DEVELOPMENT OF SUSTAINABLE CAGE CULTRE PRACTICE FOR TILAPIA (*OREOCHROMIS NILOTICUS* L.) IN RIVERINE ECOSYSTEM

Ph. D IN ZOOLOGY [FISHERIES]

THESIS BY

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A THESIS SUBMITED TO THE UNIVERSITY OF DHAKA, DHAKA, BANGLADESH, IN FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY (Ph. D) IN ZOOLOGY [FISHERIES]

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DEDICATED

TO

MY BELOVED WIFE MUKTA

&

SON AND DAUGHTER

MUGDHO, MEDHA

Certificate

This is to certify that the Ph. D Research work of **Md. Robiul Awal Hossain,** Session 2009–2010, Registration No. 90 and Re-registration No. 117, Session 2015-2016 of the Department of Zoology, University of Dhaka was done under my supervision. The work submitted as a thesis entitled “Development of Sustainable Cage Culture Practice for Tilapia (*Oreochromis niloticus* L.) in Riverine Ecosystem” and was conducted at the stated premises and analyzed at the facilities of Advanced Fisheries Research Laboratory (AFRL) of the Department of Zoology, University of Dhaka, Bangladesh.

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Declaration

I hereby declare that the whole work submitted as a thesis entitled "Development of Sustainable Cage Culture Practice for Tilapia (*Oreochromis niloticus* L.) in Riverine Ecosystem" in the Department of Zoology, University of Dhaka, Bangladesh for the degree of Doctor of Philosophy (Ph. D) is the result of my own research investigation except as cited in the references. No part of this thesis has been presented before for any degree, diploma to any university.

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ABSTRACT

This study was conducted in the Dakatia river at Echoli and Roghunathpur site of Chandpur, Bangladesh during the year from 2010 to 2011 which consisted of four trials under the two experiments on stocking density and feeding regime of tilapia (*Oreochromis niloticus*) in cage culture. Each experiment include two trials with complete randomized design (CRD). Floating net cages, having an area of 3m×3m×2m in each were installed in both sites of the Dakatia river. The initial average weight (g) of 32.31±9.59, 28.92±8.37, 36.20±11.64 and 20.76±6.14 were stocked for each treatment of the stocking density trial-1, stocking density trial-2, feeding regime trial-1 and feeding regime trial-2 respectively. The duration of each trial was 120 days having three treatments with three replications to assess sustainable cage culture practice for tilapia in the riverine ecosystem. The physicochemical parameters of cage water were monitored fortnightly. Final weight (g), weight gain (g), relative growth rate (%), specific growth rate (%/day), food conversion ratio and survival rate (%), gross production (kg/cage), net production (kg/cage), net profit (Tk/cage), benefit cost ratio of tilapia in cages were determined after completion of the each trial. Growth parameters such as weight gain (g), relative growth rate (%), specific growth rate (%/day), and food conversion ratio was also measured monthly basis. The physicochemical parameters of cage water were found suitable for cage fish culture in all the trials. Correlations of different physicochemical parameters were related to each other and the relationship was found significant in most of the parameters. All growth parameters of stocking density trial-1 revealed highly significant differences ($p < 0.001$) among three treatments. The maximum survival rate was found in T_1 (85.61%) followed by T_2 (81.92%) and T_3 (67.58%) respectively, having highly significant differences ($p < 0.001$). The highest benefit cost ratio was achieved in T_1 (1.20) followed by T_2 (1.19) and T_3 (0.88) but highest profit was found in the T_2. In stocking density trial-2, it was exhibited that all growth parameters were highly significant differences ($p < 0.001$) among three treatments. The highest survival rate was found in T_1 (97.92%) followed by T_2 (86.73%) and T_3 (84.38%) respectively which was highly significant differences ($p < 0.001$) among them. The highest benefit cost ratio was achieved in T_1 (1.81) followed by T_2 (1.37) and T_3 (1.07) respectively. The net profit was found similar as highest in T_1 and followed by T_2 and T_3. In case of feeding regime trial-1 the final weight, weight gain and specific growth rate showed significantly different ($p < 0.05$) among the treatments, while the relative growth rate and food conversion ratio was found highly significant differences ($p < 0.001$) among three treatments. The highest survival rate was found in T_1 (97.33%) followed by T_3 (96.88%) and T_2 (96.44%) respectively which was not significantly different. The maximum benefit cost ratio was achieved in T_1 (1.71) followed by T_2 (1.36) and T_3 (1.17) respectively, which was similar as achieved net profit of the three treatments. The final weight, weight gain and specific growth rate of feeding regime trial-2 were exhibited significant differences ($p < 0.01$) among the three treatments, whereas the relative growth rate and food conversion ratio was found highly significant differences ($p < 0.001$) among three treatments. The highest survival rate was found in T_2 (97.22%) followed by T_1 (97.00%) and T_3 (96.66%) respectively but not significantly differ with each other. The highest benefit cost ratio was determined in T_3 (1.93) followed by T_2 (1.44) and T_1 (1.25) respectively, which was similar as determined net profit. The proximate composition of used floating feeds was found suitable for tilapia culture but the crude protein (%) showed some differ from labeled crude protein. It could be concluded that stocking density of $50/m^3$ and feeding regime with 4% of body weight feed through the culture period was found suitable for practice tilapia cage culture in the riverine ecosystem.

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CHAPTER-1 INTRODUCTION

Background

Bangladesh is a south Asian country located in between latitude 20°34' and 26°38' north and longitude 88°01' and 92°41' east has only an area of 1, 47,570 sq. km. The country is crisscrossed with hundreds of rivers. Bangladesh is blessed with vast freshwaters and abundant fisheries resources. Bangladesh has altogether 230 rivers, big and small. Of these, 54 are shared with the upper riparian country, India. The Ganges, Brahmaputra, Meghna and several smaller rivers unite in Bangladesh to form the largest deltaic system in the world. This constitutes one of the largest riverine systems in the world. She is also blessed with a vast expose of inland waters in the forms of canals, estuaries, lagoons, haors, baors, beels, ponds, lakes and many others.

Fisheries sector contributed 4.37% to national GDP and 23.37% to the agricultural GDP and 2.01% to foreign exchange earnings by exporting fish products in the year 2012-2013. Fish provides 60% of national animal protein consumption (DoF 2014). Fisheries sector also plays an important role in rural employment generation and poverty alleviation. More than 11% of total populations of the country are directly or indirectly dependent on fisheries and related activities for their livelihood. This sector provides full-time and part-time employment facilities in which about 17.1million people engaged as fishermen and 14.69 million people involving in fish culture (DoF 2014).

The inland fisheries resources of Bangladesh are considered to be one of the richest in the world. These are about 4,699,387 ha of inland water areas, of them 3,916,828 ha are open waters and 782,559 ha are closed waters. In open waters, the total area of rivers and estuaries are 853,863 ha. These rivers have extensive flood plains, i.e., low lying lands along both shores of the river courses. The floodplains remain submerged for 4-5 months during the monsoon season. The estimated total area of the flood plains in Bangladesh is about 2,702,304 ha. Rivers and estuaries are the main sources of inland capture fisheries production. Inland capture fisheries (from rivers and estuaries, Sundarban, beels, Kaptai Lake and flood plain) contribute 961,458 metric tons which is 28.19% of the total fish production and Inland culture fisheries produce 1,859,808 metric tons of fish which is 54.54% of the total fish production of 3,410,254 metric tons in the year 2012-2013 (DoF 2014). Inland culture fisheries include culture of fishes in ponds and ditches, baors and coastal shrimp/prawn farms. But the production of fish per hectare in our country is low in comparison to our demand. But we can easily increase the production of fish because we have large number of water bodies to be utilized properly and scientifically for fish culture.

Although Bangladesh has vast water resources, the total production of fish from hatcheries and natural sources cannot fulfill the demand of increased population. Moreover, large portion of inland water are not used in fish production. Cage culture is such a technique to use this inland water-body properly and have significant impacts on aquaculture production, income and employment generation and the nutritional status of people of Bangladesh. It offers good opportunities for resource poor people often located next to *khas* (public owned) water-body to involve in aquaculture (Hassan 1983).

Cage culture: the new technology

Cage culture is a technique of growing aquatic organisms in cages made of nylon nettings and bamboo or pipe (GI/PVC) frames that are floated, submerged and fixed at the bottom. Further, cage culture of fish is defined as the raising of fish from fingerlings to harvestable size in containers (cages) enclosed on all sides and bottom by wooden stalls, hard wire cloth, net or other materials that allow free circulation of water in and out of the cages (Schimittou 1969). It utilizes waters as dams, rivers, lakes, bays, reservoirs and coves. This is one of the effective technologies used in raising aquatic organisms. Fish culture in cages is not a traditional practice in Bangladesh like fish culture in ponds. It is relatively a new technology in Bangladesh though it has successful history in many other countries in Asia. Cage culture gradually increasing in Bangladesh for easy to handling, inventory & harvesting of fish, easy to control of fish population, efficient to control of fish competitors and predators, effective to use of fish feeds, reduce mortality, high stocking rate, total harvesting & swift or immediate return of investment, less manpower requirement and minimum supervision. There are some risks also in cage culture such as natural disasters, sudden changes in water quality, disease outbreaks, cutting of the cage net by crabs and other biofoulers, stealing, etc.

Fish in cages is easy to manage, advantageous to rear quality and selective fishes easy to harvest. It is easy to eliminate predation and competition and easier to treat diseases and parasites. It also provides for closer observation of feeding and other behavior of fishes. Fishes can be stocked at a much higher density in cages when compared to other forms of fish culture. Cage culture could be practiced in any types of aquatic environment such as lakes, rivers, streams, ponds, irrigation canals, mining pits, tidal streams, haors, baors, beels, estuaries, bays and coastal region. It can be practiced intensively in low productive water bodies. It permits manipulation of harvest to fit the market whenever more profitable. Thus it could be very profitable for poor farmers (CARE 2000).

Cage culture is an on-growing culture system that could be easily accepted by rural people of Bangladesh. Majority of rural poor people have no land or marginal land but pond aquaculture is only practiced by the farmer who have won pond and land to construct pond. For this reason, poor farmers are not interested to or have no ability to undertake aquaculture. Therefore, cage culture will be the alternative income source for those people. Cage aquaculture has certain advantages over other aquaculture systems that are potentially important for control and safe environment for fish production. In other perspective, if access to a water body can be achieved, rural people can grow fish in cages, and obtain household nutrition and income from the fish produce.

Cage culture has been successfully practiced most Asian countries adopting which China, Vietnam, Thailand, Taiwan and Malaysia have increased their national fish production by several folds and leading the international tilapia market and producing better sized tilapia whole frozen and fillet (Am. Tilapia Assoc. 2010). As Bangladesh has high population density and regularly loosing agricultural lands for urbanization, closed water bodies to produce fish are limited; and production has reached to high enough of its capacity. Bangladesh has vast inland open water resources. Fish culture has not been tried seriously in this open water. Our vast open water bodies are still unused. Now is the time to introduce cages in flowing river-water to increase the fish production promptly. Vast open water-bodies are still unused. Following the other countries of Asia, cage culture here may be the appropriate tool for additional fish production. Although for the last three decades Asia is leading in cage culture whereas Bangladesh was and still is far behind despite having huge water resource (Baqui and Bhujhel 2011). Various attempts were made in promoting cage culture as summarized in Table 1.

Table 1: History of cage culture in Bangladesh

Duration	Activities	Remarks	Sources
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 project in Kaptai Lake.	Poor management and lack of technical know-how resulted ending of project.	
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.	DoF 2000
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 Chirirbondor and Parbotipur.	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 Aditmari.	Tilapia was found to be the best species for cage culture followed by Pangasias.	

Duration	Activities	Remarks	Sources
2002-04	TROPECA Cage culture research initiated between University of Stirling, UK and University of Dhaka	Re-invent the issues in small scale pond aquaculture	TROPECA 2002
2006-07	AwF-VOSD small scale cage culture project for rural women in Bangladesh	Women led low-cost cage culture technology in rural pond	VOSD 2007
2003/04-2013/14	BFRI-RS initiated Research on suitable species, stocking density and feed and feeding regime for riverine cage culture	Refinement of Cage culture technology	Annual reports 2004-14
2010-11	Development of Sustainable cage culture practice for tilapia (*Oreochromis niloticus* L.) in riverine ecosystem	Optimization of stocking density and feeding regime of tilapia in cage culture	This work

Tilapia – species for cage culture

Tilapia are widely recognized as one of the most important fish species for farming in a wide range of aquaculture systems from single small scale waste feed fish ponds to intensive culture systems (Pullin 1985). They form the mainstay for many poor fish farmers. World tilapia production exceeds 2.5 million tonnes in 2005 (FAO 2007). There is significant tilapia culture in China, Indonesia, Philippines, Srilanka, Thailand and Vietnam. Interest in tilapia culture is also increasing elsewhere in the Indian sub-continent and pacific region countries. Tilapia has been dubbed the "aquatic chicken". Among the wide variety of cultured tilapias the most widely farmed stock is the Nile tilapia (*Oreochromis niloticus*).

The introduction of tilapia in Bangladesh was first initiated in 1954 with *O. mossambicus* (Peters) from Thailand (Ahmed 1956). But its introduction to freshwater ponds soon became unpopular to fish farmers due to some bad characteristics. Later in 1974, high yielding species of tilapia (*O. niloticus*) was introduced by UNICEF (Rahman 1989) also from Thailand with a hope that it would make a significant contribution to protein supplement for the malnourished multitudes. Fisheries Research Institute again brought a fresh batch of nilotica from Thailand in 1987. With this batch, the institute at its Fresh water Station at Mymensingh initiated on-station and on-farm research and developed low input and low cost technologies. Such technologies, meanwhile, have been transferred through Government extension workers and NGO's to hundreds of farmers throughout the country.

The Nile tilapia, *Oreochromis niloticus* is one of the most important freshwater fish in world aquaculture. It is widely cultured in many tropical and subtropical countries of the world. Rapid growth rates, high tolerance to adverse environmental conditions, efficient feed conversion, and ease of spawning, resistance disease and good consumer acceptance make it a suitable fish for culture. Shelton (2002) describe the fish as currently being ranked second only to carps in global production, hence gaining popularity among the fish farmers as a readily available source of animal protein in the diets of rural and urban dwellers especially those belonging to the lower socio-economic strata.

The culture practices of tilapia can be extensive, semi-intensive and intensive. There has been a gradual shift in tilapia culture from traditional semi-intensive to non-traditional intensive farm systems. But, deciding the optimal culture method for tilapia farming can be quite complex. Cage culturing makes it possible to grow tilapia in water bodies where draining and seining would be difficult or impossible. Cages are for instance utilized in lakes, large reservoirs and rivers. Nile tilapia *Oreochromis niloticus* which is called super tilapia, the product of the Genetic Improvement of Farmed Tilapias (GIFT) is the most widely farmed variety and performs 60% better in growth and survival than commercially available strains of tilapia. It performs well on cheap feed and fertilizer and can be raised in large tracts of water and cages (Eknath *et. al.* 1993).

Prospects of cage culture in Bangladesh

The first attempt to introduce cage culture in Bangladesh occurred during 1980s when Bangladesh Fisheries Development Corporation (BFDC) and Bangladesh Krishi Bank jointly started cage project in Kaptai Lake. In 1991 and 1992 DoF and Overseas Development Agency (ODA now DFID), supported the Northwest Fisheries Extension Project in collaboration with CARE starting cage culture in northwest Bangladesh (MacGrory and Williams 1996). The target groups were women, initially successful, the project failed due to high level of post-stocking mortalities. CARE-CAGES (Cage Aquaculture for Greater Economic Security) were the first project in Bangladesh to focus exclusively on cage aquaculture throughout the country. Established in September 1995, the project attempted to develop a range of systems that offer resource-poor farmers an opportunity for successful cage culture, within their social, economic and institutional environment. The project covered seven regions of Bangladesh, which included Barisal, Comilla, Jessore, Dhaka, Natore, Sylhet and the Chittagong Hill Tracts. The target groups were mainly the resource poor women who did not own nor had access to pond, where fish-cages could be set in different types water bodies available in the regions (CAGES 1997). Naser (2002) reported that small scale cage culture could be the future source of income for the rural people of Bangladesh. Tilapia for two or three cycle with feed can produce as much a 40-60 kg table from one cubic meter cages in pond. Salam *et al.* (2004) described the cage culture potential in open water in rainy season to improve the livelihood of poor and marginal farmers in Bhaluka Upazilla, Mymensingh, using GIS as a tool. The study identified 2,755 ha of very suitable and 59,113 ha moderately suitable seasonal water bodies at the Bhaluka upazilla for cage culture potential. Culturing fishes in cages could open an avenue to the acceptance of cage culture in wider fish culture in community. Thus small scale cage fish production technique has now been extensively experienced and Tilapia is the best candidate for cage fish culture.

However, large scale commercial cage aquaculture from large sized net cages from river ecosystem has not been studied in Bangladesh. Increasing pressure 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 potential vast water by promoting culture fish in cages could assist in fulfilling the demand of national protein intake as in other Asian countries through a number of NGOs (e.g. DANIDA, CARE and other) along with the relevant government department tried for decades but unfortunately due to some factors the technology did not sustain in the country. So, it is strongly felt that all sorts of efforts need to be employed to increase the fish production in open water bodies like rivers in controlled way (like nee cages) to fulfill the protein demand of the people. But, it is true that the vast water bodies have not yet been properly utilized for fish culture due to lack of adequate knowledge and proper technology. Therefore, culture system development is one of the most important factors to increase fish production (Asaduzzaman *et al*. 2006). A widespread and profitable culture of fish and prawns in cages has developed successfully elsewhere in Asia, Europe and America in the last two decades (Bardach *et al*. 1972 and Beveridge 1987). Although it is not a traditional form of fish culture in Bangladesh, but recent research efforts have been spurred by the belief that cage culture could have a significant impact on aquaculture production (Golder *et al*. 1996), and on the nutritional standards of family members if managed by women (Gregory and Kamp 1996).

Cage culture trials in Bangladesh earlier concentrated on Indian major carps, grass carp, catfish and tilapia (Karim 1987). These experiences suggested that, those fishes have high price, grow rapidly, high survival rate, proved acceptance to supplemental feed, can adapt to high densities and are suitable for cage culture. In this connection, BFRI, NADP, CARE and BAU made several trials for selection of suitable fish species for cage culture. It was initially recommended that sutchi catfish (*Pangasius hypophthalmus*) and tilapia (*Oreochromis niloticus*) are suitable for cage culture. But due to present market price *P. hypophthalmus* culture in net cages is not economically profitable. From a preliminary study from local approaches on river cage culture by private entrepreneurs showed that the cage aquaculture approached in the river ecosystem hampered for some unsustainable attempt like technology unavailability, suitable density for culture species and feed management practice. Cage culture package for river ecosystem has yet to be developed in Bangladesh for public demand and production increase.

Rationale of the study

The land requirement of increasing people for housing, marketing, extension, roads, offices etc. the water resources are declining every year. Therefore, to make animal protein available to the country people, it is essential to increase the cage fish production in Bangladesh. However, government and non-government organizations (NGOs) have been exerting efforts and allocating resources for production oriented research and also initiation and encouraging the rural people to increase cage fish culture. In this circumstance, cage fish culture may play vital role in minimizing protein gap of the country.

Sustainable cage culture practice for tilapia in net cage mostly depends on supplemental feed and standard stocking density. Cage culture of tilapia not yet found sustainably profitable economically due to optimum/suitable stocking density. Various stocking densities are being practices for tilapia culture in net cage in different area of Bangladesh. In Chandpur, Laxmipur district, farmers are using about 25-30/m3 stocking density. Farmers of Munshiganj area are practicing about 100-150/m3 stocking density. Farmers of Thailand, Vietnam, and China are practicing 35-45/m3. Suitable stocking density is required for sustainable tilapia culture in net cages in river ecosystem. Cage culture practice mostly depends on supplemental feed. Assessment of proper requirement of feed supplement is most important to achieve the goal of profitable fish culture in cage. Lower and higher feed supplement causes loosing concern due to less growth of fish and sometimes fish health hazard and environmental degradation. Requirement of feed may vary from different stage of growth of fish. Sustainable practice of tilapia culture in cage depends on suitable feed supplement in different stages of growth. It is very important to know the nutritional status of the feed used in cages for proper growth of fish. The percent (%) of nutritional factors present in the feed are usually shown on the commercial feed bag but most of the time they may be varied from those percent (%) nutrient when tested. So it is necessary to find out the original proximate composition of the used feed such as moisture (%), ash (%), crude protein (%) and lipid (%) for actual nutritional status.

Water qualities also have a vital role in any type of culture system. Physico-chemical parameters of inland open water bodies are normally found in good ranges for aquaculture except some industrial area. Tilapia is a fish species which can survive in wide ranges of fluctuations in water quality parameters. Determination of suitability of ecosystem, physico-chemical quality parameters of cage water during culture period is very important.

Cage culture in open water bodies has tremendous prospects for Bangladesh. A package of cage culture technology in lotic (i.e. riverine) environment will be developed by using this study output. It will ultimately help the country to exploit the vast underutilized riverine water area to boost up the fish production. However, present study has envisioned to developed cage aquaculture of tilapia in selected riverine ecosystem.

General aims of the research work

The broad aim of the research work is to develop a suitable guideline for environment friendly sustainable open water cage aquaculture techniques for farmers. The research work is aimed to develop suitable cage culture technique in lotic (river) water that could be disseminated to other lotic habitat of the country.

Specific Objectives of the Research Work

To achieve the goal, stocking density, growth, survival, yield and farm profitability of Monosex tilapia will be assessed. The flowing specific objectives are to be addressed:

- to determine suitable stocking density for monosex tilapia in net cages in river ecosystem
- to optimize feed requirement of monosex tilapia culture in net cages in river ecosystem
- to assess the physicochemical parameters of cage water in river ecosystem
- to assess the proximate composition of commercial feed used in cages
- to assess growth parameters of monosex tilapia cultured in net cages
- to assess the food conversion ratio (FCR) by using different commercial feed used in cages

CHAPTER-2 REVIEW OF LITERATURE

According to Thiemmedh (1961), cage culture has been practiced since the beginning of 19^{th} century in some of the Southeast Asian countries like Cambodia, Thailand and Indonesia.

Schimittou (1969) observed cages were being used to culture Atlantic salmon (*Salmo salar*) in the early 1960s and in Scotland the white fish Authority commenced Salmon cage rearing trials around 1965s.

Collins (1971) found that cat fishes grew more rapidly and food conversion was better in cages with greater surface area.

Collins (1971) reported that cat fish can be grown successfully in cages and the channel cat fish is a more desirable species for this type of culture.

Rho and Pyen (1971) studied on puffer (*Fuga rubripes*) in floating nets and found the higher survival rate in cage of big fishes, whereas the smaller fishes gained more weight that the bigger fishes.

