	30.5^0c	26.5^0c	30^0c
TDS	90	70	100	90	95	60	90
Transparency	30cm	33cm	31.1cm	40cm	40cm	12.2cm	39cm
DO	5.6 ppm	5.8 ppm	5.8 ppm	4 ppm	4 ppm	5.4 ppm	6ppm
pH	7.2	7	7.5	7	7.1	7	7.2
Hardness	54	57	56	29	29	57	26
CO_2	7 ppm	6.5 ppm	6 ppm	6.2 ppm	6 ppm	6.5 ppm	6 ppm
NH_3	0.0198 ppm	0.0124 ppm	0.011 ppm	0.014 ppm	0.0074 ppm	0.0032 ppm	0.00756 ppm
Nitrite (NO_3)	0.4 ppm	0.3 ppm	0.5 ppm	0.3 ppm	0.3 ppm	0.1 ppm	0.2 ppm

The maximum temperature 30.5°C was recorded in pond on 4^{th} and 5^{th} sampling day might be due to high intensity of sunlight and absent of cloud in the sky. The lowest water temperature was recorded (26.5°C) in pond on 6^{th} sampling day might be due to low intensity of sunlight and some rains. (Dewan et al., 1991, Nirod, 1997, Rahman, 2000, Kohinoor, 2000, Sarker, 2000, Hasan, 2007 and Maghna, 2012) found water temperature in ponds of BAU Campus, Mymensingh range between 29 to 32˚C, 21.8 to31.10˚C, 29.7 to 29.9˚C, 18.5 to 32.9˚C, 19.8 to 22.8˚C, 21 to 32.8˚C and 32 to 34.3˚C, respectively. Aminul, (1996) stated that the water temperature ranged from

25°C to 35ºC is suitable for fish culture. In the present study water temperature was within the suitable range.

In the present study, the transparency of water varied at different sampling dates, which might be due to variations in abundance of plankton. Transparency values of about 15-40 cm are appropriate for fish culture (Boyd, 1982). The observed transparency of water in the present study indicates that the experimental ponds were suitable for fish culture.

Banerjee, (1967) considered 5.00 to 7.00 mgl^{-1} of dissolved oxygen content of water to be fair or good in respect of productivity, and water having dissolved oxygen below 5 mgl^{-1} to be unproductive. Slightly lower dissolved oxygen was found at the mid in the present study but this level was within the desirable limit of fish farming.

The pH values of pond water under different treatments were found to be alkaline in the present study and ranged from 7 to 7.5. According to Swingle, (1969), pH of 6.5-9.0 is suitable for pond fish culture. Mondal, (1997) found pH 7.70 to 8.65 while Begum, (1998) recorded pH 7.05 to 8.02 in the research ponds of BAU campus, Mymensingh. The observed pH of water in the present study indicates that the experimental ponds were suitable for fish culture.

Unionized ammonia (NH_3) is highly toxic to fish, but ammonium ion ($NH4^+$) is relatively nontoxic for fish. In culture condition, the better quality of water for fish contains the lower value of total ammonia. The major source of ammonia in pond water is the direct excretion of ammonia by fish (Tucker and Boyd, 1979). Meade, (1985) noted that the maximum safe concentration of ammonia was unknown and he concluded that the permissible level was higher than the value of 0.012 $mgl\text{-}^1$ commonly accepted by fish culturists. Chen, (1998) found that lower than 1 $mgl\text{-}^1$ of ammonia gas content in pond water was good for fish culture. In the present study, the lowest and the highest concentration of total ammonia were 0.0032 and 0.0198 $mgl\text{-}^1{}_,$ respectively which were within the acceptable limits.

Nitrate (NO_3) is very important factor as a nutrient in supplying nitrogen for protein synthesis. NO_3 is contributed to the ecosystem as a byproduct of nitrification. NO_3 is removed from solutions through utilization by green plants and through bacterial de-nitrification to uncombined nitrogen and reduction to NH_3-N. The ranges of NO_3-N measured in the present study were 0.1–0.5 mgl^{-1}. Bhuiyan, (1970) reported that the range of NO_3-N from 0.06 to 0.1 mgl^{-1} is suitable range for fish culture which is more or less similar to the NO_3 range recorded in the present study.