Bardach *et al.* (1972) found a pioneer catfish culturist produced 675 kg of channel cat fish (*Ictalurus punctatus*) of marketable size in cages (3m x 1.5 m x 1.4 m) in the U.S.A.

Collins (1973) studied on cage culture of catfish and concluded that the survival and growth of fish was superior at optimum range of temperature and feeding intensity.

Kelly (1973) reported that cages made of welded wire fabric and iron angle frame could be used for 20 years with replacement of wire every 5 to 6 years.

Shiloh and Hamifraz (1973) conducted a research on nutritional requirement of carp reared in cages. They observed that the cage of $1m^3$ size with stocking density of 200 fishes/m^3 was 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.

Ramirios and Bayne (1974) conducted a research by stocking *Tilapia aureus* in pens using natural food with supplementary feed of poultry manure or pellets containing 30% coffee pulp and also observed that pellets gave the best result.

Dahm (1975) found a special advantage of cage culture lie in the easy handling of fishes during the feeding and easy harvesting and no problem of water supply.

Konikoff (1975) conducted research on the feasibility of cage culture in lake and running water and tried to select suitable species for cage culture. He also presented a specific recommendation in favor of cage culture in running water.

Bayne *et al.* (1976) found no significant difference in survivality and average weight gain between groups of *Tilapia aurea* cultured in cages using two experimental feeds consisting of different food ingredients in different combinations but the weight gain was much less in cage of controls receiving no supplementary diet.

Coache (1976) studied 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 varied from one species to another.

Dimitrov (1976) studied on carp culture in net cages and found that at stocking density of 50 fishes/m^3 gave better growth than 25 fishes/m^3 and 80 fishes/m^3 but density of 80 fishes/m^3 gave more yield.

Chaitiamvong (1977) conducted an experiment on floating cage culture of *Pangasius sutchi* in Thailand and achieved a production of 65 kg/m^2 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^2 was obtained from *Oreochromis niloticus.*

Coche (1977) studied on the culture *Oreochromis 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 also found 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.

Guerrero (1977) reported that supplemental feed containing fish meal and rice bran gave the best result of *Oreochromis 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.

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

De Kimpe (1978) observed that fish production in floating cages was relatively costly and suggested that the development of new technique should be innovated. He achieved fruitful results from breeding experiments of *Oreochromis niloticus* and *Clarias* in 18 cages of 20 m^3 in a lagoon in Ivory Coast.

Ghittino (1978) found that 35 to 50 kg of catfish could be produced in a cage of 168 x 122 x 90 cm in dimension placing the cages in small lakes.

Guerrero (1978) studied on the feeding of *Tilapia nilotica* in floating cages. Stocking densities of 100 to 200 fish per m^3 were used. Only commercially available ingredients were used in the feed. Results of the studies showed that diets containing fish meal, fine rice bran and copra meal had significantly better feed conversion ratios than diets with ipil-ipil leaf meal. Diets with 25% fish meal and 10% copra meal were found to be efficient and economical for *T. nilotica*. Chicken grower mash enriched with fish meal did not significantly differ from a diet consisting of 25% fish meal and 75% fine rice bran. Fish given moist pellets had significantly higher production than fish fed with dry pellets.

Akbar (1979) assumed that the Karnafuli Reservoir (Kaptai Lake) has immense prospects for aquaculture as shown by recent limnological and biological studies. It is therefore expected that fish cages culture will become a booming industry in Karnafuli Reservoir.

Battes *et al.* (1979) observed the 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.

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

Anonymous (1984) found the advantage of cage culture were the easy to harvesting of fish and observing of feed consumption. He also reported that food conversion in caged fish was good.

Hasan *et al.* (1985) evaluated the effects of supplementary diet on the growth performance of Nile tilapia (*Oreochromis niloticus*). Four supplemental feeds using combinations of rice bran, wheat bran, mustard oil cake and fish meal in different proportion were tested. Fishes were stocked at the rate of 15 fish/m^3 in all the floating ponds. Fishes were found to survive and grow well in floating ponds having no mortality. The observed variations in gain in length exhibited by different supplemental feeds were statistically significant, but the body weight gains were found to be significant. Supplemental feed containing 30% rice bran + 30% wheat bran + 40% fish meal was significantly ($p < 0.05$) superior to rice bran 25% + wheat bran 25% + mustard oil cakes 25% + fishmeal 25% and rice bran 30% + wheat bran 30% +fishmeal 25%. Though the first one gave the best growth, but was not statistically significant over the feed with rice bran 40% + mustard oil cakes 50% and fishmeal 25%.

Mollah *et al.* (1987) conducted research on the growth of silver carp (*Hypophthalmichthys molitrix*) in floating net cages under different dietary conditions for 150 days. Growth rate in terms of increase in length and in weight of silver carp was found unsatisfactory in cages. Variations in the growth rate obtained for different treatment was not statistically significant. The supplemental diet with fish meal gave higher growth followed by the diet with ipil ipil leaf meal and the diet with wheat bran.

Ahmed (1989) studied the effects of supplementary diets on the growth of *Hypophthalmichthys molitrix* (Val.) *Labeo rohita* (Ham.), *Cirrhina mrigala* (Ham.) and *Catla catla* (Ham.) in terms of increase in weight were carried out for a period of one year from 2 January 1988 to 8 January 1989 in twelve floating net cages kept afloat in kaptai Lake, Rangamati. The effective size of all the floating net cages were kept at 2.0m x 2.0m x 1.5m deep and stocked with fishes at the rate of 15 individual m^{-2} in which the species ratio were silver carp 40%, ruhu 25%, mrigal 25% and catla 10%. Three supplemental feeds were prepared using rice bran, mustard oil cake, fish meal and wheat bran in different proportions. Feed was administered at the rate of 10 percent day^{-1} of the total body weight of the stocked fishes throughout the investigation period. The number of replication for each treatment was three and three floating net cages were kept as control. The relative growth of each species was studied by monthly sampling till the final harvesting the completion of one year rearing. Mortality rate was found to range from 2.88 to 14.32 percent. The gains in weight exhibited by different treatment were found statistically significant over control at 1 percent level of probability. Treatment II gave the highest growth rate but the increment was not statistically significant over Treatment I and III. The species combinations under different dietary condition were also statistically highly significant at 1% level of probability. Growth of ruhu and silver carp were significantly better than mrigal and catla.

Watanabe *et al.* (1990) studied the growth survival and feed conversion of juvenile, monosex male Florida red tilapia (*Oreochromis*) of 8.78 g average weight. He planted twenty four floating cages ($1m^3$) in a sea pass on Great Exuma, Bahamas and stocked at densities of 100, 200 and 300 fish / m^3. The test period was for 84 days and the fish were fed on commercially prepared diets containing 28 or 32% protein. Final mean weights were higher for fish fed the diet with 28% protein (average = 176.8g) than those fed at 32% protein (average = 166.4g), under all densities. Final biomass densities increased with increasing stocking density (range = 16.1 - 52.2 kg/m^3) and were higher for fish fed the 28% protein diet than those fed the 32% protein diet under all densities. Daily weight gain (average = 1.94g/d), specific growth rate (average = 3.54%/day) and survival (average = 97.9%) were higher and feed conversion ratios (average = 1.88) lower for fish fed the 28% protein diet than for those fed the 32% protein diet under all densities. No significant effects of stocking density on these parameters were observed. A significant effect of stocking density on final size variation was 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%). In case of dissolved oxygen fell to <3 ppm during the study due to declining ambient levels suggesting that higher biomass densities are attainable, given higher ambient dissolved oxygen.

Jameson (1991) observed the plankton feeding of *Oreochromis 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 *Oreochromis 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 *Oreochromis mossambicus.*

Scog *et al.* (1992) 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.

Swar and Pradhan (1992) reported that **c**age culture of fish in Nepal began in Lake Phewa in 1972. At present, 3 lakes in Pokhara Valley are being used for this purpose, Lakes Phewa, Begnas and Rupa. The major species are planktivorous fishes, *Aristichthys nobilis* and *Hypophthalmichthys molitrix*, which are raised in floating cages, usually of nylon or polyethylene, without supplemental feeding. Fish stocking density varies with the trophic state of the lake; in Lake Phewa, 6 fish/m^3 and in Lakes Begnas and Rupa, 10 fish/m^3. Annual production rates per m^3 are 3.4 kg in Lake Phewa, 4.7 kg in Lake Begnas and 5.0 kg in Lake Rupa. Mortality during the production period is about 5%. A 5-cage system has proven to be sufficient additional work for one fisher family and can add Nepali rupees 9,000-14,000 to their annual income. Cage culture faces several constraints, especially the shortage of fingerlings. A hatchery facility and technical support are needed to expand and intensify cage fish culture in the Pokhara Valley.

Nielsen and Hall (1993) reported that ever since the shrimp farming industry took off in Bangladesh and West Bengal, shrimp fry collection has developed into a major income-generating activity for thousands of people living in the coastal belts of these areas. This paper describes trials with nursery rearing of the tiger shrimp (*Penaeus monodon*) in floating cages. They were carried out in Ramnagar, Medinipur District, West Bengal, India, from 1990 to 1992. The purpose was to introduce a technology by which the fry-catchers could augment their income by nursing the shrimp fry to a larger size, with higher marker value, and be in a better bargaining position vis-a-vis the traders.

Norberg and Stenstroem (1993) studied 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 is presented and analyzed for flows of energy and phosphorus. The percentage out flow 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.

Santiago and Arcilla (1993) reported the results of their studies on rearing of tilapia in cages and the oxygen profile of the Sampaloc Lake. Commercial feeds became the main source of allochthonous organic matter in the lake. Total feeds given annually for the 28-hectare cage culture at 3 cropping per year amounted to 5250 tons. At feed conversion ration 2:1 a significant portion of the feeds given ended as organic wastes in the lake. An assessment of the dissolved oxygen condition of Sampaloc Lake showed ominous trends which might adversely affect the use of Sampaloc Lake for fishery.

Angell (1994) reported that the shrimp culture industry of Bangladesh depends on catches of the wild fry of tiger shrimp (*Penaeus monodon*). Employment as fry-catchers has been generated for thousands of rural poor. However, the marketing system is not well developed and high fry mortality occurs due to poor handling. The growing freshwater prawn farming sector, however, continues to demand increasing quantities of large juveniles. This report, based on field trials from 1990 to 1993, describes the results of cage nursery culture trials with both tiger shrimp (*Penaeus monodon*) and giant freshwater prawn (*Macrobrachium rosenbergii*) fry. It was thought that fry-catchers would be able to increase their earnings through sales of nursed post-larvae and juveniles. The survival of nursed post-larvae in the distribution system would also be increased. However, it is unlikely that tiger shrimp fry nursing can be made profitable. On the other hand, cage culture of a combination of hatchery-reared post-larvae and wild-caught fry of the freshwater prawn would be profitable.

Leboute *et al*. (1994) conducted a trial with all-male Nile tilapia fry, *Oreochromis niloticus*, to evaluate their performance in cages, when submitted to 4 different stocking densities (fish/m^3): 40, 60, 80 and 100. During a 5-month experiment, fish body weight was monitored monthly. They observed that forty fish/ m^3 was the best stocking density, and after 5 months, mean body weights were 104.50; 84.10; 79.80 and 71.00 at densities of 40, 60, 80 and 100 fish/m^3, respectively. Mean survival rate 2 months after the beginning was 93%.

Siddiqui *et al.* (1994) applied two fish feeds, one locally produced and the other imported, as tilapia (*Oreochromis* sp.) diets in intensive culture. He found no difference in durability, water absorption and water stability among the pellets of both feeds. But the loss of imported feed packed in wire netting bags and immersed in water was more than the local feed ($p < 0.05$). Large-size tilapia reared on large pelleted local feed showed better growth and feed conversion efficiency than tilapia reared on imported feed ($p < 0.05$). Medium size tilapia showed no difference in the growth rate and feed conversion efficiency reared on two types of feeds ($p < 0.05$), but the performance of tilapia reared on local feed was better. Small size tilapia reared on two types of feeds also did not show any significant difference in the growth rate and feed conversion efficiency ($p < 0.05$), but the imported feed gave better growth and feed conversion ration. For all size-classes of tilapia no difference was found in the condition factor (k), except for medium size tilapia where the condition factor of tilapia reared on local feed was higher than the tilapia reared on imported feed. Survival rate in all the treatments was 100%.

Al-Ahmed *et al*. (1995) studied on the production of tilapia (*Oreochromis spirulus gunther*) in sea water cages at two water depths of 2m and 3m. Four floating net cages (two replicates each) measuring 2.5 X 2.5 X 2 m^3 and 2.5 X 2.5 X 3m^3 respectively were used. Fingerlings acclimated to sea water (40 ppt) with an average weight of 35g were stocked at a density of 175 fish/m^3. The fish were fed 6 days a week with sea bream sinking pellets (46% crude protein) and a feeding rate, declining with time, from 6 to 25% of the biomass. Upon harvest after 172 culture days, no significant difference ($p < 0.05$) were observed between the two cage depths in mean individual weight, survival rate, growth, feed conversion ratio, total yield, individual length and condition factor. The specific growth rate was significantly ($p < 0.05$) higher at the 2m cage depth than that at the 3m cage depth. This was probably due to less variation in the sample than due to actual increase in SGR. On average marketable tilapia (> 250 g) constituted 76.5% of the total yield (40.4 kg/m^3) for the two cage depths, males represented 36.5% of this yield and were significantly ($p < 0.001$) larger than females. The study indicated that tilapia production level of 40 kg/m^3 can be achieved in sea cages and that increasing the depth from 2 to 3 m has no apparent adverse effect on production parameters.

Webster *et al*. (1995) studied on the effects of dietary protein and lipid levels on growth and body composition of sunshine bass *(Morone chrysops* **X** *M. saxatilis)* reared in cages. Juvenile sunshine bass with an average weight of 125 g were stocked into 24 floating cages (1.2 X 1.2 X 2.4 m) and fed one of 8 practical diets formulated to contain various percentages (30, 36,42**,** and 48%) of protein. Due to differences in composition of feed ingredients, diets were analyzed as having 29, 36, 41, and 46% protein. Each protein level was formulated with two lipid levels: low (between 6.5 and 9.8%) and high (between 13.3 and 17.1%). Fish meal composed a constant percentage (56%) of the dietary protein in all diets. Fish were stocked at a rate of 200 per cage and fed twice daily at 08.00 and 16.30 h. Fish were fed all they would consume in 30 min for approximately 150 days. Percentage weight gains and specific growth rates (SGR) of fish fed diets containing 41 and 46% protein (99 and 116 mg protein/kcal, respectively) were higher ($P<0.05$) than fish fed diets containing 29 and 36% protein, 67 and 82 mg protein/kcal, respectively. No differences ($P> 0.05$) in survival or feed conversion ratio (FCR) were found among treatments. Percentage dress-out, abdominal fat, hepatosomatic index, and body composition of sunshine bass was affected by dietary protein and energy level ($p<0.05$). Percentage protein and lipid in carcass and waste (head and viscera) of fish fed diets containing 116 mg protein/kcal had higher ($p<0.05$) protein levels and lower lipid levels than fish fed diets containing 67 and 82 mg protein/kcal. These data suggest that juvenile sunshine bass require a diet containing 41% protein, or a protein to energy ratio greater than 99 mg protein/kcal, when fish meal comprises 56% of the dietary protein.

Khan (1996) studied the growth performance and production potential of GIFT, tilapia in cages under pond condition. The highest yield 4.18 kg/m^3 was fed with 90% wheat bran and 10% fish meal. The initial length and weight were 3.11cm and 18.82g and percentage net gain in length and weight and Specific Growth Rate (SGR) were 0.313g and 1.70 respectively.

Yi *et al.* (1996) conducted an experiment for 90 days at the Asian Institute of Technology in Thailand to investigate the appropriate stocking density of large Nile tilapia placed in cages in earthen ponds where small Nile tilapia were stocked in open water to utilize the wastes derived from the cages. Large male tilapias (141 f 11 .l-152 k 2.1 g) were stocked at 30, 40, 50, 60, and 70 fish m^{-3} in 4-m^3 net cages. One cage was suspended in each of 15 earthen ponds, and three replicates were used for each density. Small male tilapias (54 + 2.3-57 k I .2 g) were stocked at 2 fish m^{-3} in open water of all ponds. Caged tilapia were fed twice daily at 3%, 2.5%, and 2% body weight day^{-1} during the first, second, and third month, respectively, with commercial floating pellets containing 30% crude protein. Water quality was analyzed biweekly. Stocking densities of caged tilapia had significant ($P < 0.05$) effects on the survival, growth, and food conversion ratio of caged tilapia, and on the growth of open-pond tilapia. The survival of caged tilapia decreased from 91.4% ± 5.0 to 57.2% ± 8.1 with increased stocking densities from 30 to 70 fish m^{-3}, while survival of pond tilapia was higher than 90.0% in all treatments. The average treatment mean weights of tilapia harvested from cages ranged from 509 ± 26.0 to 565 ± 13.9 g. The growth of pond tilapia was quite slow, with daily weight gain increasing from 0.30 f 0.02 to 0.47 k 0.08 g per fish day^{-I} in response to increased feed inputs to caged tilapia. The combined net yield of both caged and open-pond tilapia was highest in the treatment with 50 fish m^{-3}. Water quality analyses indicated that the wastes from caged tilapia were insufficient to generate abundant natural food for the growth of open-pond tilapia.

Otubusin (1997) conducted a study for 150 days to determine the potential of cage culture of some commercially important fish species in Lake Kainji, Nigeria, the microphagous/planktivorous *Citharinus citharus, Oreochromis niloticus* and *Sarotherodon galilaeus* recorded high growth rates expressed in gm per day (g/d) of 3.31, 2.82 and 2.03 rates, respectively. *Clarias gariepinus* on the other hand, had a daily growth rate of 3.28 g/d. It was demonstrated that in addition to the popular tilapias, *C. citharus* with no previous record of use in cage culture, was shown to be suitable for cage culture. This conclusion derives from its growth performance, fecundity adaptability, feeding at the base of the food chain and particularly late maturity: an advantageous feature over the tilapias.

Al-Mohsen (1998) observed that Nile tilapia (O. *niloticus)* males grow faster than females in mixed gender groups under intensive aquaculture because of their early maturation and frequent breeding. This study was designed to determine if the saturation kinetic model could be used to describe weight gain and net nutrient deposition as a function of nutrient intake. Nutrient response curves were developed for female, male, and mixed gender groups fed varying levels of a commercial diet for six weeks. The shape of the curve (n), curve parameters (R_{max} , $K_{0.5}$,b), and calculated maintenance level (ML) varied between gender groups. All-male Nile tilapia gender groups grew faster than female or mixed-gender groups. Males exhibited higher R_{max} and $K_{0.5}$ for growth than female or mixed-gender groups because they used fat, protein and energy more efficiently. Based on our results, methods to provide all-male tilapia for aquaculture should be used to maximize growth and performance.

Beveridge and Stewart (1998) reported that cage aquaculture in lakes and reservoirs continues to expand and intensify, especially in Asia, despite conflicts in resource use and social inequity, problems arising, from waste production and questions regarding sustainability. Environmental impacts arise from the consumption of resources (environmental goods) and the production and release of wastes into the environment, which is relied upon to disperse and assimilate those wastes (environmental services). Cages may have slightly greater demands than ponds in terms of consumption of environmental goods and services per unit fish production. However, environmental impacts are much more strongly related to intensity of production methods and scale of development within a lake or reservoir. In view of the likely scale of operation, cage-based hatcheries and nurseries are unlikely to pose much of an environmental threat. In some circumstances such impacts may be beneficial in terms of enhanced fisheries production. Problems of resource use conflict may be anticipated by addressing questions of ownership of the lake or reservoir and the use and control of resources within tile water body.

Cline and Masser (1998) observed that many land owners who are interested in aquaculture may not have the financial and physical resources or the practical experience to start a large-scale aquaculture enterprise. Growing catfish in cages can be a means for landowners with existing ponds to produce fish for supplemental income and to gain experience in aquaculture. Cage culture is an intensive form of aquaculture that has its own particular set of advantages and problems. The advantages of cage culture include the following: Many water resources can potentially be used, including ponds, lakes, strip pits, rivers, and streams. Cage culture requires a relatively small financial investment. Feeding, sampling, observation, and the harvesting process are comparatively simple. The pond or water resource can still be used for other farming activities and for other types of recreation such as sport fishing. Cage culture also has particular disadvantages because of the intense crowding and confinement of the fish, including the following: There is a relatively high incidence of disease, and the disease spreads rapidly in cages. There is localized poor water quality, such as low dissolved oxygen, in and around cages. Caged fish need a nutritionally complete, fresh feed. Cages are attractive to predators, vandals, and poachers. Alabama growers produce more warm-water fish in cages than any other state. Since the late 1980s the cage culture of catfish and tilapia has expanded to be a viable alternative enterprise and a supplemental source of income for many Alabama pond owners. The growth of the cage industry throughout the Southeast has led to expanded cage research at Auburn University and other southern universities. With over 17,000 acres of existing ponds and an additional 135,000 acres of potential pond sites in the east central, "Piedmont" region of Alabama alone, there is obviously tremendous growth potential for this form of fish culture. Aquaculture has expanded rapidly since the 1980s. Worldwide aquaculture accounts for more than 15 percent of all seafood production. In the United States, aquaculture, particularly catfish production, was one of the bright spots in U.S. agriculture in the 1980 s and is continuing expansion in the mid-1990 s. The advantages and disadvantages of cage production should be considered carefully by perspective producers before making an investment. The potential to lose fish to disease, low dissolved oxygen, poor nutrition, and poaching should not be discounted.

Fish can be produced profitably in cages, but these problems should be anticipated, and methods to manage each problem need to be examined.

Hu and Liu (1998) reviewed the present status and the achievements of cage culture in China and evaluated its enhancement role in lake, reservoir and riverine culture with reference to data and survey reports during the period 1978-1996. The authors also indicated the constraints to the development of cage culture in China at the present time. In this 18-year period, the area of cage culture in China has expanded at an average annual rate of 71%. The fish production from cage culture increased year by year. During the period 1978-1993, fish production of cage culture per ha increased by an average of 9.8% per annum. A variety of species is being cultured in cages. Special aquatic products have been successfully cultured in cages in recent years, increasing economic return of cage culture. Cage culture is adaptable to various inland water bodies and is an effective way to utilize and develop inland water resources.

Oduro-Boateng (1998) reported that floating fish cage culture facilities were designed and constructed to study the economic and technical feasibility of tilapia cage culture enterprises in Ghana. Using trained local participants two locations were selected for tilapia production in cages. Least-cost and easily available local ingredients were used for the reading trails and FCRs of 3.5 and 3.0 were obtained for fish from station A and B FCRs respectively. Economic viability of the production system was evaluated using net present value (NPV). A sensitivity analysis was conducted on the impacts of changes in input prices and productivity on the internal rate of returns (IRR). The IRR signified the yield of the project is approximately 58%. Compared with bank loan interest rates in Ghana, which range between 40% and 48%, the yield is higher by a margin of 10% to 18%. This is quite substantial incentive to support investment into the project. Technically, the system used is easily adoptable by the rural farmer and if properly managed can help solve the stunting problem associated with tilapia culture in Ghana.