CHAPTER V
SUMMARY

SUMMARY

Over the last three decades, Nile tilapia, *Oreochromis niloticus* production has been significantly developed all over the world and now it is considered as one of the most productive and internationally traded food fish in the world (Frei et al., 2007; Hernandez et al., 2013). Tilapia is an emerging fish species in the aquaculture system of Bangladesh. But there is a perception in the general people that there may have some negative effect of hormone on human health which is used for sex-reversal tilapia production and a large number of consumers do not prefer to use mono-sex tilapia for home consumption. This is why the experiment was carried out to assess the comparison of production performance and economics between mixed-sex and mono-sex tilapia, *Oreochromis niloticus* using cage culture system for a period of 99 days from 7 May to 12 August 2014, in a pond of Sylhet Agricultural University, Sylhet. There were two treatments with 6 replications each for this experiment. Each of the cages was $1.5m^3$ size. Mixed-sex tilapia was stocked in T_1 and mono-sex (all-male) tilapia were stocked in T_2. Stocking density was same 70 m^{-3} in all the treatments. The mean initial weight of mono-sex tilapia was 1.76 ± 0.48 g and mean initial weight of mixed-sex tilapia was 1.74 ± 0.44 g. Two types of commercial feed were supplied to the tilapia which containing 28% to 30% protein.

Mean weight of tilapia at 58 days culture period was found 67.019 ± 2.255 g in T_1 and 75.652 ± 10.255 g in T_2, at 72 days mean weight of fish 103.82 ± 5.135 g in T_1 and 110.76 ± 4.701 g in $T_{2,}$ at 86 days mean weight of fish was found 144.88 ± 5.860 g in T_1 and 155.95 ± 5.257 g in T_2, at 99 days mean weight was found 167.15 ± 13.297 g in T_1 and 189.67 ± 19.142 g in T_2. Finally survival were 95.397 ± 2.122% and 95.873 ± 2.227%; FCR 1.252 ± 0.094 and 1.188 ± 0.121; SGR (% bw per day) 4.607 ± 0.080 and 4.725 ± 0.104; net yield 11.035 ± 0.835 kg m^{-3} and 12.601 ± 1.272 kg m^{-3} in T_1 and T_2, respectively. The gross yield of tilapia, at 58 days estimated in T_1 and T_2, were 4.476 ± 0.194 kg and 5.082 ± 0.749 kg, at 72 days estimated in T_1 and T_2, were 6.936 ± 0.428 kg and 7.431 ± 0.285 kg, respectively and was not any significant difference between two treatments. But at 86 days gross yield estimated in T_1 and T_2, were 9.677 ± 0.488 kg and 10.467 ± 0.434 kg, respectively and at the end of study, the gross yield of tilapia were observed 11.157 ± 0.835 kg and 12.724 ± 1.272 kg, respectively where mono-sex tilapia

performed significantly higher than mixed-sex tilapia. The total financial return at 58 days in T_1 and T_2, was found Tk. 581.86 ± 25.159 and Tk. 660.62 ± 97.473, respectively; at 72 days Tk. 901.61 ± 55.604 and Tk. 966.01 ± 37.093, respectively where there were no significant differences between the treatments. But at 86 days total financial return in T_1 was Tk. 1257.9 ± 63.448 and in T_2 was found Tk. 1360.7 ± 56.442; at 99 days total financial return in T_1 found Tk. 1450.4 ± 108.508 and in T_2 was Tk. 1654.2 ± 165.391 which are significantly different from each other. The net benefit in T_1 was 466.36 ± 108.508 and in T_2 was 615.16 ± 165.391. The benefit cost ratio in T_1 and T_2, at 99 days were estimated as 1.47:1 and 1.59:1, respectively. At 86 days and 99 days significantly higher ($P<0.05$) production and net benefits were found in T_2 than T_1. But it is observed that there were no significant differences of individual weight, gross yield and net yield of tilapia at 72 days between T_1 and T_2. The comparative study suggested that mixed-sex tilapia can be cultured economically instead of mono-sex male tilapia and it is very much important that mixed-sex tilapia is safe for human health as because it is not hormone treated.

CHAPTER VI
CONCLUSION AND RECOMMENDATION

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Tilapia is an emerging culture species in Bangladesh and getting attention to the consumers as well as fish farmers for last two decayed. Even though some of the people have perception that hormone treated mono-sex tilapia may have some adverse impact on human health. On the other hand during production of mono-sex tilapia it needs to go through some procedure along with hormone treatment, so that the cost of mono-sex tilapia fry is higher than that of mixed sex tilapia fry. Farmers also prefer to get good quality fry with minimum price to reduce the culture expenses. In this study, it is observed that within 72 days culture period there were no significant differences on production and income between mono-sex and mixed-sex tilapia. It is also observed that both mono-sex and mixed-sex tilapia gained weight 110g weight within 72 days in the cage culture system which is a good marketable size in the rural area. Considering all these things it can be concluded that mixed-sex tilapia can be cultured profitably like mono-sex tilapia until 72 days of culture period.

6.2 Recommendation

Based on the experience of the present study, the following recommendations can be given for further study and dissemination-

a) Further research is necessary for perfection of the study.
b) The same trial should be carried out in the open water, because fish grow faster in the open water than that of closed water.

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Research Title: Comparison of production performance and economics between mono-sex and mixed-sex tilapia
Organized by: Dept. of Aquatic Resource Management

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