Golder *et al.* (1999) studied on the economics of *Pangasius sutchi* cage culture in northwest Bangladesh using commercially available grow-out feed. Two hundred and twenty *Pangasius sutchi* fingerlings (mean weight 1.3 g plus or minus 0.3 g and mean fork length 5.0 cm plus or minus 0.5 cm) were stocked in three woven nylon mesh cages (stretched mesh size 0.5 cm) each measuring 4.4 x 2.5 x 1.5 m (deep) erected in a 3.5 m deep static water borrow pit at the

Parbatipur aquaculture complex. A commercial (Saudi Bangla) grow-out fish feed pellet (crude protein 27%) was fed twice daily to satiation. Fish weight was sampled monthly. The fish were cultured for 398 days (August 08, 1995-September 09, 1996) when they were sampled and their market price determined. Final mean weight and mean fork length were 1,132 g (plus or minus 241 g) and 41.9 cm (plus or minus 4.0 cm) respectively. Mean daily growth rate was 2.84 g day super (-1), mean FCR 4.51 and mean survival 95.3%. All investment costs were repaid over the 13 month trial period. A total profit of Tk. 32.949 (US$823.7 super (2)) was made from the three cages with a net profit of Tk. 46.25 (US$1.16) for each kg of *Pangasius sutchi* produced and a cost benefit ratio of 1:1.55.

Ireland (1999) reported that cage aquaculture is a relatively new technology in Bangladesh. While there are technical problems, the way in which cage aquaculture is accepted in the surrounding social environment is critical for its long-term sustainability. Trials with cages managed by groups of landless women have shown this to be a way of improving their production systems. But cages are vulnerable to damage, making group cohesion important. In four out of 13 cage trials, there were conflicts either within groups of with outsiders, of which the most important is related to access rights to the cages. In the longer term, policies to regulate cage aquaculture may need to be developed, especially to enable poor people to retain cage sites.

Roy *et al.* (1999) reported that CARE-Bangladesh CAGES project aims to develop, innovate and promote cage culture in Bangladesh utilizing the skills and experiences of farmers and other development partners considering the environmental implications. This paper reports on the results obtained from the first trial conducted as part of the process of developing strategies based on learnings. The purpose of this trial was to compare the growth, production and economics of common carp cultured in floating net cage in the Meghna River, Bangladesh at density 25, 50 and 100 m^{-3} and fed three different kinds of feed, commercial pellets (SB) and farm-made feeds (A and B) for a period of 100 days. Feed SB recorded higher ($p < 0.05$) growth compared with Feed A and B. T-test on the data showed that the average growth per fish fed a particular diet is not significant ($p < 0.05$) at different densities but SB feed results in significantly higher ($p < 0.05$) yields at all three densities. Fish recovery decreased with higher stocking densities significantly ($p < 0.05$) across all treatments. Feed B had the lowest recovery at all densities and feed SB the highest ($p < 0.05$). A negative production was also observed at density 100 with Feed A and B. Better growth in Feed SB attributed to its higher protein contain. The other main reason for poor growth was feed loss due to poor binding properties and physical disturbance by the fish and water flow. Higher recovery of fish at lower densities may be linked to fish grazing on the net on accumulated periphyton. Reducing the feed losses will be one of the key factor for economic success of the technology in Bangladesh and in addition will also help minimize the pollution of cage sites.

Baliao *et al.* (2000) described that the net cage of tilapia in dams and small farm reservoirs, which has been found to be a low-cost yet high-income earning farm activity and offers an excellent option as an alternative livelihood for poor inland fisher folks. The following aspects are covered: 1) Characteristics of a suitable site; 2) Design of the net cages - the floating cage, the stationary/fixed cage; 3) Stocking the net cages - source of juveniles, stocking rate, stocking time, acclimation; 4) Management of the cages - feeds and feeding, monitoring activities; 5) Harvesting - partial harvest, total harvest; and, 6) Profitability analysis.

Bhujel (2000) studied on a review of strategies for the management of Nile tilapia (*Oreochromis niloticus*) broodfish in seed production systems, especially hapa-based systems. He also observed that low egg production per spawning and lack of spawning synchrony are the major problems of mass seed production in mouth brooding tilapias. Collection of eggs or fry from the mouths of incubating females reared in large hapas suspended in fertilized ponds and incubating them artificially has been found to be commercially viable. However, fouling of the hapa is a major problem causing inconsistent performance of brood fish. In addition, other factors influencing with the tilapia seed output in hapa within pond systems are age and the size of the brood fish, feeding and feed management, environmental factors and management techniques. However, information on the factors affecting tilapia seed output is limited and scattered; therefore, this paper discusses the various aspects of management strategies based on the present state of knowledge and explores areas for the future research.

Brugere *et al.* (2000) made a discussion is presented on activities being conducted in the framework of the CAGES project (Cage Aquaculture for Greater Economic Security) in Bangladesh, regarding the introduction of cage culture of various aquatic species to resource-poor people in rural areas. Details are given of a survey carried out to identify issues which could affect the acceptance of cage culture by the local community. The complex interactions occurring between cage operators and other community members and resources were explored through rapid rural appraisal. In the villages selected for the survey, participants were segregated into groups, according to their use of water body and gender (cage operators, fishermen and other male water users, women and children). The groups represented a broad spectrum of the community, including cage and non-cage operators, various age groups and both genders. In this way, it is unlikely that any issues regarding the impact of cage culture on the community would have been overlooked. The CAGES project intends to carry out similar surveys in the same villages annually, in order to monitor the development of any potential conflicts in the survey areas and enable their easy resolution.

Chowdhury and Yakupitiyage (2000) reported a total of 5488 ha of oxbow lakes in Bangladesh has recently gained importance as a potential fishery resource. The growing need to utilize this resource to a fuller potential requires consideration of cage culture by resource-poor fishing communities as a compliment to existing stock enhancement programmes. In the present study, the existing management systems of eight lakes are reviewed. Water quality was analyzed with reference to the largest lake, i.e. Lake Baluhar. During the present study, > 100 cm transparency indicated the suitability of a lake for cage culture. Other water quality parameters, especially dissolved oxygen, ammonia and nitrite concentrations, also indicated suitability for cage culture. Non-fisheries activities, such as the use of agricultural pesticides in the lake catchment and jute retting in its basin, were identified as the most harmful to fish by the majority of the fishermen. An integrated pest management programme using rice-fish based rearing systems in the lake catchment is recommended. It is further recommended that a unified management system should replace the existing dispersed systems under different management bodies.

Hussain *et al*. (2000) reported that the growth and production performances of Genetically Improved Farmed Tilapia (GIFT) strain was evaluated along with two locally available tilapia breeds, domesticated as existing Nile and red tilapia strains, and with several carp species under polyculture system in ponds and subsequently in cages under on-station and on-farm conditions in Bangladesh. On-station grow-out trial of GIFT and red tilapia strains conducted in replicated ponds for six months reveals significant differences ($P < 0.05$) in both final body weight and gross production data between the two strains. At harvest, it was estimated that GIFT strain was

35.74% superior to red tilapia strain in terms of growth. In a comparative on-farm trial of a local NGO (MCC), the GIFT strain performed significantly higher growth and better survival than the existing *Oreochromis niloticus*. Production potential of GIFT strain along with several carp species was also evaluated under on-farm polyculture system. Present data reveals that the overall pond production can significantly be increased if GIFT strain might combine with other desirable species of carps viz. silver barb (*Barbodes gonionotus*), mirror carp (*Cyprinus carpio* var. specularies) and silver carp (*Hypophthalmichthys molitrix*) rather than growing out GIFT alone. The cage culture study involving only GIFT strain conducted by CARE Bangladesh, shows that a high net production (30.68 kg/m^3) can be obtained with a short period of time (124 days). These results are carefully analyzed and presented and, finally, the potential implications of adopting GIFT technology as homestead enterprise and disseminating this to the small even large scale entrepreneurs are discussed.

Kabir and Huque (2000) reported Bangladesh is a riverine country. An enormous variety of water bodies, including rivers, canals, flood plains, beels (large depression), and ponds, are dispersed throughout the country, providing considerable potential for cage aquaculture. To ensure access and utilization of these water bodies, the CARE-CAGES (Cage Aquaculture for Greater Economic Security) project has been developing cage designs suitable to the needs of the resource poor farmers in rural Bangladesh. The cage design must consider certain physical properties, including the ability to hold fish securely, which should also be within the financial means of the potential cage operators. It is argued that much of the historic failure of cage aquaculture in Bangladesh is due to the inability of the local people to afford the large, expensive cages both in terms of capital cost (cages were over-engineered for their purpose) and the cost of inputs (seed and feed) required for successful culture. The cages presently used by the CAGES project are small in size (1-8 m3), inexpensive, and simple to construct. The main cage types used in the project as well as their advantages and disadvantages are discussed in detail in this paper.

Kim (2000) described the general status of cage aquaculture in Korea. Except for the sporadic use of cages to hold live fish caught from the wild, cage aquaculture to grow fish to marketable size dates back to two decades ago in inland waters and only a little more than one decade in marine waters. The inland water cage farming was once thought to be the most important and profitable aquaculture business, but it is now totally banned by the central government due to the clean water policy after long social conflicts. Marine cage farming has instead been growing at a steady pace and now some 400 farms are under operation. Annual output from marine cage farms is now more than 40,000 tons of fish, well rivaling one of the other types of marine fish culture, land-based tank aquaculture.

Lin and Kaewpaitoon (2000) reported that despite its long history and a large number of rivers and reservoirs in Thailand, cage culture contributed only 0.3% of 200,000 tons in total fish production from freshwater aquaculture. Over the last decade, the peak of annual fish production from freshwater cages reached 2,700 tons in 1991 and declined since to a minimum of 600 tons in 1995. Although cage culture takes place in various habitats such as river, reservoirs, irrigation canals and large ponds, its predominant habitats are in flowing waters. Among a dozen of cultured species, red snake-head (*Channa micropeltes*), catfish (*Pangasius* spp.), marble goby (*Oxyeleotris marmoratus*) and tilapia (*Oreochromis* spp.) topped the list. The production of those species fluctuated drastically resulting mainly from deteriorating water quality, competing for trash fish feed, changing market value, and shifting culture practices. However, disease and fingerling supply caused the reduction and limitation in culture of the most valued marble goby. Recently, the cage culture of tilapia has gained great popularity in certain parts of the country. Cage culture has been a small-scale, artisanal operation with little research and technical innovation. Further development of cage cultures in freshwater lies on ecologically sound multiple uses of reservoirs and flowing waters. In addition, integration of intensive cage culture with semi-intensive species in ponds should also be promoted.

Menasveta (2000) observed that fish cage-culture in Thailand has been developed for more than three decades, starting with freshwater fishes and extended to coastal waters. Most cages are box-shaped and made of wooden planks, floated along the river banks. The predominant cultured species are river catfish (*Pangasius pangasius*), marble goby (*Oxyeleotris marmoratus*), and serpent-head (*Ophicephalus* sp.), which are produced in large quantities. Production, however, has declined significantly during the last decade due to dam construction in several rivers. This resulted in the reduction of flow rate making the areas unsuitable for cage culture. Coastal fish cage culture has been practiced for more than two decades during which the production increased steadily. Sea bass (*Lates calcarifer*) and groupers (*Epinephelus* spp.) are the two major groups of fish being cultured in the coastal areas. In the future, net cage culture of tilapia species will play an important role, especially in reservoirs. This is because the investment cost is comparatively lower than the culture of other groups of fishes and there is a large market demand.

Shariff and Gopinath (2000) reported that the cage culture industry is a relatively recent development in Malaysia with large scale farming in marine waters taking off only in the 1980s and in inland waters in the 1990s. In 1997, total production from cage farms amounted to 7,314 tons or 8% of the total aquaculture production. However, cage farm output amounted to US$ 29 million or 18% of the total aquaculture value. Production was oriented largely towards production of high valued finfish for the live trade. In 1997, there were 58,500 marine cages in the country with a total area of 680,893 m2. Production amounted to 5,621 tons valued at US$ 26.4 million. Unit production from marine cage farms averaged about 8.5 kg/m2.The average wholesale price of cage farmed marine finfish in 1997 was US$ 4,696/tones. The main finfish reared is the sea bass (*Lates calcarifer*), which in 1997 accounted for 50% of the total finfish production and 35% of wholesale value. Other fishes reared include the groupers (*Epinephelus* sp.) and mangrove jacks (*Lutjanus* spp.). Though groupers account for only 14% of the finfish production, they accounted for 28% of the total value. The snappers (mangrove and red snappers) and tilapia which accounted for just 5% of the total cage culture output in 1992, accounted for nearly 50% in 1997. Major constraints include seed supply, congestion of existing sites and lack of new sites for expansion. In inland waters, the number of units rose to 200% over 1992-1997, from 2,152 to 6,516 units. As with marine cage culture, the emphasis is on the production of live fish for the restaurant market. However, the value of the freshwater fish output (average wholesale value US$ 1,426/ton) is generally lower than that of cage farmed marine fish. Production increased to 250% from 484 tons in 1992 to 1,693 tons in 1997, while its contribution to overall freshwater fish production increased from 3% in 1992 to 5% over the same period. Unit production rates ranged from 18-23 kg/m2. The main species cultured include the tilapia (*Oreochromis niloticus*), sultan fish (*Leptobarbus hoevenii*), mystid catfish (*Mystus nemerus*) and striped catfish (*Pangasius sutchii*). Smaller quantities of Javanese carp (*Barbodes gonionotus*), common carp (*Cyprinus carpio*) and grass carp (*Ctenopharyngodon idella*) were also produced. The future for cage culture development in Malaysia is promising, especially for freshwater cage culture. There are over 206,000 ha of reservoir area in the country suitable for inland cage culture. However, the market for freshwater fish is more limited. On the other hand, the scenario facing marine cage culture appears to be more limited. Though markets are not constraining, the limited resource base, disease, feeds and seed supply are serious impediments to the continued growth of marine cage farming.

Victor Wu *et al.* (2000) reported that fish meal is necessary in tilapia diet for good growth response. Five experimental diets (32% protein) containing 46-51% high-lysine corn, 20% corn gluten meal, supplemented with soy grits and synthetic amino acids, with and without fish meal were formulated. The diets were fed to tilapia with average initial weight of 13 g for 70 days in aquaria. Weight gain expressed as percentage increase after 70 days or as grams/day, feed conversion ratio, and protein efficiency ratio were equal ($P > 0.05$) to a commercial feed (36% protein) for all experimental diets. It appears that 32% protein diets with 46-51% high-lysine corn and 20% corn gluten meal were adequate for tilapia based on weight gain, feed conversion ratio, and protein efficiency ratio, and that fish meal is not necessary for tilapia feed to obtain good growth response.

Alceste (2001) reported that Colombia and Brazil are two Latin-American countries that have adopted cage culture among their tilapia production strategies and have been very successful at it. The cage system is an intensive tilapia production method commonly used in Latin America as well as Asia. Cage culture offers several important advantages. Cages are production units easily managed, cost of harvesting is low, populations can be treated when diseases or parasites are detected, and they require a relatively low capital investment when compared to ponds. In this environment breeding cycles are disrupted and therefore mixed sex populations can be reared in cages without the typical problems of recruitment and stunting. Although some disadvantages include the risk of loss from poaching, fishes become less tolerant to poor water quality, and are totally dependent on nutritionally complete feeds.

Brugere *et al*. (2001) assessed gender differences affect uptake and participation in aquacultural activities, a study of a cage aquaculture development project managed by a non-governmental organization (NGO) in Bangladesh was undertaken. CAGES project (Cage Aquaculture for Greater Economic Security) aims to promote the use of low input cage systems for the benefit of the rural resource poor, including women. Using a participatory approach involving semi structured questionnaires complemented by group discussions with mapping exercises to cross-check information, the role of women was investigated. Distance of the household from the water body was revealed as a major constraint to the full participation of women, especially in the more conservative areas of the country. Time-consuming activities such as the collection and preparation of feed were generally the responsibility of women as part of their household tasks. The influence women held over post-harvest decisions varied between region, villages and households, with women in the Jessore area appearing to become more empowered from cage aquaculture activities.

Dey (2001) reported that tilapia production is growing rapidly in Asia, with an average annual growth rate 10% during 1989 to 1999. The People s Republic of China, Indonesia, Malaysia, the Philippines, Sri Lanka, Thailand, Taiwan (province of China) and Vietnam, account for most tilapia production in Asia. Though tilapia is not yet a widely cultured species in South Asian countries, its production is increasing rapidly in Bangladesh. This paper provides a comparative analysis of tilapia production in various major tilapia-producing countries of South Asia and the Far East. The comparative analysis is based on using data from household surveys conducted by ICLARM - The world Fish Center and its partners and data from secondary sources. Nile tilapia *Oreochromis niloticus*, Mozambique tilapia *Oreochromis mossambicus* and blue tilapia *Oreochromis aureus* are the main tilapia species found in Asia. Among these species, by far the most important from a production point of view is the Nile tilapia. It contributes to about 85% of the tilapia production in the region. But, the Mozambique tilapia is still the predominant tilapia species in Indonesia, contributing about 67% of the tilapia production in the country. The growth in tilapia production in Asia has come from growth in tilapia aquaculture in the region, which grew at an annual growth rate of 12% during the last decade. Fish farms raise tilapia in ditches, ponds cages/pens and concrete tanks, depending on the nature of their farmland and on their capacity to invest. Polyculture of tilapias with carps in ponds is the most popular system in PR China, Thailand, Vietnam and Bangladesh. Cage operators in these countries grow tilapia under a monoculture system. Integration of tilapia farming with livestock farming (e.g, fish-chicken farming, fish-duck farming, fish-pig farming) is widely practiced in Thailand. In the pond polyculture system in Bangladesh, the southern part of China, Thailand and Vietnam, fish are raised for seven to eight months. However, due to the long winter in the northern part of China, Thailand and Vietnam, fish are raised for seven to eight months. However, due to the long winter in the northern and central parts of China, farmers often practice a two-year tilapia production cycle: the first year for fingerling production and the second year for grow-out operations. Stocking density under different production environments (pond, cage/pen) and culture systems (monoculture, polyculture) varies widely among Asian countries. Pond operators in Asian countries fertilize their ponds and also feed the fish, though the type and quantity of feeds used vary among countries. Cage operators generally use a large amount of commercial feed. Tilapia farmers in Asia mainly culture fish in semi-intensive systems except in Taiwan, where intensive culture of monosex tilapia is widely practiced. The yield of tilapia farming varies considerably across countries, production environments and culture systems. The average yield of tilapia farming is highest in Taiwan (more than 12 mt/ha in ponds). Pond operators in China and Thailand produce around 6 mt/ha. In South Asia and the Far East, the future of tilapia farming remains bright. Prospects expansion of tilapia production in the region depend upon matching future research and development efforts to the needs of producers and of consumers in domestic and international markets.

Dey and Paragus (2001) analyzed the costs and returns of tilapia farming in Bangladesh, the Peoples Republic of China (China), Indonesia, the Philippines, Taiwan Province of China (Taiwan) and Thailand, and the relative competitiveness of these countries in exporting tilapia to the USA. The potential impacts of the adoption of the genetically improved farmed tilapia (GIFT) strain on the economics and competitiveness of tilapia farming in Asian countries are also assessed. In Asia, tilapia farming is profitable. The costs of production and profits vary considerably across countries, production environments and culture systems. Tilapia production is more profitable in Taiwan and China than in Bangladesh, the Philippines, Thailand and Vietnam. But the cost of production per kilogram of tilapia is higher in Taiwan than in other Asian countries. The costs of feed and of obtaining fry/fingerlings are the most significant production costs in tilapia monoculture (both in ponds and cages). Results show that China does not have a comparative advantage in production of tilapia in cage monoculture system. When market distortions in their domestic economies are taken into account, Bangladesh, Thailand and Indonesia are the only Asian countries that can successfully compete in exporting tilapia to the USA. To improve their competitiveness, Asian countries must improve the quality of their product. With the introduction of the GIFT strain of tilapia to Asia, it is expected that both the profitability of tilapia production, and the competitiveness of countries in the region in exporting tilapia to the USA, will improve.

Dey *et al*. (2001) reported that Asia produced about 94% of the world's total freshwater aquaculture production, with People s Republic of China (China), India, Bangladesh, Vietnam, Indonesia, Thailand, Taiwan province of China (Taiwan) and the Philippines as the top producers within Asia. This paper provides a comparative analysis of the profile of freshwater fish farmers and their farming systems, and productivity, costs and returns of freshwater aquaculture in Bangladesh, China, India, Indonesia, the Philippines, Thailand and Vietnam. This paper also analyzes the comparative and competitive advantage of some of these countries in exporting tilapia to the USA. The analysis is based on secondary information and on field survey data collected by ICLARM-The fish Center and its partner research institutes in recent years. Freshwater fish farming in Asia is carried out in ponds, cages/pens, paddy fields and ditches. The pond system of farming and polyculture is common for all the countries, except for Indonesia and the Philippines. Monoculture of tilapia in ponds/cages is the most dominant aquaculture practice in freshwater environments in the Philippines while monoculture of common carp and tilapia are widely practiced in Indonesia. Freshwater fish farming in Asia is dominated by small-scale farmers operating in predominantly rice-based farming systems. Fish farming is not the primary occupation of most households, except in China and Indonesia. The average total area cultivated by a household range from around 1.00 ha in Southern Vietnam to around 4.25 ha in India. Freshwater fish farms are operated mostly by private owners, except in China and Northern Vietnam, where a large proportion is owned by the state or by collectives. Pond operators, in all the surveyed countries fertilize their ponds and also feed the fish, though the type and quantity of feeds varies among countries. Level of input use indicates that pond operators in these countries are culturing fish using a semi-intensive system. On the other hand, monoculture in cage is mostly an intensive system, whereas fish-rice culture is an extensive culture system. Results indicate that the level of input use intensity increases with the increase in farm size (or income level of the farmers). The yield level, cost of production and profitability of freshwater fish farming vary widely in different countries, production environments, with differing input levels, culture practices and farming systems. Freshwater fish farming is a profitable activity in Asia. The costs of feed and of obtaining fry/fingerlings are the two most significant production costs in freshwater aquaculture. When market distortions in their domestic economies are taken into account, Bangladesh, Thailand and Indonesia are the only Asian countries that can successfully compete in exporting frozen tilapia to the USA. The analysis reveals that semi-intensive systems of freshwater fish farming are appropriate for the socioeconomic conditions prevailing in these countries.

Gurung and Rai (2001) reported that cage fish culture started in Nepal since 1972 in the lakes of Pokhara Valley and expanded in Indrrasarobar Reservoir, Kulakhani since 1983. Bighead carp (Aristichthys nobilis) and silver carp (Hypophthalmichthys molitrix) are the main fish species identified for cage fish culture developed in Nepal. Nylon or polyethylene mended knot-less floating cages of approximately 5-m long, 5-m wide and 2-2.5 m deep is the most popular among the farmers. In such cages 1.3-7.4 kg fish/m^3/year are produced depending on tropic status of water bodies. Since caged fish depends entirely on natural food, the most important characteristics of Nepalese extensive cage fish culture are its economic sustainability without any supplementary feed. The productivity observed from 1.3-5.5 kg/m^3 in Phewa, 1.8-4.7 kg/m^3 in Begnas and 2.0-7.4 kg/m^3 in Rupa whereas the productivity ranged from 3.9-5.3 kg/m^3 in Indrasrobar reservoir. Lakes Phewa, Begnas and Rupa are fragile aquatic environments and sedimentation is the major source of pollution in these lakes. External factors play very important roles than internals to regulate the environment of the lakes. Since cage fish culture occupy <1.0% of total lake and reservoir surface area, and at present the extensive method of cage fish culture is taken as environmentally friendly activity. The present trend suggest that cage fish culture with plankton feeding fish could be one of the best alternatives mean to provide employment and food security by recycling the nutrients and organic load entering into the lake and reservoirs in cheaper way.

Krismono and Adriani (2001) investigated that the rising amount of fish culture with floating net cages system degrades the dam water quality. However, it is an important aspect in supporting the success of fish culture. The purpose of this research is to find out data and information of water quality in Juanda dam, Jatiluhur (Indonesia). The research is conducted in ten stations during May to December 2000, by using stratification method. Its parameters are water temperature, cleanness, and pH, Oxygen, N-NH_3 and H_2S. Its findings show that since

September to December 2000 there is a degradation of cleanness and O_2. Generally, the concentration of N-NH_3 and H_2S is beyond the standard. Based on the finding, in order to make a successful fish culture with floating net cages system, it is necessary to consider the decreasing water quality from September to December.

Vaishali and Matsuda (2001) reported that fish cage farming generates large amount of organic waste in the form of unconsumed feed and faecal matter resulting in farm sediment deterioration and threatening its own sustainability. In order to evaluate the sustainability of fish cage culture systems, an index which can be standardized and is flexible enough to cover the wide range of environments in which fish farms are located, is developed. A study was undertaken to identify the appropriate parameters that provide a comprehensive picture of the condition of the fish culture grounds. It revealed that the magnitude of effect of fish farming varies with aquaculture load and the capacity of the environment to react to the changes carried out by fish farming. A positive correlation was observed between organic carbon input to the farm in the form of feed and the farm sediment quality in terms of AVS-S content. The sediment AVS-S content was also found to vary with the embayment degree of the area that is a measure of flushing capacity. Therefore, aquaculture load, flushing capacity and sediment quality were incorporated as the components of sustainability index.

Hambrey *et al*. (2001a) observed that recent articles in the World Aquaculture magazine, by Hecht (March 2000) and Edwards et al. (December 2000), and letters to the Editor (September 2000) have argued and demonstrated the pros and cons of aquaculture in the world s developing countries, and particularly in rural areas where poverty, malnutrition, and unemployment are all paramount. As a further contribution to this important social issue, studies have recently been carried out in Bangladesh and Viet Nam on cage aquaculture and its potential for poverty alleviation. The projects were funded under the UK Department for International Development Aquaculture Research Programme by DFIDs Fisheries program through CARE Bangladesh. The approaches of the two projects were different. In Bangladesh cage culture was developed specifically as a poverty alleviation tool in association with local NGOs and the help of supporting research. In Vietnam the existing social situation and the nature of existing technologies were first studied to assess the potential of cage culture to help alleviate poverty, and then appropriate ways identified and implemented to take it forward. This first article discusses the potential of the small scale cage aquaculture developed by CARE Bangladesh. The next issue will carry an article on cage culture in Vietnam, and will include a broad overview of the potential of cage culture for poverty alleviation.

Hambrey *et al*. (2001b) explained this is the second of two articles that assess the potential of cage culture for the alleviation of poverty in some of the world s poorest countries. The first article, which appeared in the last issue of World Aquaculture magazine (March 2001), described freshwater activities in Bangladesh. This second article describes developments in the coastal waters of Vietnam. The approaches in the two countries were different. In Bangladesh cage culture was developed specifically as a poverty alleviation tool in association with local NGOs and the help of supporting research. The project in Vietnam was less technology focused, and sought to understand the causes of poverty and the needs, resources and capacity of poor people, using rapid and participatory rural appraisal techniques. Existing marine cage culture technologies were then compared with a range of possible alternatives in terms of their suitability for poverty alleviation.

Chinabut (2002) repoted that tilapia is one of the most economically important species of cultured fish and is more resistant to disease than many other species. However, when raised in intensive culture systems, tilapia suffer from increased parasitic and other infectious disease problems. Recently, cage culture of red tilapia (*Oreochromis niloticus*) in small reservoirs and sandpits throughout Thailand has increased, with the normal culture period being four months. A severe isopod infestation of tilapia in these cage-culture systems in central Thailand was recorded between June 1998 and January 1999. The mortality rate was 50-100% within 2-7 d after initial infestation. Trichlorfon at a concentration of 0.5-0.75 ppm for 24 hr is being recommended for pond treatment. However, chemical treatment for cage culture is not practical. Therefore, biological control may be the method of choice for prevention. Since the immature form of the isopod is planktonic, stocking more plankton-feeding species or cleaner-fish into the reservoir is recommended. Economic losses due to isopod infestation based on 50-100% mortalities were estimated at between US$234-468/cage.

Hemre *et al.* (2002) reported that the utilization of dietary carbohydrates and their effects on fish metabolism are reviewed. Details on how dietary carbohydrates affect growth, feed utilization and deposition of nutrients are discussed. Variations in plasma glucose concentrations emphasizing results from glucose tolerance tests, and the impact of adaptation diets are interpreted in the context of secondary carbohydrate metabolism. Our focus then shifts to selected aspects of hormonal regulation of carbohydrate metabolism and dietary carbohydrates and their variable effects on glycogen and glucose turnover. We analyze the interaction of carbohydrates with other nutrients, especially protein and protein sparing, and de novo synthesis of lipids, and finish by discussing the correlation of dietary carbohydrates with fish health.

McAndrew (2002) reported that the CARE-CAGES Project (Cage Aquaculture for Greater Economic Security) was initiated in Bangladesh in September 1995, began cage-aquaculture activities in 1996, and were worked with approximately 4,200 households, through 45 partner non-governmental organisations (NGOs). Species farmed by cage farmers in the project in 1998 were *Oreochromis niloticus*, *Barbodes gonionotus*, *Ctenopharyngodon idellus*, *Pangasius hypophthalmus*, and *Hypophthalmichthys molitrix*. The only pathogens that had been observed in caged fish are the parasitic isopod *Alitropus typus* (Milne-Edwards, 1840), and epizootic ulcerative syndrome (EUS). EUS effects mostly Java barb (*Barbodes gonionotus*) during the winter season, resulting in chronic low level mortalities. Although found sporadically in other sites, *A. typus* only significantly effects cage-farming operations in one river in the Jessore region. It was suspected that the large amount of aquatic vegetation present in this river is a pre-requisite for large parasite numbers. He also observed that this parasite made cage culture impossible due to 100% fish mortalities in late spring. When the monsoon begins, parasite numbers reduce, and with lower numbers, there is milder damage and no mortalities. Other pathogens may be present, however, due to lack of appropriate resources, these have not been observed. Fish health concerns for CARE-CAGES largely relate to providing quality fingerlings and feeds, good site selection and cage management. A breakdown of mortalities for the CARE-CAGES project for 1998 and 1999 is provided, and key issues relating to fish health highlighted. Total losses of stocked fish were reduced from 36% in 1998 to 22% in 1999. All categories (stocking mortalities, mortalities during culture, escapees, poaching and other) were reduced, and this is due principally to greater farmer experience in this new culture system.

According to Guo and Li (2003) in recent decades, net-cage aquaculture has become one of the main patterns of the intensive fish-culture in the lakes, reservoirs and even rivers in China. This aquaculture pattern results in enriching exogenous nutrients in water and, consequently, accelerates the process of lakes eutrophication. To ensure that normal environmental conditions and fisheries in a lake remain sustainable, qualitative estimations of nutrients in relation to ecosystem changes are essential. A study, mainly on nitrogen (N) and phosphorus (P) influences due to cage fish-culture was carried out in a shallow 35.5 ha bay in Niushanhu Lake, a shallow lake located in middle Yangtze Basin, during the period from March to December 2000. Net-cages in total covered an area of 1000 m^2 and the annual fish yield was 16.0 metric tons (MT). Fish feeding residue entering the water during the period was equivalent to 1532.9 kg of total N and 339.2 kg of total P. Sampling and analyses of the total N and total P concentrations, diversity and biomass of plankton and Chl-a were made monthly, while data on zoobenthos were collected twice, respectively, at the beginning and the end of the study. Results showed that the Chl-a content in water was correlated negatively to distance from the cage. The Chl a content that is converted into wet biomass of phytoplankton may be expressed by the regression: B = 2.673 - 0.0016D (B, biomass in mg/l; D, distance in km; r = 0.9362; n = 7). The biomass of rotifers inside or near the cages was higher than that in areas more distant, while that of the cladocerans was the opposite. No significant difference of copepod density or biomass was detected between cages and open water. Changes of zoobenthic community were remarkable. At the beginning of fish farming, there were nine zoobenthic taxa inside and 13 outside the cages. Only two saprophilous taxa, chiefly oligochaetes, were present in the cages at the end of the culture. Density and biomass of benthic animals decreased as well. Several bioindices, such as Shannon-Wiener index, Simpson index, and Margelef index, also exhibited a declining tendency. Through this study, the authors are of the opinion that mass-input of exogenous nutrients may cause negative effects on water quality in areas from the cage to a distance of 50 m outwards.

Huchette and Beveridge (2003) carried out a 3-month study (March–June) in the Meghna–Gumti River (Bangladesh) to assess the potential for periphyton-based cage aquaculture. The growth of genetically improved farmed tilapia (GIFT) strain (*Oreochromis niloticus*) was monitored during a trial conducted in nine 2.5-m^3 floating cages. The importance of periphyton in tilapia diets was assessed using three treatments. In the first treatment, the periphyton biomass was increased using additional substrates placed in the cage. In the second treatment, additional substrates were used and the diet was supplemented with a locally available compound feed. The third treatment had no additional substrate but received some supplementary feed. The effect of grazing on periphyton biomass was also assessed in a parallel experiment. Biomass was assessed by measuring ash, ash-free dry weight (AFDW), chlorophyll a, phaeopigments and respiration. Net production of fish ranged from 0.12 to 0.19 kg m^{-3} $month^{-1}$ and specific growth rate (SGR) from 0.7% to 0.95% body weight day^{-1}. Jaw abnormalities affected 33% of fish and reproduction was observed in fish as small as 35 g. Productivity of a 1 m^2 of net located in the uppermost 50 cm of the water column, however, was estimated at 0.94 g fish day^{-1}. The periphyton biomass dropped in just 2 days from 1.12 to 0.34 mg/ cm^2 after the introduction of the fish in the cage. The fish fed on plankton, artificial supplementary feed and periphyton growing on substrate in the cage. Filter feeding and grazing on the cage net appeared to be the most important source of energy. The effect of the additional substrates placed in the cages was marginal. The periphyton-based cage aquaculture described here was not economically viable and the main economic constraints were the costs of cage material (net and bamboo poles) and fry. Periphyton-based cage culture could be made more profitable by using local fish species, less expensive cage design, better substrate and by using adapted management techniques to improve periphyton productivity.

Kibria (2004) reported that the Oxbow Lakes Small - Scale Fishermen Project (OLP-II) is a "Social Fisheries Project" based in Jessore that works in the surrounding five districts of southwestern Bangladesh. The project aims to alleviate poverty of the poorest users of the oxbow lakes through institutionalized fisheries management by the target group themselves. This project was implemented by the Department of Fisheries (DoF) through a government loan from The International Fund for Agriculture Development (IFAD) and the UN World Food Programme (WFP). The Danish International Development Agency (DANIDA) funded a Technical Assistance Team (DTA) that assisted the Project Implementation Unit (PIU) of the DoF and the NGO BRAC (Bangladesh Rural Advancement Committee) implemented the project. Oxbow lakes (local name: baors) are semi-closed inland water bodies that are situated in the southwestern part of Bangladesh. They were created when young meandering rivers grew old, straightened their course and leaving the erstwhile bend and deepest parts separated from the main flowing river course. The separated (lotic) bends have been converted into stagnant (lentic) water bodies apart from the river, looking like a horse-shoe or ox-yoke and, therefore, they are called oxbow lakes. Fish culture in ox-bow lakes is being done on the basis of natural productivity without extra energy input. Although overall production is satisfactory, recovery is still low compared to pond aquaculture. Cage culture is a new method of aquaculture in oxbow lakes. This type of fish culture practice has never done in oxbow lakes of Bangladesh before this study was launched. The study on which this article is based was conducted in Kannadah lake, which is situated in the Jessore district of Bangladesh. The study was designed to test the feasibility of cage culture by a demonstration trial that employed standardized construction material, feed, cage size and cage culture systems, including species selection and stocking density.

Al-Arabi *et al.* (2005) stated that the possible ecotoxicological effects of a paper and pulp mill effluent were investigated by measuring selected contaminants and biomarkers in caged Nile tilapia (*Oreochromis niloticus*) and sharptooth catfish (*Clarias gariepinus*) from the Karnaphuly River, Bangladesh. Fish were caged for 28 d at two upstream reference sites (2 and 4 km) and four downstream sites (3, 5, 8, and 12 km) from the effluent outlets. Organochlorine contaminants and bile biomarkers were bio-accumulated to higher levels at downstream polluted sites than at the reference sites, including hexachlorobenzene (HCB), hexachlorocyclohexane (HCH), polychlorinated biphenyls (PCBs) in liver, and chlorophenolic compounds like 2,4-dichlorophenol and 2,4,6-trichlorophenol in bile. Levels of glucose, protein, and aspartate aminotransferase were analyzed in plasma, whereas cytochrome P4501A (CYP1A) levels were determined in S-12 supernatants of liver. The results, including CYP1A induction and bile biomarkers, clearly indicated that, in addition to the paper and pulp mill effluents, the downstream sites appear to receive other inputs of contaminants. This field assessment in a Bangladeshi river demonstrates biomarker measurements in caged fish as a promising approach for evaluating accumulation and effects of industrial effluents in fish of developing countries.

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 *Oreochromis niloticus* (L.) 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.

Vista *et al.* (2006) reported that stakeholders of the Taal Lake fish cage industry face the challenge of producing fish in a situation of frequent fish kill occurrences, attributed to the deteriorating water quality owing to nutrient pollution from fish cages. This study explored the nature of the fish cage production in Taal Lake and the interdependencies of cage production inputs and output with nutrient enrichment in cage areas. Fifty operators in the municipalities of Agoncillo, Laurel, San Nicholas and Talisay were surveyed, and the production data elicited were used in estimating a Cobb-Douglas production function. Results showed that ownership arrangement (i.e., owner as operator) and location (i.e., Laurel) were inversely related to tilapia yield. Marginal analysis revealed that operators were over-utilizing stocking density relative to feeding ration. The marginal productivity of feeding ration and stocking density were less than the price ratios of inputs. In this regard, increasing these inputs is discouraged. Decreasing the intensity of cage production activities is recommended, specifically for the town of Laurel. With the current fish cage production technology and institutional setup, nutrient pollution is inevitable.

Gomes *et al.* (2006) studied on cage culture of tambaqui (*Colossoma macropomum*) in a central Amazon floodplain lake. Tambaqui, *Colossoma macropomum*, a native fish species of the Amazon basin, has been tested in cages placed in floodplain lakes with promising results. The present study evaluated culture performance and economic feasibility of tambaqui raised at different stocking densities in cages placed in a central Amazon floodplain lake. Fish were stocked in triplicate 6-m^3 cages at 20, 30, 40 and 50 fish/m^3. Fish were fed a 34% crude protein (CP) extruded feed six days a week during the first two months and a 28% CP extruded feed for six months. The experiment lasted for 240 days. Mean survival rates were over 97% and were not significantly affected by fish density. Tambaqui growth rate and weight gain were not affected by the tested densities. Fish growth rate did not decline during the culture period, indicating that fish carrying capacity per cage was not reached. Fish hematological parameters, as well as, glucose, cortisol and ions did not show significant differences among the four tested densities. Fish raised at 40 and 50 fish/m^3 had significantly lower feed conversion ratio (FCR) than fish stocked at 20 or 30 fish/m3. FCR presented an inverse relationship to stocking density, with lower FCR at higher densities. Economic sensitivity analysis showed that economic performance of tambaqui raised in cages is more sensitive to sale price then to feed cost. To increase fish yield/m^3, higher stocking densities should be tested.

Rahman *et al.* (2006) made a study on cage culture of sutchi catfish, *Pangasius sutchi* (Fowler 1937): effects of stocking density on growth, survival, yield and farm profitability. The sutchi cat fish was grown at10 stocking densities in cages suspended in a river-fed channel during the summer of 2000. Cat fish fingerlings (mean length (9.1-9.7) cm and mean weight (5.9-6.7) gm were stocked at densities of 60, 70, 80, 90, 100, 110, 120, 130, 140 and 150 fish m^{-3}. After 150 days, growth and yield parameters were studied and a simple economic analysis was carried out to calculate profitability. The mean gross yield ranged from 15.6 ± 0.27 to 34.5 ± 0.44 kgm^{-3} and the net yield ranged from15.2 ± 0.22 to 33.5 ± 0.36 kgm^{-3} and showed significant variations ($P < 0.05$). The Mean weights of fish at harvest were inversely related to stocking density. Both gross and net yields were significantly different and were directly influenced by stocking density but the specific growth rate, survival rate and feed conversion rate were unaffected. Higher stocking density resulted in higher yield per unit of production cost and lower cost per unit of yield. The net revenue increased positively with increasing stocking density. A density of 150 fish m^{-3} produced the best production and farm economics among the densities tested in this experiment.

Munguti (2007) conducted the study to identify sustainable alternative protein sources using locally available feedstuffs for Nile tilapia *(Oreochromis niloticus* L) production in three eco-regions in Kenya. The first step was geared towards identifying feedstuffs which were locally available and which were not used as human food to avoid direct competition between fish and human food. Based on their availability, content of protein and fibre and the feasibility of removal of anti-nutritional factors, hydrolysed feather meal, boiled tea leave residues, leaves of *Ipomoea batatas, Manihot esculenta* and *Papaya carica* were identified as most promising potential non-conventional feedstuffs. In step two of the study diets for *O. niloticus* were formulated using hydrolysed feathers as animal protein source. Five isonitrogenous (250g kg^{-1})

and isocaloric (2,940 kcal kg^{-1}) diets were prepared by substituting freshwater shrimp meal (FSM) *(Caridina nilotica)* with hydrolysed feather meal (HFM) at rates of 0, 25, 50, 75 & 100% and fed to fish in aquaria; diets at substitution levels 0, 50 and 100% were also fed to fish in cages. Fingerlings averaging 26 and 36g were cultured in indoor aquaria with re-circulating water, and in cages that were installed in an 800 m^2 fertilized earthen pond, respectively. All fish were fed at 10% body weight day^{-1} in three replicates for 84 days. Results indicated that substitution of FSM at HFM levels above 50% in aquaria led to significant growth reductions. However, substitution at 100% with HFM did not significantly affect growth of fish in the cages. In both experiments, survival was similar among treatments, but protein digestibility decreased with increasing levels of HFM in the diet. In conclusion, 100% substitution of FSM with HFM may be possible in semi-intensive culture of *O. niloticus,* where natural food is available. Both in cage and aquaria setup, the 50% diet gave the best performance overall and therefore the highest potential for *O. niloticus* production. Step three was based on the results of the second experiment; in this set up the 50% diet as given above was used as a control diet. The aim was to improve the nutritive value and digestibility of feather meal by use of *papaya carica* leaves, which contain proteases of the papain superfamily and bleomycin hydrolases, which potentially improves protein digestion. To evaluate this hypothesis, a study was conducted to analyse the effects of different levels of hydrolysed feather meal and pawpaw *(Papaya carica)* leaves (PLM) on growth, digestibility and survival rate of *O. niloticus* under laboratory aquarium and cage cum-pond culture conditions. Fingerlings averaging 22 and 30g were cultured indoor in aquaria with re-circulating water, and in cages that were installed in a fertilized earthen pond of 800 m^2, respectively. Five isonitrogenous (250g CP kg^{-1}) and isocaloric (2,940 kcal kg^{-1}) diets were formulated using different levels of wheat bran and carboxyl methyl cellulose for balancing CP and energy contents: three diets contained 6 % of freshwater shrimp meal (FSM) and 4.5 % HFM (control), supplemented either with papain (treatment 2) or 4.5 % PLM (treatment 3). In two diets FSM was completely substituted by 8.6 % HFM plus papain (treatment 4) or 8.6 % HFM plus 8.6 % PLM (treatment 5). All fish were fed at 10% body weight day"1 in three replicates for 58 days. Results indicated that in aquaria dietary levels of HFM and PLM above 4.5% each led to significant ($P<0.05$) growth reductions. However, substituting FSM with HFM at 8.6 % did not significantly ($P>0.05$) affect growth of fish in the cages. In both experiments, survival was similar among treatments, but protein digestibility decreased with increasing levels of HFM in the diet. In conclusion, a combination of the protein sources FSM, HFM and PLM tends to give the highest growth performance in both aquaria and cages. Locally available non-convectional feedstuffs can sustainably be utilized in *O. niloticus* production.

Silva *et al.* (2007) studied on the effect of feeding rate and frequency on tambaqui (*Colossoma macropomum*) growth, production and feeding costs during the first growth phase in cages. They reported that feeding costs contributes up to 60% of the variable costs of cage culture systems. Therefore the objective of their study was to establish an optimal feeding frequency and feeding rate for rearing tambaqui in cages during the first growth phase. A factorial experiment was carried out in twelve 1 m^3 fish cages, with two feeding rates (5 and 10% body weight per day—BW/day) and two feeding frequencies (2 and 3 meals/day), over a period of 45 days. At the end of the experiment 20% of fish from each cage were sampled for length and weight measurements. Survival, feed conversion ratio, weight gain, final biomass and feeding costs were calculated. Fish that received 10% BW/day divided in 3 meals/day, presented higher growth rates in weight, length and specific growth rate, when compared to fish fed with other treatments. Fish fed 5% BW/day divided in 3 meals/day presented a lower growth rate. Production parameters evaluated also showed a better performance with fish that received 10% BW/day divided in 3 meals/day. Total cost of feeding was higher for those who received 10% BW/day divided in 3 meals/day, however, the cost of unit produced was similar to other tested treatments. This suggests that the best feeding strategy for tambaqui during the first growth phase in cages is 10% BW/day divided in 3 meals/day.

Gibtan *et al*. (2008) conducted a research to investigate the effect of stocking density on the growth performance and yield of *Oreochromis niloticus* in cage culture in Lake Kuriftu. The treatments had stocking densities of 50 (50F), 100 (100F), 150 (150F), and 200 (200F) fish per m^{-3}. All treatments were in duplicate. Juveniles with an average weight of 45. 76±0.25 g was stocked in the treatments. The fish were fed a composite mixture of mill sweeping, cotton seed, and Bora food complex at 2% of their body weight twice per day using feeding trays for 150 days in powdered form. The growth performance of *O. niloticus* was density dependent. The final mean weight of *O. niloticus* ranged 147.76±0.28–219.71±1.42 g and the mean daily weight gain was 0.69±0.01–1.15±0.02 g day^{-1}. Fish held in cages with lower density were heavier than the ones held at higher densities, and showed higher weight gain and daily weight gain. The most effective stocking density, in terms of growth parameters, was 50 fish m^{-3}. The gross yield (4.5–20.55 kg $cage^{-1}$) showed a significant difference with increasing stocking density ($P<0.05$). Moreover, the apparent food conversion ratio (2.48–7.22) was significantly affected by stocking density ($P<0.05$). However, survival rate was not affected by stocking density ($P>0.05$). It can be concluded that the most effective stocking densities were at 50 fish m^{-3} cage for larger size fish demand in a short period and 200 fish m^{-3} for higher gross production with supplementary feed.

Guimaraes *et al.* (2008) studied on apparent amino acid availability coefficients and protein digestibility of four animal products [fish meal (FM), meat and bone meal (MBM), poultry by-product and feather meal] and four plant protein-rich products [soybean meal (SBM), cottonseed meal-28, cottonseed meal-38 and corn gluten meal (CGM)] were determined for Nile tilapia, *Oreochromis niloticus*. Ingredients were incorporated to a practical reference diet at a 7:3 ratio (70% of reference diet and 30% of test ingredient). Chromic oxide was used as external digestibility marker. Among animal products poultry by-product meal (PBM; 89.7%) and FM (88.6%) presented the highest apparent protein digestibility (APD) while MBM (78.4%) and feather meal (78.5%) presented the lowest APD. Among plant protein-rich products CGM (91.4%) and SBM (92.4%) presented the highest APD values while cottonseed meal-28 presented the lowest APD (78.6%). Average apparent amino acid availability of feed ingredients was similar to protein digestibility with 92.3%, 89.6%, 73.4%, 80.7%, 88.9%, 84.4%, 91.2% and 79.7% values for SBM, CGM, cottonseed meal-28 and 38, FM, MBM, PBM and feather meal respectively. These results indicate that *O. niloticus* is able to utilize efficiently different feedstuffs.

Khatun (2008) studied on explores the livelihood approach of beneficiaries adopted to small scale aquaculture in the selected area of Bangladesh. Serveral visits were made in different rural communities of Bangladesh in August to Octover 2004. On the basis of some criteria it was found that Matlab was the most suitable for small scale cage culture. Selection of villages was made by analysis resources and livelihoods assessment of Matlab area. Six villages Rarikandi, Balurchar, Balurcher Palalokdi, Panchani and Gajra were selected by considering some positive criteria. All villages are within the Meghna-Dhonagoda irrigation system. Households information was collected through communities various PRA tools. From the study it was evident that livelihoods means of rural people at Matlab Upazila are diverse, with households relying on a combination of activities and relationships (from the natural resource base or other) to secure their well-being. Most of the people of the studied villages were engaged in agriculture activities except village Gajra where community was Hindu and were involved mostly on fishing. From the time line analysis it was found that natural fish production is decreasing and the aquaculture practice is blooming in the Matlab area due to simple water supply of embankment by the irrigation project. From the resource mapping it was found that the irrigation canal also led to the development of agriculture expansion. Most ponds were located in village Rarikandi followed by Palalokdi, Panchani and Gajra. The ponds soils are clay-loam type which indicates water retention capacity of these areas as well as good opportunities for fish culture. Some problems were identified from these villages which are heavy rain and excessive use of pesticides. From the wealth ranking analysis Rarikandi is the wealthier than other villages. Gajra is the less wealthy and Balurchar is poorest of all. The livelihoods strategies of six villages are almost similar, as in large they share a common social norm. Assets, household livelihood strategies were analyzed into two well-being groups such as rich and middle class, poor and poorest class. The primary livelihood stategies of poor households in the six villages including share-cropping, daily labour, fishing and vegetable cultivation. To introduce new aquaculture technology such as cage culture at six villages of Matlab Upazila, twenty women and nine ponds were selected. The ponds were very near to their house and they had no privious idea on cage culture technology. A fish technology initiative package was developed and disseminated to them in 2005. Some physical parameters of the ponds were recorded before stocking and after stocking. The pond water where cages installed pH level was 6.5 to 8.5 within the recommended level. Air temperature at the site of all nine ponds was almost uniform and decreasing from October. They were given two days training, monosex nile tilapia's fries (*Oreochromis niloticus*), cages materials and fish food for first month. The women used 1 cubic meter cages and 250 fries were stocked in each cage. The culturists were taught to prepare fish feed, consisting of hand-made dough containing rice bran (30%), mustard oil cake (20%), molasses (10%), kitchen wastes (20%) and fish meal or dry fish powder (20%). This supplemental feed was presented 2 to 3 times at a total rate of 5% of the body. Very low mortality (5-10%) was observed, mostly within the first 7 days of stocking. Monthly monitoring was done. The average harvesting weight of first was 202.21 g/fish in the first culture cycle and 212.04 g/fish in second culture cycle for a period were 150 days. The SGR were 2.86 in the first cycle and 2.80 in the second cycle. The food conversion for two cycles was 1.89 and 1.80 respectively. The cost analysis showed that in the first cycle cost for a cage culture was Tk 1320 and in the second cycle was Tk 975. This is due to the cage cost as excluded in the second cycle. It was found from the two cycles that feeding cost 41.29% and 61.54% respectively. Feed costs for tilapia were very low because women were used kitchen wastes and spinaches around the pond as tilapia's food. A survey was conducted on the impact of cage culture technology from May to December 2006 after completion of the first cycle towards the second cycle. The level of acceptance showed that the twenty women beneficiaries from the first cycle, one new beneficiary was added towards the second cycle. The result also showed that contribution of cage culture to overall family income is not significant but created opportunities of social interactions that enhanced harmony among the communities. From the research finding it is concluded that monosex tilapia culture in small scale cages is a low risk activity for resource poor women groups in a community. This species has a strong market demand and value, thus a small scale cage culture seems to be a favorable livelihood option for rural women of wetland based area. Alternate uses of cages are evident for value addition to the farmers. Small scale cages could be used for fish seed production, shrimp fry rearing, fish fattening, supplies of live fish to the elite customer may be considered for future enhancement. For this, local initiatives, innovative farmers, fish seed supply and financial support to the cage culture initiative by the agencies should be provided.

Abimorad *et al.* (2009) conducted a study to evaluate the effect of dietary supplementation of lysine and/or methionine on growth performance, nitrogen retention and excretion in pacu juveniles reared in cages. Five diets were prepared; four diets based on plant ingredients containing 23% digestible protein (DP), basal: Lys- and Met-deficient, 23L: basal supplemented with lysine only, 23M: basal supplemented with methionine only, and 23LM: basal supplemented with both amino acids and a protein-bound AAs diet based on fish and soybean meal, containing 30% DP. Survival, specific growth rate, protein efficiency rate and feeding cost were not influenced by the dietary treatments (PN0.05). Fish fed basal diet showed the lowest mean of N retention. Fish fed 30DP diet showed the best results of weight gain (WG) and apparent food conversion rate (FCR) among the dietary treatments. On the other hand, WG in the 23LM group and FCR in the 23LM and 23M groups were not significantly different from the group fed 30DP diet, and showed the highest mean of N retention. There was higher N excretion

(Pb0.05) when the fish were fed 30DP and 23L diets than the other dietary treatments. Fish fed plant protein-based diets containing 23% DP supplemented with both amino acids or methionine alone showed satisfactory growth and N retention results when compared with fish fed 30DP diet, with the advantage of lower N emissions into water. The results also evidence the pacu's great potential to be reared in cages.

Chakraborty and Banerjee (2009) studied on culture of monosex nile tilapia under different traditional and non-traditional methods in india. They reported that little is known about the growth performance of sex-reversed, all male *Oreochromis niloticus* under different traditional and non-traditional culture methods practiced in India. In this study, 17- methyl testosterone treated monosex tilapia was cultured in concrete tank, flow-through system, cage, pen and earthen pond. Similar feeding regime and stocking density of fish were maintained for all the culture systems. Different growth parameters like body weight, length, depth, daily weight gain (DWG), specific growth rate (SGR) and proximate body composition were analyzed at the end of the four month culture period. It was found that culture in earthen ponds yielded the highest weight, length, depth, DWG, SGR and protein content compared to other four culture methods. On the other hand, culture in concrete tanks showed the lowest growth among all culture methods. There was no significant difference in fish yield for flow-through, cage and pen culture systems. Additional availability of energy-rich natural food materials and uniform water flow in ponds may attribute to such trend in growth pattern of the fish among the culture systems. Thus, culture of androgen treated monosex tilapia in earthen ponds can be regarded as the ideal method for socio-economically sustainable augmented fish production in India.

Cuvin-Aralar *et al.* (2009) conducted a study on cage culture of the Pacific white shrimp *Litopenaeus vannamei* (Boone, 1931) at different stocking densities in a shallow eutrophic lake. Postlarvae of *Litopenaeus vannamei* were acclimated and stocked in lake-based cages at the following stocking densities: 10, 20, 30 and 40 shrimp m^{-2}. Another set of shrimp was stocked in concrete tanks as reference samples at 30 shrimp m^{-2}. Significant differences were observed among stocking densities throughout the 95-day culture. The final weight at harvest decreased with increasing stocking density: mean weights of 23.3, 15.8, 13.0, 10.9 and 14.6 g for the 10, 20, 30, 40 shrimp m^{-2} and reference tanks were observed respectively. There were no significant differences in survival throughout the culture period, ranging between 69% and 77%. Daily growth rates (range: 0.11-0.24 g day^{-1}) and specific growth rates (range: 3.54-4.34%) also differed significantly among stocking densities, both increasing with decreasing stocking density. The feed conversion ratio in the cages did not differ among the stocking densities, ranging from 1.53 to 1.65. The relationship between stocking density and mean individual weight at harvest followed the equation $y= 581.06x^{-0.54}$ (R^{-2}=50.938) and that of stocking density and production (in gm^{-2}) is $y=558.01x^{-0.46}$ ($R^2 = 0.834$).

Osofero *et al.* (2009) carried out the study to evaluate the effect of varying stocking densities on the growth, survival, and yield of tilapia (*Oreochromis niloticus*) at the freshwater reservoir (average depth, 1.7 m) of the University of Agriculture Abeokuta, Nigeria, for a period of 3 months. Tilapia juvenile with a mean weight of 29 ± 4.81 g were randomly (Complete Randomized Design) stocked at 50, 100, 150 and 200 specimen per cage (1 m3) were fed with commercial feed (34.55% Crude Protein). 20% of stocked fish was sampled for growth fortnightly. Profit index of the fish harvested under each treatment was evaluated. Relevant physico-chemical parameters like pH, conductivity, temperature, water depth and dissolved oxygen were also monitored forth nightly. The experimental fish and fish carcass (before the experiment and at harvest) from each treatment were analyzed in replicates for their proximate composition. There were no significant differences ($P > 0.05$) in daily weight gain, specific growth rate, final weight, relative growth rate, feed conversion ratio (FCR), survival, and protein efficiency ratio for all the treatments. However there were significant differences ($P < 0.05$) in fish production (harvest), profit index, crude protein, crude fat, and ash composition of the fish carcass (at harvest). As stocking density increased, the crude protein content of the fish carcass decreased indicating an inverse relationship. 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 considered best on the basis of the profit index of 2.01 compared with the range of 1.45 to 1.82 for the other three treatments.

Zhou *et al.* (2009) conducted a study on the effects of dietary potassium diformate (KDF) on growth performance, feed conversion and intestinal bacterial community of hybrid tilapia (*Oreochromis niloticus* ♀×*O. aureus* ♂).The aim of the study was to investigate the effect of dietary inclusion of potassium diformate (KDF), a possible non-antibiotic growth promoter, and two widely-used antibiotics, flavomycin and quinocetone, on growth performance, feed conversion ratio and gut microbiota of hybrid tilapia. An 8 week feeding trial was conducted with five levels of KDF: 0 (C), 3.0 (KDF3), 6.0 (KDF6), 9.0 (KDF9), and 12.0 (KDF12) g kg^{-1} diet and three antibiotic treatments: flavomycin (8 mg kg^{-1}, AF), quinocetone (100 mg kg^{-1}, AQ), and flavomycin (4 mg kg^{-1}) +quinocetone (50 mg kg^{-1}) (AFQ). At the end of the experiment, fish were starved for one day and bulk weighed. Pooled gut contents sampled from four replicate tanks were analyzed for bacterial community by 16 S rDNA PCR, denaturing gradient gel electrophoresis (DGGE) and Bio-1D++ software. The results indicate that the addition of dietary KDF and antibiotics had no significant effect on tilapia growth performance, feed conversion ratio or survival compared to the control group. Among the experimental groups, however, fish fed the KDF3 and KDF6 diets showed improved growth performance and feed conversion ratio with higher final body weight and specific growth rate and lower feed conversion ratio compared to those fed the AFQ diet. Dietary KDF and antibiotics showed effects on the gut microbiota. Dietary KDF3 and KDF6 improved the relative richness of some intestinal allochthonous bacteria such as *Mycobacterium* sp. partial MHSD12-like, *Mycobacterium* peregrinum-like, *Pseudomonas* sp. HMPB4-like and six uncultured bacterium like species. However, alpha *Proteobacterium* IMCC1702-like, *Rhodococcus* sp. P14-like, and three uncultured bacterium-like species were depressed in the gut. Based on these results, the possible beneficial effects of KDF on gut bacteria will be discussed.

Ahmed *et al.* (2010) was carried out a study to elucidate the distribution and occurrence of different parameters of water quality of the greater Comilla region- Comilla, Brahmanbaria and Chandpur districts', freshwater resources of Bangladesh. To study the different physicochemical parameters, surface water samples from the Meghna, Gumti, Titas, Hoara and Dakatia Rivers and groundwater samples from almost every Upazilas were collected and analyzed. Water samples from the freshwater resources were collected from different points and at different seasons for continuous monitoring during the hydrological years 2008-2009. Collected samples were analyzed for the following parameters: pH, EC, TDS, TSS, TS, DO, transparency, acidity, dissolved carbon dioxide, total alkalinity, total hardness, chloride, ammonia-N, sulphate-S, o-phosphate-P, BOD, COD, nitrate-N, nitrite-N, total nitrite and nitrate-N, arsenic, iron, manganese, copper, nickel, chromium, cadmium, lead, calcium, magnesium, sodium and potassium using the procedure outlined in the standard methods. Arsenic was analysed for groundwater and Coli form only for surface water samples. Results of water quality assessment identified the problem areas in respect of arsenic. The results also provided data to understand and quantify the threat of the impact of climate change on freshwater resources of this region. The results also provided data for water quality of surface and groundwater resources of Comilla region to match national and international standards for drinking, agricultural, industrial and livestock requirements**.**

Alam (2010) conducted an experiment to study the cage culture of tilpia *Oreochromis niloticus* in the Brahmaputra River and observation of their growth performance at different densities in the Brahmaputra River at Taltola, Khagdohor, in Mymensingh Sadar. Five stock densities (50, 100, 150, 200 and 250 fish/m^3) of different initial body weights (30, 1.4, 3.0, 3.95 and 9 g) were used with two replicates each. The fishes were supplied with commercial feed with high protein (30%). Feed was supplied at the rate of 10% of the body weight of stocked fishes two times daily. During the experimental period, the ranges of water temperature (20-30°C), transparency (4-6 feet), dissolved oxygen (10-13 ppm), pH (7-8), phosphate (1-2 ppm), ammonia (0) and nitrate nitrogen (0) found were within the productive limit and more or less similar in all the cages. The weight gain obtained from the different stocking densities 50, 100, 150, 200 and 250 fishes/m^3 were 185g, 48,6g, 87.5g, 76.55g and 94g respectively. The specific growth rates (SGR) were 0.634, 1.150, 1.096, 0.970 and 0.784 in the density 50, 100, 150, 200 and 250 fishes/m^3 respectively. On the other hand, total production (g/m^3) was 9250, 4860, 13125, 15310 and 23500 g in the densities 50, 100, 150, 200 and 250 fishes/m^3 respectively. According to ‘t’ test between net fish productions under different densities it is found that net productions of tilapia were not significantly different and higher fish density (250 fishes/m^3) affect the fish growth and production than that of lower fish density (50, 100, 150 and 200 fishes/m^3). Stocking density did not significantly influence live weight gain, specific growth rate (SGR % day). The initial weight has influenced live weight gain and specific growth rate (SGR % day). From the experiment it is found that higher stocking densities (250 fishes/m^3) results in higher production rate (23500 g/m^3) with higher mean initial weight.

Biswas *et al* (2010) conducted an experiment in brackish water environment to determine the optimal feeding frequency for growth, effective feed conversion, survival, shooters emergence and size variation in Asian seabass fry reared in the net cages. Four feeding frequencies of one

(T_1), two (T_2), three (T_3) and four (T_4) times a day were evaluated as treatments in triplicate for a period of 5 weeks. Hatchery produced weaned sea bass fry (25.9±0.3 mm/203.8±4.6 mg size) stocked at 120 numbers per cage were fed with a commercial marine fish larval diet containing 55% crude protein at 10% of the biomass daily for the first 3 weeks, followed by 8% for the remaining 2 weeks. Although the highest growth was recorded in T_3, the final length (45.9±0.3 mm) and weight (1203.8±4.6 mg) did not differ significantly (PN0.05) from that of T_4. Whereas, fish with one or two times feeding exhibited significantly lower growth (Pb0.05). Daily weight gain, percentage weight gain and specific growth rate were significantly higher in T3 (Pb0.05), while there was no significant variation (PN0.05) between T_3 and T_4. Significantly higher survival of 75.89±4.17% was recorded in T_3 than those of one and two times fed fish (Pb0.05). The fish in T_3 had significantly improved feed conversion ratio (Pb0.05). No significant differences were recorded among treatments for the cumulative number of shooters separated and coefficient of variation in the harvest weight, which were ranging from 9.67 to 12.00 and 0.113 to 0.124, respectively. This study infers that the Asian sea bass fry can achieve maximum growth, survival and better feed conversion when they are fed a given ration with three times feeding daily in brackish water net cage rearing. The findings also have practical significance towards establishing Asian sea bass seed rearing package and will directly benefit the nursery operators.

Chakraborty and Banerjee (2010a) reported that cage culture is one of the important methods for intensive culture of tilapia in large water impoundments. But, information related to growth performance of androgen-treated monosex tilapia population during cage culture under the ecological conditions of India is limited. The aim of this study was to compare the growth potential of control, mixed-sex and androgen-treated, monosex tilapia in confined environment of cages. Control and hormone treated fish were stocked separately in mesh cages at a density of 50 fry / m3 and it was found that the androgen treated monosex fish grew significantly larger than their control mixed-sex counterparts. The monosex population showed a significantly higher weight, length, depth, specific growth rate, daily weight gain, protein efficiency ratio and body protein content than the mixed-sex tilapia population. Thus, culture of hormone treated monosex tilapia in cages can be considered ideal for augmented production of the fish under Indian context.

Chakraborty and Banerjee (2010b) reported that stocking density is considered one of the important factors affecting fish growth. But, information related to impact of stocking density on growth performance of monosex tilapia population under the ecological conditions of Gangetic plains in West Bengal, India is limited. The aim of their study was to compare the growth potential of monosex tilapia at various stocking densities and to determine an ideal stocking density for culture of all-male monosex fish. The males were isolated by examination of genital papilla region and were stocked separately in 0.01 ha earthen ponds at different stocking densities (5000, 10000, 15000, 20000, 25000 and 30000 fingerlings/ha). They also found that the highest weight, length, daily weight gain, growth rate and protein content were observed for the 20000 fish/ha density class. Thus, culture of monosex tilapia at a density of 20000 fish/ha can be considered ideal for augmented production of the fish under Indian context.

Khatun *et al*. (2010) trial on tilapia, (*Oreochromis niloticus*) culture in low cost bamboo framed one cubic meter net cages was performed in six villages of Matlab Upzilla. Chandpur from July to November 2005. In total 20 poor women were selected through an NGO. They were provided with two days training on culture and management, cage materials, tilapia fries (250 per cages) and fish food for one month. The women used kitchen wastes and plant supplements as tilapia's food. After 120 days of stocking, the results showed that the final production of fishes in cages under two cycles varied from 64.9 kg to 142.93 kg. Considering the nine ponds in six villages the maximum production was observed in the pond at Gozra village (average production 47.64±0.32 kg) where three cages were installed followed by the pond at village Pachani (average production 42.52±0.50 kg) for two cages. The lowest production was found in two ponds at village Balurchar (18.2±0.59 kg). The production was significantly varied among cages (F=42.723, *Ps* 0.00) and as well as among villages (F=57.140. *Ps* 0.00). This was due to the variation of survival (F=10.989. *Ps* 0.00) and daily growth (F=28.259; *Ps* 0.00) of fish in cages. Pond size, management effort and public interest can differ village to village. These factors alone or collectively influence upon the specific growth rate, harvested fish number and production of fishes in cages. In small scale pond cage tilapia culture, the loss of production was due to the poor management practice by the owner. It is evident from the study that tilapia culture in cages is a suitable technology for an additional income source for rural women for the improvement of their livelihoods and household nutrition in these villages.

Ahmed *et al*. (2011) was carried out an extensive study to elucidate the distribution and occurrence of different physicochemical parameters of water quality of the greater Noakhali region- Noakhali, Lakshmipur and Feni districts, water resources, Bangladesh. Temperature, transparency, pH, EC, TDS, TSS, DO, BOD, COD, acidity, total alkalinity, total hardness, nitrite-N, nitrate-N, o-phosphate-P, sulphate-S, chloride, iron, manganese, zinc, copper, lead, cadmium, cobalt, nickel, arsenic and chromium were measured in surface and groundwater samples collected from different rivers and tube wells of this region.Water samples from the freshwater resources were collected from different points and at different seasons for continuous monitoring during the hydrological years 2008-2009. Average value of pH of the surface waters was found in the alkaline region. Lead, carbon dioxide, EC and TDS values were found higher for some surface water samples. Chloride content of the Meghna and Feni rivers exceeded the EPA limit. From the BOD value of these rivers it can be concluded that except the Meghna other rivers water is clean. For the groundwater samples, pH was found slightly acidic to alkaline and TDS of all the districts exceeded the BSTI acceptable limit. Higher values of chloride, total hardness, alkalinity and lead of some groundwater samples exceeded the BSTI limit. This region is more prone to arsenic and in concentration far above the BSTI permissible limit was detected in some samples. The results provided data to understand and quantify the threat of the impact of Climate change on freshwater resources of this region. The results also provided data for water quality of surface and groundwater resources of this region to match national and international standards for drinking, agricultural, industrial and livestock requirements. The assessment data can be used to help determine the efficacy of existing water quality policies and to help analysts determine the need for, and likely consequences of new policies. The assessment data can be supplied to the proper Govt. authority for making new national and regional policies and appropriate preventive measures can be taken prior further deterioration of water quality. The assessment will increase the awareness of the people of the risk and affected areas so that they could ready to face the disaster due to climate change.

Ali *et al*. (2011) stated that water quality production and economics of small scale cage aquaculture were studied for a period of four months from September, 2008 to December, 2008 at Mahananda river of Chapainawabganj district, Bangladesh under three different treatments of aquaculture species (T_1: prawn, *Macrobrachium rosenbergii*, T_2: tilapa, *Oreochromis niloticus* and T_3: sarpunti, *Barbodes gonionotus*), each with three replications. Mean water temperature (°C), transparency (cm), DO (mg L^{-1}), pH, CO_2 (mg L^{-1}), alkalinity (mg L^{-1}) and NH_3-N (mg L^{-1}) varied from 26.90±2.32 (T_1) to 27.02±2.32 (T_3), 33.63±8.72 (T_1) to 33.71±8.75 (T_3), 5.27±0.07 (T_2) to 5.39±0.08 (T_1), 7.10±0.09 (T_1) to 7.12±0.10 (T_2) and (T_3), 3.36±0.14 (T_2) to 3.47±0.14 (T_1), 74.07±1.43 (T_2) to 74.09±1.44 (T_3) and 0.29±0.07 (T_2) to 0.38±0.07 (T_1), respectively. Mean final weight (g), weight gain (g), SGR (%,bwd^{-1}), Survival rate (%) and yield (kg/1m^3cage/4 months) significantly, varied from 28.67±2.19 (T_1) to 68.67±1.86 (T_2), 5.82±0.61 (T_1) to 15.84±1.70 (T_2), 1.38±0.39 (T_1) to 2.16±0.85 (T_2), 82.50±3.82 (T_3) to 95.67±0.33 (T_2) and 4.87±0.08 (T_1) to 13.14±0.33 (T_2), respectively. The mean total cost (Tk./1m^3 cage/4months), net benefit (Tk./1m^3cage/4months) and CBR of prawn/fish significantly varied from 332.67±0.67 (T_3) to 1213.67±2.33 (T_1), 550.00±0.00 (T_3) to 1583.33±41.67 (T_2) and 0.90±0.07 (T_1) to 2.60±0.04 (T_2), respectively. Better performances in productions and economics with treatment T_2 indicates that tilapia can potentially be used for cage farming in river ecosystem. This study also recommends for study on the optimization of tilapia stocking density for cage farming in river.

Xie *et al.* (2011) undertaken a 21-days growth trial to investigate the effect of water temperature (25, 28, 31, 34, 37°C) on growth, feed utilization and energy budget of juvenile Nile tilapia (*Oreochromis niloticus*) (initial body weight around 12 g) with four replicates at each temperature. Feed intake energy (IE), recovered energy (RE), faecal energy (FE), excretory energy (UE + ZE) and heat energy (HE) were calculated to obtain the energy budget. The results showed that feeding rate and ammonia excretion were not significantly affected by water temperature. Specific growth rate in wet weight (SGRw) and FE was significantly lower in the fish reared at 37 °C while no significant difference was observed between the fish reared at 25–34 °C. Protein retention efficiency was highest at 28 °C and lowest at 37 °C. The proportion of IE channelled into RE and UE + ZE was lower while those lost in HE was higher in the fish reared at 37 °C. The optimal growth temperature was estimated as 30.1 °C based on the regression of SGR and water temperature. Energy budget at maximum growth (34 °C) was: 100 IE = 27.0 RE + 1.1 (ZE + UE) + 10.6 FE + 59.2 HE. HE accounted for 69.3% and RE for 30.7% of metabolizable energy.

Gupta *et al.* (2012) conducted a research on growth performance of tilapia fingerling in cage in ponds managed by *Adivasi* households: An assessment through length-weight relationship of cage reared GIFT strain of tilapia (*Oreochromis niloticus*) fingerling by using length-weight (LW) relationship technique. They also observed condition factor (K) of fish and pond water quality parameters. For LW relationship and K, a sample size of 120 fingerlings was made from randomly selected three different cages in a pond at Tarala village in Kaharole Upazila of Dinajpur District, Bangladesh. The length-weight relationship of tilapia fingerlings reared in cages managed by *Adivasi* people was significant. The value of correlation coefficient (r) and the coefficient of determination (r^2) were 0.97 and 0.94 respectively. They found the growth of tilapia from fry to fingerling was normal in cages. The condition factor of different size group of fish was almost closed to 2, indicating fish health as satisfactory. All the water quality parameters including temperature, transparency, dissolved oxygen, ammonia-nitrogen, phosphate-phosphorus, nitrate-nitrogen and pH were within suitable range both in cages and outside the cage in pond. They indicate the growth of tilapia fingerling in cages was satisfactory which was technically sound for landless *adivasi* households.

Kumar *et al.* (2012) observed 73 percent hatching rate of cage reared Nile Tilapia in Muhuri River of Bangladesh by maintaining water pH 7.8 and 7.6, Dissolve oxygen concentration (DO) 6, 6.8 and 7.1 mg/L, salinity 0.2 and 0.5‰, NO3 concentration 11 and 14 μg/L and water temperature 27oC and 26oC and stocking 268 gm (female) and 300 gm (male) in cage 1 and 208 gm (female) and 335 gm (male) in cage 2.

Mallasen *et al.* (2012) conducted a research to understand the influence of a net cage tilapia culture on the environment, water quality parameters were investigated during the period between December, 2005 and November, 2007. Three sampling stations were established in the reservoir of Nova Avanhandava (Zacarias, Sao Paulo State) as follows: upstream of net cage area (P1), in the rearing place (P2) and downstream of net cage area (P3). The mean values of the parameters examined in the water sampling stations were within the standards of water quality recommended by resolution no. 357/2005 of the Conselho Nacional do Meio Ambiente for class 2 freshwater bodies. A significantly higher mean concentration of total phosphorus ($p < 0.05$) in the P2 (0.035 mg L^{-1}) was the result of the uneaten feed and feces of fish. The average concentration of total phosphorus in P3 was lower (0.015 mg L^{-1}), which was assimilated by the aquatic ecosystem. The frequent monitoring of the water parameters is fundamental, so the producer can adjust the management according to environmental conditions, by reducing fish density or changing feeding rates for example, to mitigate or avoid water quality deterioration.

Yakubu *et al.* (2012) conducted a research on growth performance of Nile tilapia (*Oreochromis niloticus*) as affected by stocking density and feed types in water flow through system. They also reported that mixed-sex population of *Oreochromis niloticus* fingerlings were collected from a reputable farm and acclimatized for a week and randomly stocked at three densities of 300 fish m-3, 450 fish m 3 and 600 fish m-3 in twelve (12) circular fiber glass tanks, each with capacity of 3.08m3 of water at a nominal flow rate of 2L/min. Each stocking densities were fed with two types of feed {Multi feed (foreign), NIOMR feed (local)}. Each density/feed combination represents a treatment and each treatment replicated twice for statistical validation. Based on this present study, overall growth rate differed significantly among treatment ($P<0.05$) with low and intermediate stocking density treatments having higher growth than the high density treatment but with significant difference between the two different types of diet. On the other hand, the results of the experiment indicated that fish that were fed Multi feed diet had similar mean weight and percentage weight gain and grow significantly better ($P<0.05$) than those fed with NIOMR diet, although no significant difference was observed in specific growth rate between the NIOMR and Multi feed diet among all the treatments. In terms of the feed conversion ratio (FCR) between fish fed NIOMR feed and Multi feed, it was observed that the fish fed Multi feed had the best feed conversion ratio. Observations during this research indicated no record of spawning in any of the fiber tanks throughout the culture period of 24 weeks. Thus, it could be asserted that intensive tank culture of Nile tilapia in a flow-through system is a successful culture system in controlling excessive reproduction of *O. niloticus*. Overall results therefore recommended the suitability of NIOMR feed and Multi feed as a diet for *O. niloticus* fingerling.

Bhujel (2013) describes the on-farm feed management practices used in the culture of the Nile tilapia (*Oreochromis niloticus*) in Thailand. A survey was undertaken to establish the feed practices used in pond grow-out systems, river-based cage systems, and hatcheries. Pond culture is common in Thailand, especially in rural areas. Almost all of the subsistence tilapia farms employ polyculture systems whereas most of the commercial farms practice single species all-male tilapia culture. Silver barb (*Barbonymus gonionotus*), snakehead (*Channa spp.*), hybrid catfish (*Clarias gariepinus* x *C. macrocephalus*), common carp (*Cyprinus carpio*), and some Chinese and Indian major carps are among the species used for polyculture. Almost all the farmers fertilize their ponds with either chicken manure and/or chemical fertilizers to enhance the natural productivity of the culture systems. Feeding is undertaken on a supplementary basis. Although good quality aquafeeds are available in Thailand, their high prices and the low price attained for pond-grown fish make their use currently uneconomic. The cheapest feeds and feed by-products available are used to minimize production costs, thereby maximizing profits. Almost all the farmers surveyed employed hand feeding twice per day, and generally reported FCR values of less than 1:1. However, as the fish receive a considerable amount of nutrients from the natural productivity in the ponds, the true FCR values accruing to the supplementary feeds are difficult to establish. The feeds/ingredients that are used are not of a standard quality in terms of nutrient composition and moisture which further exacerbates the problems associated with establishing accurate FCR values. In recent years, cage farming in rivers and canals has become a popular culture option. Almost all the cage farmers practice monoculture, using varieties of red or black Nile tilapia. Although commercial pellets are used, the feeds are normally of a low quality with a low crude protein level (~20 percent). On average, cage farmers feed three times a day, and attain FCR of 1.4–1.8:1, and growth rates of 2–3 g/day.

Dasuki *et al*. (2013) reported that African Catfish (*Clarias gariepinus*, Teugels) were reared at three different stocking densities in bamboo-net cages to evaluate the effects of stocking density on growth, survival rate and food conversion ratio. Three hundred (300) fish with a total weight of 1.8Kg were stocked at 25, 50 and 75 fish/m^3 cage with a mean weight of 5.6±0.23g, 5.9±0.23g and 6.3±0.23 g/m^3 respectively. The growth trial lasted for 150 days (May 2009 to October 2009). Twenty percent (20%) of the total biomass of the fish in each cage was weighed monthly and the bulk weights were calculated. Mortalities were recorded monthly. The final mean weights (±S.E) of the fish stocked at densities of 25, 50 and 75 fish/m^3 cage were 828.0±1.83g, 774.0±20.18g and 693.0±34.20g. The corresponding mean values of Specific Growth Rate were 3.33, 3.25 and 3.43. Temperatures ranged between 24.5^{0}C - 32.6^{0}C while salinity ranged between 24 – 95 ppm. The Feed Conversion Ratio (FCR) was 4.99, 4.73, and 3.43, and cumulative survival rates were calculated as 99.84, 99.66 and 99.50% respectively. The results revealed that stocking density had a significant (P>0.05) effect on growth and survival rates of

Clarias gariepinus. Fish held at the highest stocking density exhibited the lowest growth and survival rate. Cages with 50fish/m^3 stocking density had the best production with total final weight (38.67Kg) and profit index (3.27) compared to other treatments (P>0.05).

Gan *et al*. (2013) investigated the effects of lysine and dissolved oxygen on grass carp, the grass carp were fed with 13, 15 and 17 g kg^{-1} lysine diet at about 6 mg L^{-1} (high dissolved oxygen, HO group) or 3.5 mg L^{-1} (low dissolved oxygen, LO group) dissolved oxygen level, for 8 weeks. The fish were fed to apparent satiation by hand. The results showed that apparent digestibility of protein, energy and dry matter were decreased significantly when grass carp were fed at 3.5 mg L^{-1} dissolved oxygen, and feed intake (FI) was also inhibited by low dissolved oxygen ($P < 0.05$). Weight gain, protein retention, protein efficiency, feed conversion ratio and amino acid retention of fish at 6 mg L^{-1} dissolved oxygen level were significantly improved at 3.5 mg L^{-1} dissolved oxygen level ($P < 0.05$). Weight gain, protein and amino acid retention, and feed efficiency of grass carp at the two dissolved oxygen levels were significantly improved by lysine supplementation ($P < 0.05$). The dietary lysine level and dissolved oxygen of water had an interaction effect on feed conversion ratios ($P < 0.05$). Grass carp fed at low dissolved oxygen level showed lower liver protein and fat contents. Plasma aspartate aminotransferase (AST) activity of grass carp fed at 3.5 mg L^{-1} dissolved oxygen level was significantly increased compared to 6 mg L^{-1} dissolved oxygen level ($P < 0.05$). Their result showed that low dissolved oxygen level of water is harmful to the liver of grass carp.

He *et al*. (2013) reported that dried distiller's grain (DDG) is considered as an alternative ingredient of dietary feed due to its high contents of protein, fibre and fat. In their study, 60g kg^{-1} of DDG was used to feed grass carp (*Ctenopharyngodon idella*), bluntnose black bream (*Megalobrama amblycephala*), gibel carp (*Carassius gibelio*) and black carp (*Mylopharyngodon piceus*) for 8 weeks, and its effect on fish production and gut allochthonous microbiota was investigated for the development of a suitable fish feed high in nutrients and low in cost for polyculture freshwater fish. DDG supplementation resulted in the less weight gain and higher feed conversion ratio of black carp ($P < 0.05$), but had no significant effects on other fish or parameters. PCR–denaturing gradient gel electrophoresis (DGGE) analysis indicated that all four fish species had some common and unique bacteria in their digestive tracts, and the gut microbiota of bluntnose black and gibel carp fed the control diet and DDG diets were very similar (Cs > 91%); of them, the total counts of intestinal bacteria studied by qPCR increased in grass carp ($P < 0.05$) and depressed in black carp ($P < 0.05$) when fed dietary DDG. Thus, we assumed that dietary DDG modulated production and gut microbiota of fish in a host-specific way.

Mensah and Attipoe (2013) studied on two commercial aquaculture feed diets available on the Ghanaian market was subjected to daily feeding of *Oreochromis niloticus* and growth parameters and economic profitability evaluated in a 66.67 m3 cages. The 12 week trial performed using 16,000 fish with mean weight 102.17 ± 3.1 g was sampled, counted and divided equally to four cages. The two test diets (Diet I: Nicoluzzi and Diet II: Rannan) were in duplicate. Mean live weights of fish in trial groups reached 420.23 ± 20.44 g and 408.62 ± 54.31 g for test Diets I and II respectively. Growth data indicated that, the final live weight, average daily weight gain, condition factor showed no significant difference among test diets ($p > 0.05$). The best FCR of 1.47 was obtained from test Diet I. Specific growth rate also showed similar values. High gross and net yield was recorded for fishes fed with Diet I and could be due to their relatively good growth performance, good feed conversion rate, relatively high survival rate which, in turn, gave high profit index of 1.87. The total feed fed to fish allotted Diet II was high which reflected in the total cost of feed, coupled with the high price of feed per kilo. This increased the cost of production (in Diet II cages) affected the profit index (1.76) generated from the sale of fish although not significant from fish fed Diet I. The results suggest that, both test diets with almost similar crude protein level, is economical and may be recommended for production. However, alternative source of cheap and cost effective feeds needs to be investigated and encourage our local industry in the production of relatively cheaper aquaculture feeds.

Mustafa (2013) represent the present status of cage culture in Chandpur and Lakshmipur districts. The study area was covered with a total of eight villages of Sadar upazila of the two districts. Data were collected on the basis of surveying a total 52 cage farmers in two districts. The study was conducted for five months from July to November, 2013. Data analysis revealed that a total of 2614 cages were found in two districts. Average size of cage was found about (20x10x5) cubic feet i.e. 18 m3. Stocking density was found about 500-700 pieces per cage. About 85% fish fingerlings were collected from local hatcheries. The species choice for the commercial culture was monosex tilapia (*Oreochromis niloticus).* Marketing pattern was found from farmer to paikars/retailers to local market and market price of tilapia was 145-160 (BDT) per kg. The production found in Chandpur of one cycle duration (5-7 months) varied from 491 to 512 ton and in Lakshmipur a total of 136 to 142 ton tilapia produced in one cycle. Income of per cycle of cage farmers in Chandpur was from 7, 11, 95,000 to 8, 19, 20,000 (BDT) and income of per cycle of cage farmers in Lakshmipur was from 1, 97, 20,000 to 2, 27, 20,000 (BDT). Benefit cost ratio was found 0.103-0.196. The problems found in the study area were damages of cage, disease, theft/poaching, lack of skilled manpower, and high cost of fingerlings. If the suggested constraints could be solved, the cage culture production in Chandpur and Lakshmipur possibly might be increased tremendously.

Phimphakan *et al*. (2013) observed cage-based aquaculture in rivers raises issues of natural resource management more familiar to fisheries management than does aquaculture in fish ponds on private land. Hybrid red and black Nile tilapias (*Oreochromis niloticus* L) are reared for 4 - 5 months in cages in the upper Ping River in northern Thailand. Observed mean stocking density was 49 ± 16 fish·m^{-3}, feed conversion ratio 1.47 ± 0.43 kg feed per kg fish and yield density 26.6 ± 8.1 kg·m^{-3}. Input costs were dominated by feed (70%) and stock (16%). Most farms borrowed money and participated in contracts. Fish farming was usually a component of a portfolio of household activities but for some a core business. To succeed fish farmers must manage a combination of market, climate and environmental-related risks. Cage-based aquaculture in rivers faces many challenges; further research on farm practices and vulnerabilities, river and water management, and the commodity- chain are needed.

Trong *et al.* (2013) studied on heritability and genotype by environment interaction estimates for harvest weight, growth rate, and shape of Nile tilapia (*Oreochromis niloticus*) grown in river cage and VAC (Vietnamese acronym for garden, pond and livestock pen) in Vietnam. They found within the breeding nucleus, heritability was high for HW (harvest weight), DGC (growth rate expressed as daily growth coefficient), but low for K (condition factor), EL–H (mid sagittal plane), EL–T (transverse plane), and EH–T (frontal plane) and DGC was positively correlated with condition factor K (rg=0.59), while the rg of HW with K was non-significant. They suggested that selection for harvest weight alone will not result in fish with higher condition factor. Genetic correlations between HW and body dimensions (L, H, T) were 0.89–0.98, but genetic correlations of DGC with ellipticity showed that fish selected for high growth rate will become more rotund rather than simply larger. GxE was minor for harvest weight and for growth, but substantial for shape traits. For DGC, genetic correlation was 0.77 between cage and VAC, but higher between the breeding nucleus and cage or VAC. For EL-H, substantial GxE (rg 0.54) was found between cage and nucleus pond. GxE was also found for EL–T between cage–VAC (rg 0.51), and for EH–T across all three environments, although with high standard errors of estimates.

Ahmed *et al*. (2014) was carried out a study in experimental cages in the Dakatia River, located about 3 km southeast of the Bangladesh Fisheries Research Institute (BFRI), Riverine Station (RS), Chandpur campus, to evaluate the effect of dietary probiotic supplementation on growth performance and survival of male mono-sex Tilapia (*Oreochromis niloticus*) during April 2013 to August 2013. A commercial probiotic named "Biotics" used at the rate of 2 and 3 g/kg feed for treatments 2 and 3 respectively with no probiotic for treatment 1. Nine net cages were divided into three treatments each having three replicates. Average stocking weight was 33.66±6.23g and stocking density was 50/m in each cage. Final weight in probiotic treated cages (T-2 and T-3) was significantly ($P<0.05$) higher than control (T-1). Final weight gain, Average Daily Gain (ADG) and production per cage were the highest in T-2, 237.82±13.69, 1.98±0.11 and 476.79±27.41 kg respectively and found to be significantly different from both T-1 and T-3. FCR was the best in T-2 (1.11±0.047) and significantly different from T-1 but not from T-3. The highest Survival rate was found in T-2 that was significantly different from T-1 but not from T-3.

CHAPTER-3 MATERIALS AND METHODS

The present study was carried out in two sites of the Dakatia river at Chandpur (Figure1). Dakatia River, one of the trans-boundary rivers of Bangladesh. It enters the country from India's tripura state at Bagsara of comilla district. It is a tributary of the Meghna. The main source of flow of this river was the Kakrai, but the Little Feni cuts back and captured its upper portion. The Dakatia now has its source in Chauddagram Khal, which connects it with the Little Feni. The Dakatia sends out a channel southward, which forms the Noakhali Khal. The main channel meanders westward to Shekherhat, from where the old course goes south to join the Meghna at Raipur, and the new and stronger channel passes through Chandpur Khal to join the Meghna west of Chandpur town. Tidal currents feed the Dakatia through the Meghna throughout the year. The descriptions of the two sites of the Dakatia river are given bellow.

3.1 Study area

3.1.1 Site - Echoli

Echoli site is a selected suitable cage culture site of the Dakatia river located at Chandpur sadar upazilla of Chandpur district (Plate 1). The site is about two and a half kilometers distance from Chandpur town and situated in latitude 23º12.878′ N and longitude 90º40.448′ E. The water depth of the site was 3.2 - 4.3 meters during study period.

3.1.2 Site - Roghunathpur

Roghunathpur site is also a selected suitable cage culture site of the Dakatia river located at Chandpur sadar upazilla of Chandpur district (Plate 1). The site is about two kilometers distance from Chandpur Puran bazar and situated in latitude 23º12.622′ N and longitude 90º39.827′ E. The water depth of the site was 4.2 - 5.3 meters during study period.

3.2. Installation of cages

The experimental cages were installed in both sites of the Dakatia river at Chandpur. The frames of cages were made by GI pipe. Empty iron drams of 250-liters capacity were used as cage float.

Floating net cages, having an area of 3 m × 3 m × 2 m made of plastic net (mesh size 2.5 cm) and knot-less polyethylene net (mesh size 1.1 cm) were installed as outer and inner layer respectively. Net cages were hanged with cage frame (made of 1.0 inch GI pipe) with bamboo rafts. Each cage was covered at the top with another piece of net to prevent escape of fish by jumping and bird predation. The entire structure were fixed with bamboo poles at each corner of the structure by making loop with nylon rope to facilitate easy floating of cages depending on water level. The structures were also fixed by anchors at both side of water current and bank of the river.

3.3. Collection and stocking of fingerlings

The fingerlings of monosex tilapia *Oreochromis niloticus* L. were collected from the nursery ponds of Bangladesh Fisheries Research Institute (BFRI), Riverine Station, Chandpur (plate 2). The fish were stout and naturally moving. Before start of the each experimental trial the fingerlings were acclimatized to the new environment in floating cages for fifteen days. Then the fishes were stocked in experimental cages according to experimental design (plate 2).

3.4. Experimental design

This study is consisted of two experiments on stocking density and feeding regime. Each experiment also consisted of two different trials with complete randomized design (CRD).

3.4.1. Stocking density experiment: Optimization of stocking density of monosex tilapia culture in net cage

Two trials were undertaken under the stocking density experiment. One in Echoli site and another one in Roghunathpur site of the Dakatia river.

3.4.1.1. Stocking density trial - 1: Identification of suitable stocking density for monosex tilapia culture in net cages of Dakatia river at Echoli, Chandpur

The experiment was undertaken in Dakatia river, Echoli, Chandpur from 15 April to 13 August, 2010. The duration of the experiment was 120 days. The stocking densities were used 30/m^3, 50/m^3 and 70/m^3 monosex tilapia in three different treatments with three replications.

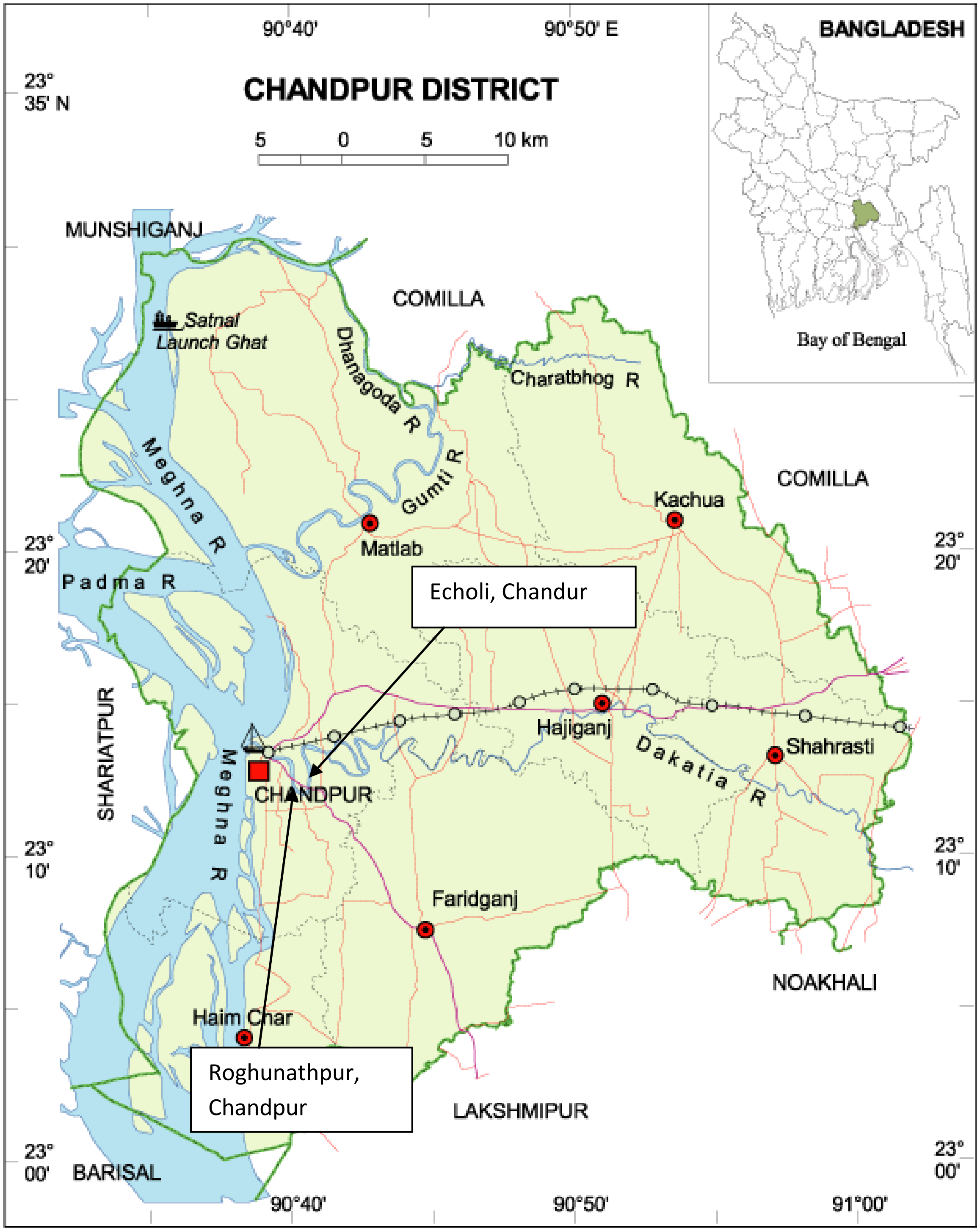

Figure 1: Site map of cages in Raghunathpur and Echoli points of Dakatia river, Chandpur.

Plate 1: Experimental sites of the Dakatia river, Chandpur, Bangladesh (Photograph A & B showing the Echoli site and photograph C & D showing the Roghunathpur site of cage culture experiment).

The initial average weights of fingerlings were 32.31±9.59 g. The fishes were fed twice daily, half of the ration in the morning at 10.00-10.30 am and another half in the afternoon at 3.30-4.00 pm with pelletized semi-buoyant feed (floating type) at the rate of 5 - 3% (1^{st} and 2^{nd} months 5% then 3^{rd} and 4^{th} months 4 and 3%, respectively) of total body weight towards the end of the culture period. The amounts of feed were determined through the sampling that was carried out after every 30 days interval throughout the culture period. A number of fishes (at least 50) were randomly sampled by partially lifting the cage netting and removing fish with a scoop net from in each cage and then weight of each fish was taken separately to monitor growth performance and to adjust their feeding regime accordingly. After 120 days fishes of the net cages in all the treatments were harvested.

3.4.1.2. Stocking density trial - 2: Identification of suitable stocking density for monosex tilapia culture in net cages of Dakatia river at Roghunathpur, Chandpur

The experiment was undertaken in Dakatia river, Roghunathpur, Chandpur from 5 June to 3 October, 2010. The duration of the experiment was 120 days. The stocking densities were used 50/m^3, 75/m^3 and 100/m^3 monosex tilapia in three different treatments with three replications. The initial average weights of fingerlings were 28.92±8.37 g. The fishes were fed twice daily, half of the ration in the morning at 09.30-10.00 am and another half in the afternoon at 3.00-3.30 pm with pelletized semi-buoyant feed (floating type) at the rate of 5 - 3% (1st and 2nd months 5% then 3rd and 4th months 4 and 3%, respectively) of total body weight towards the end of the culture period. The amounts of feed were determined through the sampling that was carried out after every 30 days interval throughout the culture period. A number of fishes (at least 50) were randomly sampled by partially lifting the cage netting and removing fish with a scoop net from in each cage and then weight of each fish was taken separately to monitor growth performance and to adjust their feeding regime accordingly. After 120 days fishes of the net cages in all the treatments were harvested.

3.4.2. Feeding regime experiment: Optimization of feed requirement of monosex tilapia culture in net cage

Two trials were undertaken under the feeding regime experiment. Both of the trials were undertaken in Roghunathpur site of the Dakatia river.

3.4.2.1. Feeding regime trial - 1: Growth performance of monosex tilapia cultured under different feed supplements in net cage of Dakatia river, Raghunathpur, Chandpur

The experiment was undertaken in Dakatia river, Roghunathpur, Chandpur from 15 April to 13 August, 2011. The duration of the experiment was 120 days. The fishes were fed twice daily, half of the ration in the morning at 09.30-10.00 am and another half in the afternoon at 3.00-3.30 pm with pelletized semi-buoyant feed (floating type) at the rate of 5 - 3, 6 - 4 and 7 - 5% (1st month 5, 6 and 7% then 2nd month 4, 5 and 6% and next two months 3, 4 and 5% body weight in treatments-I, II and III respectively) of total body weight in the treatments-I, II and III respectively, towards the end of the culture period. The initial average weights of fingerlings were 36.20±11.64 g. The stocking densities of the fingerlings were 50/m^3 in all the treatments with three replications. The amounts of feed were determined through the sampling that was carried out after every 30 days interval throughout the culture period. A number of fishes (at least 50) were randomly sampled by partially lifting the cage netting and removing fish with a scoop net from in each cage and then weight of each fish was taken separately to monitor growth performance and to adjust their feeding regime in all the treatments accordingly. After 120 days fishes of the net cages in all the treatments were harvested.

3.4.2.2. Feeding regime trial - 2: Growth performance of monosex tilapia cultured under different feed supplements in net cage of Dakatia river, Raghunathpur, Chandpur

The experiment was undertaken in Dakatia river, Roghunathpur, Chandpur from 03 June to 01 October, 2011. The duration of the experiment was 120 days. The fishes were fed twice daily, half of the ration in the morning at 10.00-10.30 am and another half in the afternoon at 3.30-4.00 pm with pelletized semi-buoyant feed (floating type) at the rate of 6, 5 and 4% of total body weight in the treatments-I, II and III respectively, throughout the culture period. The initial average weights of fingerlings were 20.76±6.14 g. The stocking densities of the fingerlings were $50/m^3$ in all the treatments with three replications. The amounts of feed were determined through the sampling that was carried out after every 30 days interval throughout the culture period. A number of fishes (at least 50) were randomly sampled by partially lifting the cage netting and removing fish with a scoop net from in each cage and then weight of each fish was taken separately to monitor growth performance and to adjust their feeding regime in all the treatments accordingly. After 120 days fishes of the net cages in all the treatments were harvested.

3.5. Fish Sampling

Initial weights of the fishes were properly recorded at the time of initiation of the every trial of the experiments by using a weighing balance. The fishes were sampled once in 30 day. For this purpose, at least 50 fishes were randomly sampled from each cage and their individual weight was recorded to the nearest grams (plate 3). During sampling, the fishes were visually examined to determine the possible outbreak of diseases. After 120 days of rearing i.e. at the time of termination of the each trial of the experiments, the final weights (g) of the individual fishes were carefully recorded. The total fish biomass in each cage was determined with a precision weighing balance. The cage nets were also cleaned once in 30 day just after each sampling.

3.6. Fish harvest

At the end of the study, all experimental cages were emptied and fish in each cage graded (plate 4), counted and weighed to determine average fish weight and survival. Production input costs were recorded throughout the trial and net income and return on investment calculated at the end of the trial.

3.7. Benefit-cost ratio (BCR) and profit

Benefit cost ratio and profit of all the treatments were calculated after completion of the experiments as follows:

BCR = Total income ÷ Total expenditure
Profit (Taka) = Total income – Total expenditure

3.8. Analysis of data

Data collected during the experiment and after completions of each trial were analyzed by using the following parameters.

3.8.1. Weight gain (WG)

The weight gain was calculated monthly and also finally after completion of each trial as follow:

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

3.8.2. Relative growth rate (RGR)

The relative growth rate was determined monthly and also finally after completion of each trial by using the following formula (Goddard 1996):

$$\text{Relative growth rate (\%)} = \frac{W_2 - W_1}{W_1} \times 100$$

Where, W_1 = Live body weight (gm) at time T_1 (day).
W_2 = Live body weight (gm) at time T_2 (day).

3.8.3. Specific growth rate (SGR)

The specific growth rate of fishes was determined monthly and also finally after completion of each trial by using the following formula (Goddard 1996):

SGR (%/day) = G × 100

Where, G is the instantaneous growth rate,

$$G = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{T_2 - T_1}$$

Where, W_1 = Initial live body weight (g) at time T_1 (day).

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

3.8.4. Food conversion ratio (FCR) of pelletized feed used in net cages

Food conversion ratio (FCR) was calculated monthly and also finally after completion of each trial as follow:

Food conversion ratio = total feed fed (dry weight) / live fish weight gain.

3.9. Survival rate and Production

After completion of each trial the survival rate and production of the fishes were determined as follows:

Survival rate (%) = (No. of fishes harvested × 100) / No. of fishes stocked.

Gross production (kg/cage) = Average final weight (kg) × No. of fishes harvested.

Net production (kg/cage) = Average final weight (kg) – initial weight (kg) × No. of fishes harvested.

3.10. Proximate composition of commercial feed used in net cages

The proximate composition of the used feed such as moisture (%), ash (%), lipid (%) and crude protein (%) were determined in laboratory by AOAC (1980).

3.11. Water quality parameters

The physicochemical parameters of cage water were monitored on fortnightly in every month of the experimental period. Physicochemical parameters such as water temperature, water transparency, water depth, current velocity, Total dissolved solids, dissolved oxygen (mg/l), free carbon dioxide (mg/l), pH , total alkalinity (mg/l), total hardness (mg/l), ammonia (mg/l), and nitrite was recorded between 09-30 am to 10-30 am for each sampling. Water temperature was monitored by centigrade thermometer, water transparency was determined in centimeter by Secchi-disk reading and water depth was recorded in centimeter by a bamboo pole (plate 2). The current velocity of the flowing water in the cage was determined in centimeter/second by velocity meter. Total dissolved solids (TDS) were determined in mg/l by TDS meter (Hanna). The chemical parameters of cage water such as dissolved oxygen (mg/l), free carbon dioxide (mg/l), pH , total alkalinity (mg/l), total hardness (mg/l), ammonia (mg/l) and nitrite (mg/l) was determined by HACH water analysis kit (HACH model-FF2, USA) (plate 3).

3.12. Statistical analysis

Data were statistically analyzed according to the technique of one way analysis of variance (ANOVA) for the completely randomized design to test the significance of the differences, least significant difference (LSD) and coefficient of variation (CV%) between treatments and the means of different parameters including monthly growth parameters of all the trials. Differences were considered significant at the level of 0.1% ($p < 0.001$), 1% ($p < 0.01$) and 5% ($p < 0.05$). All computations and statistical analysis were performed using the facility of computer with Excel and software package R version 3.0.0 (2013-04-03). Physicochemical parameters of water quality compared by ranged, mean with standard deviation. Pearson correlation coefficients within physicochemical parameters were determined using computer with Excel and software package SPSS version-16.0. Correlations were considered significant at the level of 1% ($p < 0.01$) and 5% ($p < 0.05$).

Plate 2: Collection of tilapia fingerlings from nursery pond and releasing in cage and monitoring of physical parameters of water quality of the Dakatia river (Photograph A, B and C – Collection of tilapia fingerlings from nursery pond, photograph D – carrying of fingerlings, photograph E and F – releasing of fingerlings in cage, photograph G and H – measurement of water depth and secchi-disk transparency).

Plate 3: Water quality monitoring of different chemical parameters of cage water and weighing of tilapia during sampling (Photograph I, J, K, L and M – assessment of different chemical parameters of cage water, photograph N – collection of tilapia for sampling from cage, photograph O and P – weighing of tilapia during sampling).

Plate 4: Feeding and harvesting of tilapia in cage (Photograph A – feeding of tilapia in cage, photograph B – harvesting of tilapia, photograph C, D, E and F – tilapia produced in cage).

CHAPTER-4 RESULTS AND OBSERVATIONS

4.1. Stocking density trial -1

4.1.1. Physicochemical parameters of cage water

The physicochemical parameters of cage water of stocking density trial-1 were monitored fortnightly in Dakatia river, Echoli, Chandpur during 15 April to 13 August, 2010. Throughout the experimental period, the monthly variations recorded of different physicochemical parameters of cage water are shown in Appendix 1 and graphically presented in Figure 2-11. In this study, water depth ranged from 3.2 m in April to 4.3 m in July. Current velocity of water fluctuated from 17 cm/sec in April to 32 cm/sec in August. Secchi-disk transparency varied from 41 cm in July to 54 cm in April. The recorded highest water temperature 32.8°C was in August and lowest 30.1°C in April. Water temperature showed a positive correlation with water current velocity ($p < 0.01$; $r = 0.976$) (Table 2). Total dissolved solids diverse from 6 mg/l to 10 mg/l in the month of May, April and August respectively. Dissolved oxygen varied from 4.12 mg/l in August to 5.63 mg/l in May. Free CO_2 fluctuated from 5.26 mg/l in August to 8.83 mg/l in June. The water pH ranged from 7.37 in July to 7.75 in May. The total hardness of cage water found lowest 38.44 mg/l in July and the highest 93.8 mg/l in April. Total hardness expressed inversely correlated with water temperature ($p < 0.01$; $r = - 0.994$) and current velocity ($p < 0.05$; $r = - 0.958$) whereas, positively related with sechi-disk transparency ($p< 0.05$; $r = 0.880$) (Table 2).Total alkalinity also found lowest 33.68 mg/l in June and the highest 107.6 mg/l in April. Total alkalinity had a positive correlation with sechi-disk transparency ($p < 0.05$; $r = 0.914$) (Table 2). During the study period, salinity, Ammonia-NH_3 and Nitrite-NO_2 were found nil (Appendix 1).

4.1.2 Growth parameters of stocking density trial-1

Final weight (FW)

After completion (120 days) of the stocking density trial-1 the mean final weight of the tilapia of different treatments in cage ranged from 202.28g to 247.27g from the initial average weight of 32.31g for each treatment, while the highest final weight attained in T_1 (247.27g)

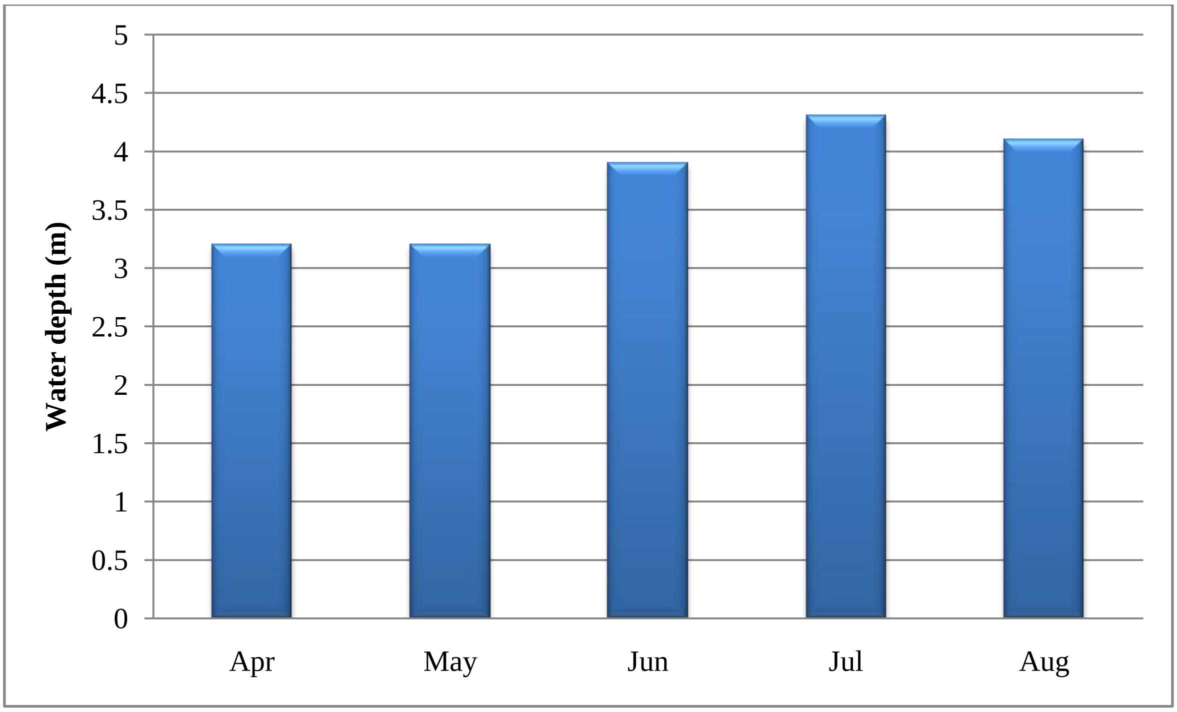

Figure 2. Monthly variations of water depth of Dakatia river, Echoli, Chandpur during stocking density trial-1 of cage culture

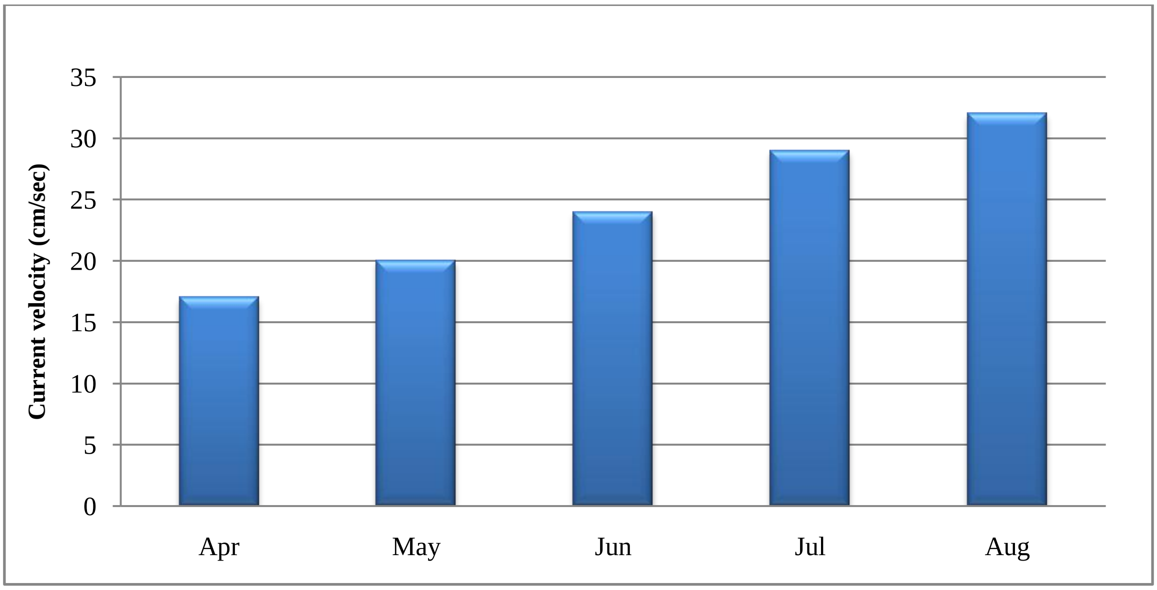

Figure 3. Monthly variations of water current velocity of Dakatia river, Echoli, Chandpur during stocking density trial-1 of cage culture

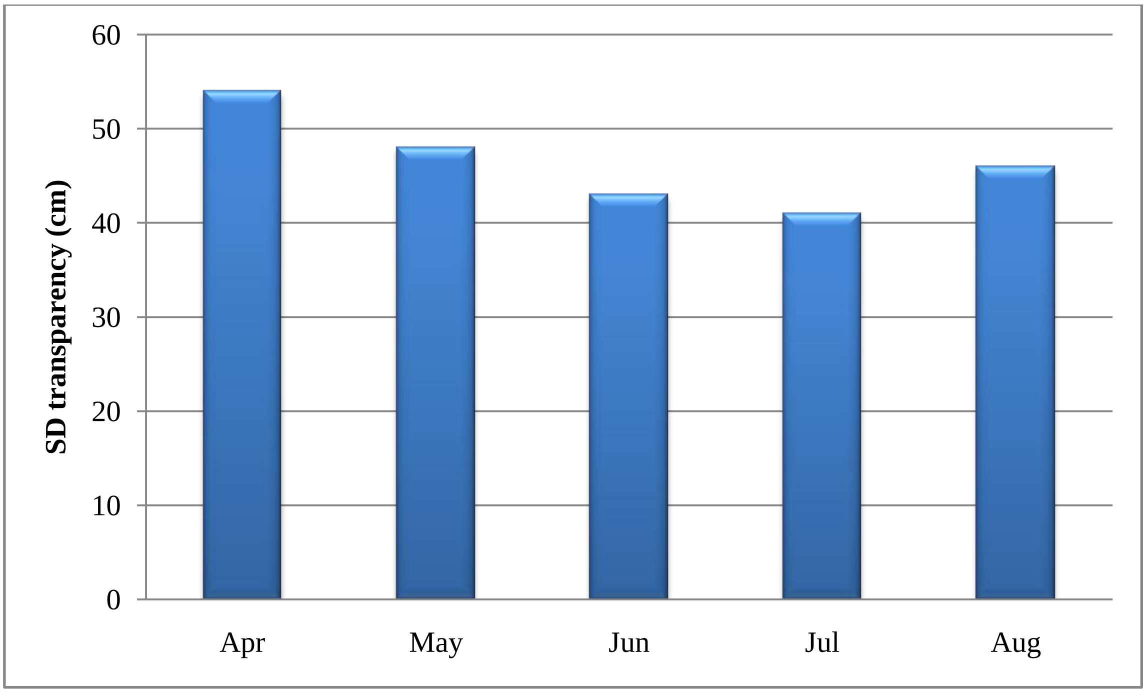

Figure 4. Monthly variations of Secchi disk transparency of water in Dakatia river, Echoli, Chandpur during stocking density trial-1 of cage culture

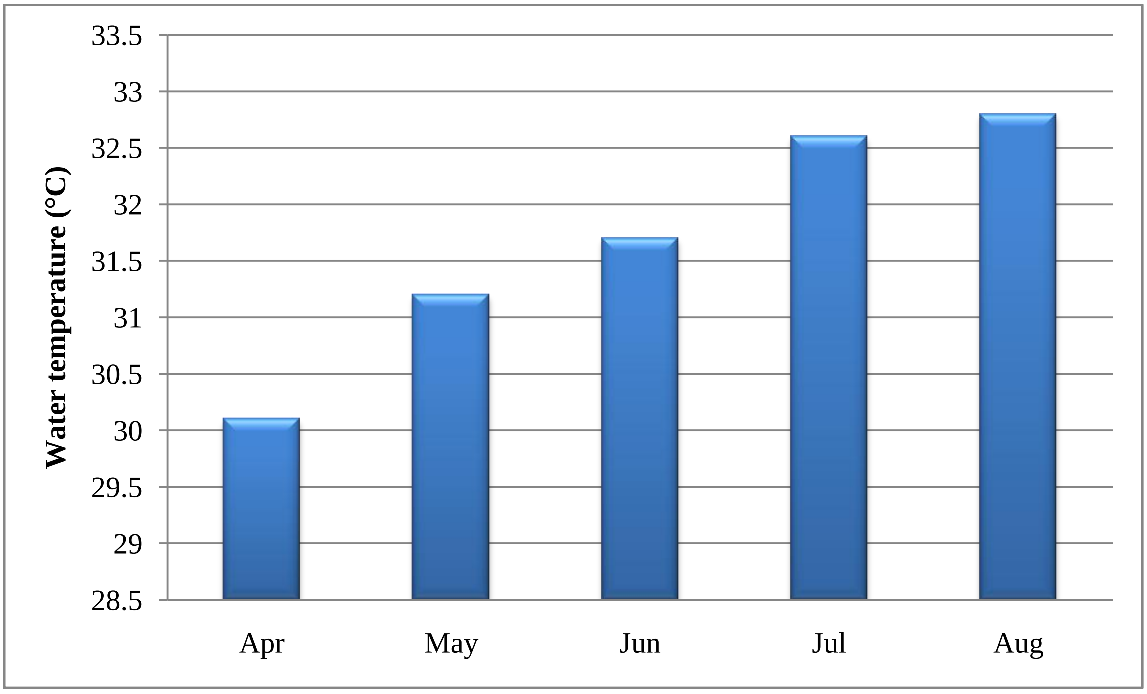

Figure 5. Monthly variations of water temperature in Dakatia river, Echoli, Chandpur during stocking density trial-1 of cage culture

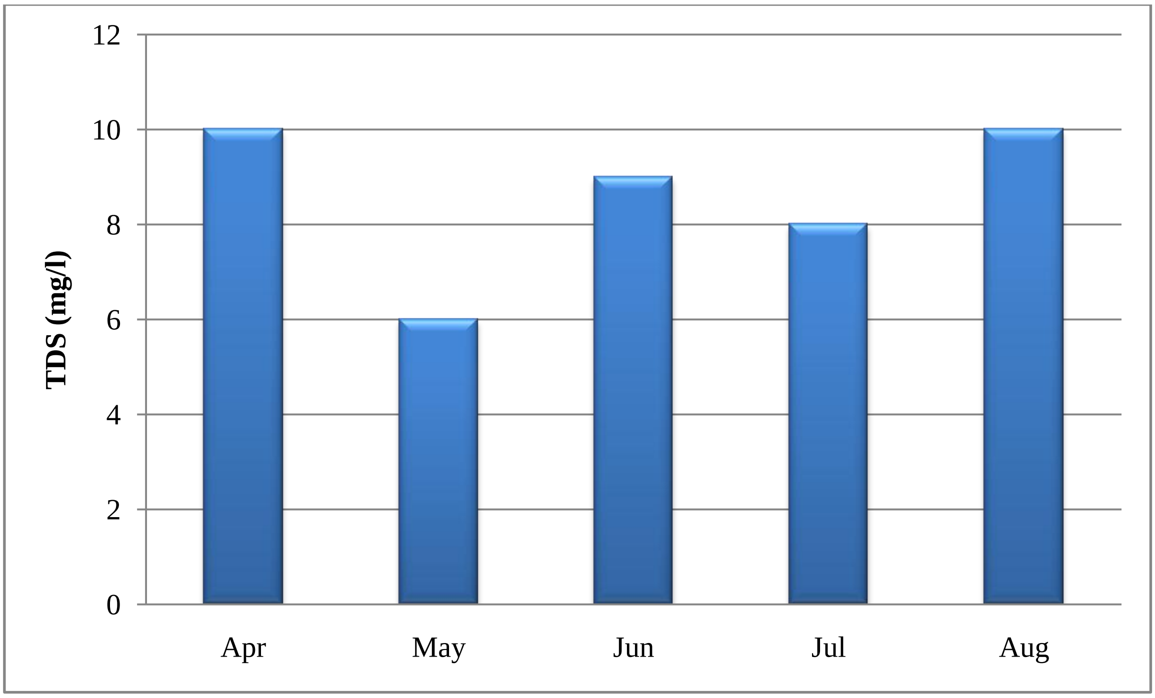

Figure 6. Monthly variations of total dissolved solids of water in Dakatia river, Echoli, Chandpur during stocking density trial-1 of cage culture

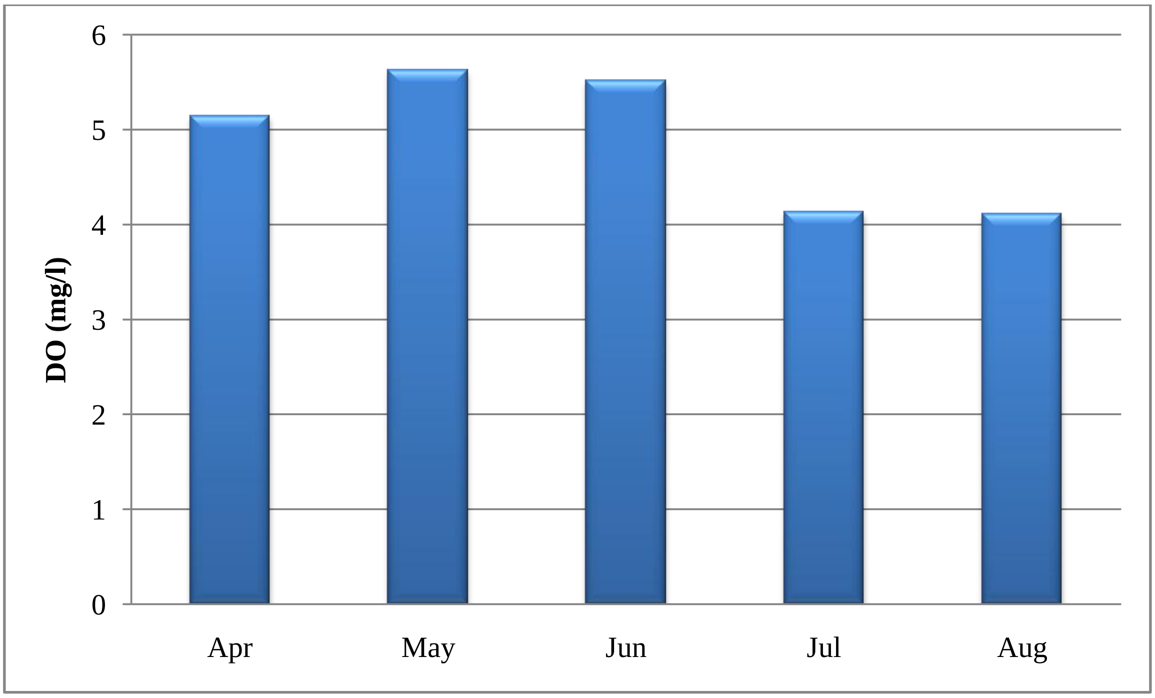

Figure 7. Monthly variations of dissolved oxygen of water in Dakatia river, Echoli, Chandpur during stocking density trial-1 of cage culture

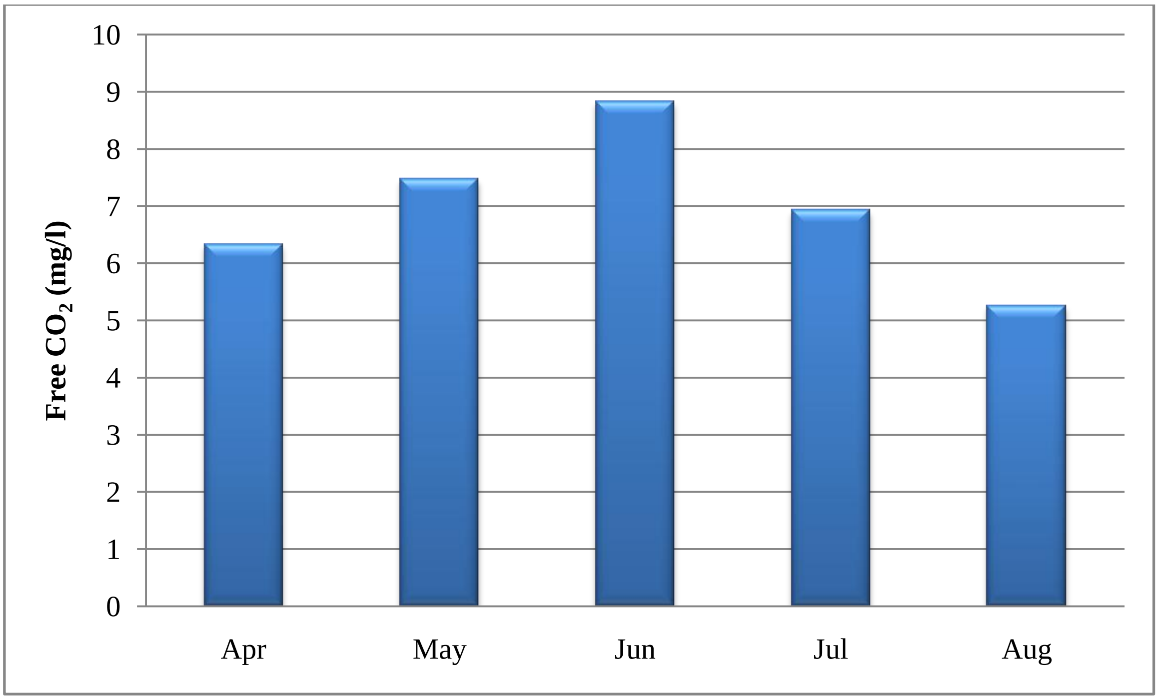

Figure 8. Monthly variations of free carbon dioxide of water in Dakatia river, Echoli, Chandpur during stocking density trial-1 of cage culture

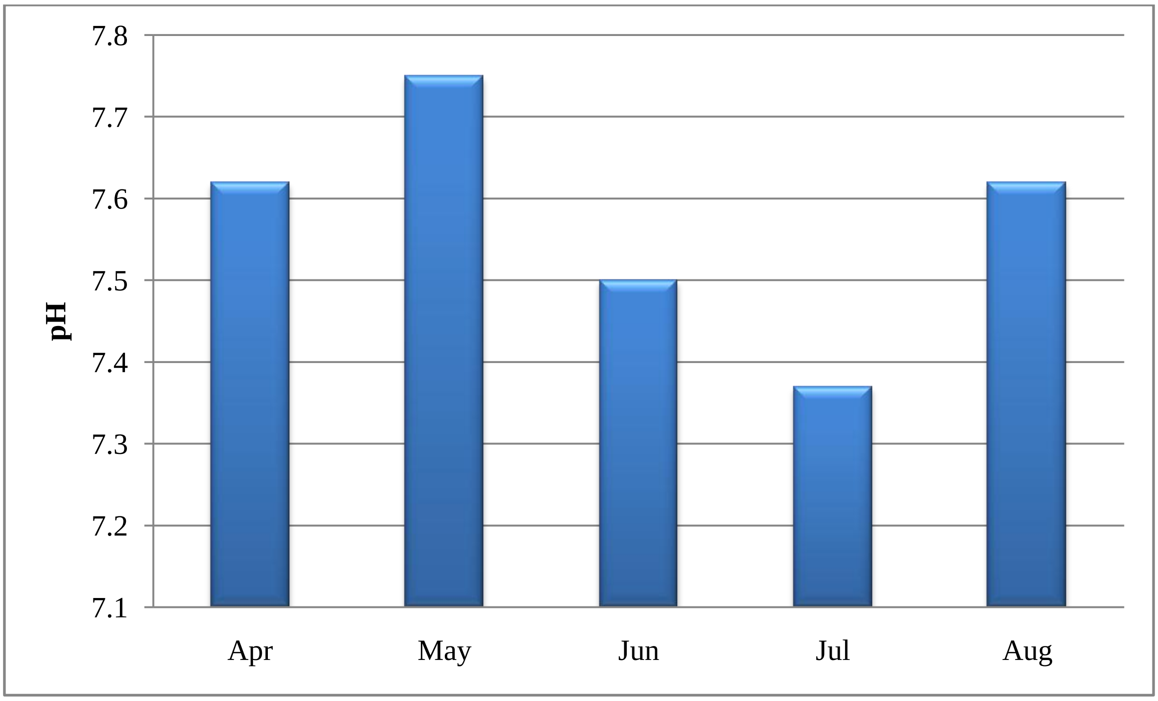

Figure 9. Monthly variations of water pH in Dakatia river, Echoli, Chandpur during stocking density trial-1 of cage culture

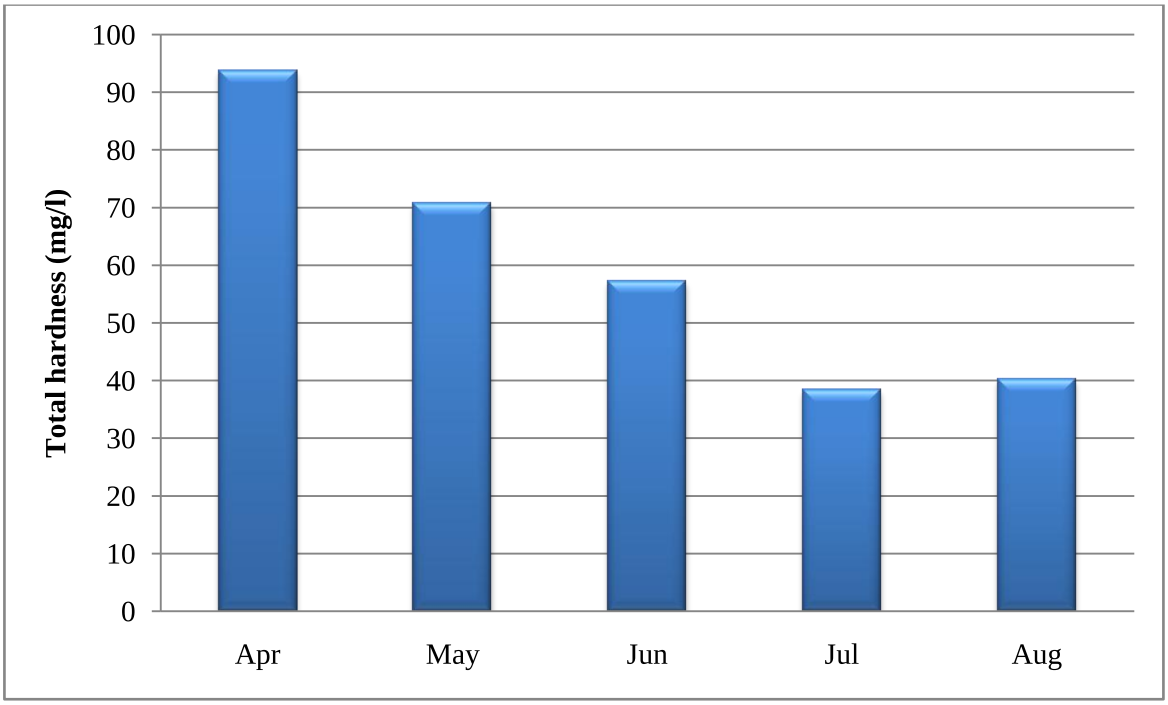

Figure 10. Monthly variations of total hardness of water in Dakatia river, Echoli, Chandpur during stocking density trial-1 of cage culture

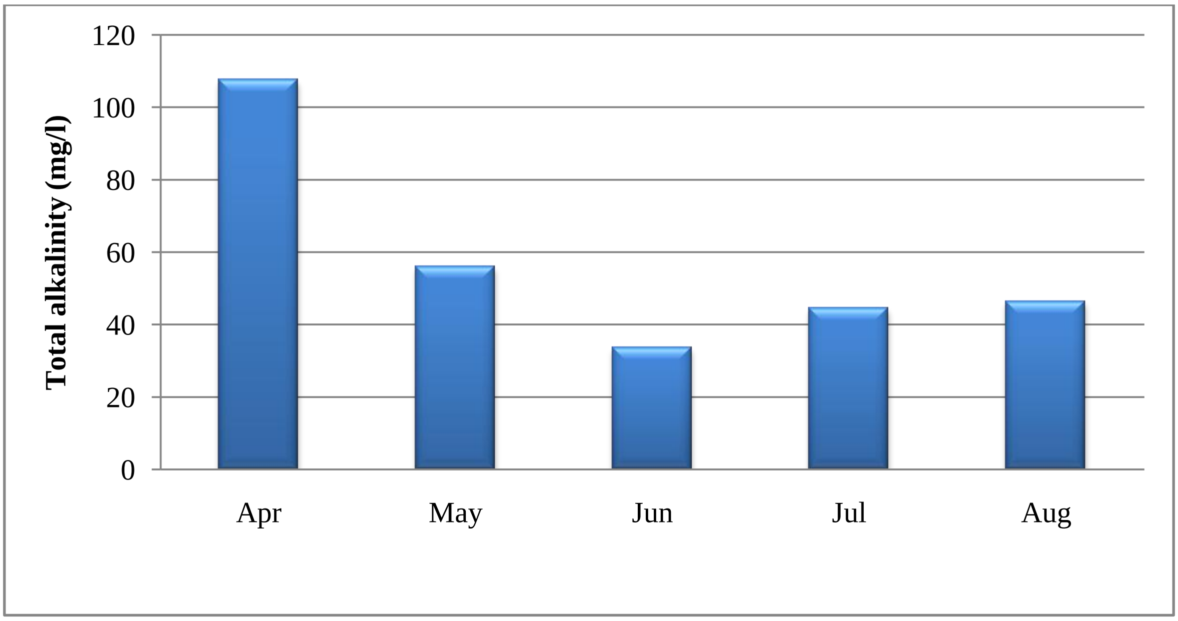

Figure 11. Monthly variations of total alkalinity of water in Dakatia river, Echoli, Chandpur during stocking density trial-1 of cage culture

Table 2. Correlation Matrix of Water Quality parameters during culture period in stocking density trial-1

	WCV	SDT	WT	TDS	DO	CO_2	pH	TH	TA
WCV	1								
SDT	-.721	1							
WT	.976**	-.826	1						
TDS	.212	.232	.008	1					
DO	-.809	.363	-.713	-.393	1				
CO_2	-.347	-.355	-.196	-.430	.697	1			
PH	-.471	.681	-.468	-.246	.506	-.197	1		
TH	-.958*	.880*	-.994**	.023	.685	.110	.540	1	
TA	-.693	.914*	-.809	.292	.177	-.375	.357	.837	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

WCV = Water Current Velocity, SDT = Secchi Disk Transparency, WT = Water Temperature, TDS =Total Dissolved Solids, DO = Dissolved Oxygen, CO_2 = Carbon Di-oxide, pH = Hydrogen Ion Concentration, TH =Total Hardness, TA =Total Alkalinity

followed by T_2 (231.23g) and T_3 (202.28g) respectively (Table 3 & Figure 16). The final weight exhibited highly significant differences ($p < 0.001$) among the three treatments (Table 5).

Weight gain (WG)

Throughout the study period, in stocking density trial-1 the monthly weight gain fluctuated from 29.32g to 68.46g in T_1, whereas in $T_{2,}$ it ranged from 23.08g to 68.18g. While, it diverse from 13.88g to 59.88g in T_3 (Appendix 5 Figure 12). The monthly weight gain was found significantly differences among three treatments in first month ($p < 0.001$) and between T_1 and T_3 in third month ($p < 0.05$) (Table 4). All three treatments, the highest weight gain observed 214.96g in T_1 and followed by T_2 (198.92g) and T_3 (169.97g) respectively (Table 3 & Figure 17). The weight gain had found highly significant differences ($p < 0.001$) among the three treatments (Table 5).

Relative growth rate (RGR)

The monthly relative growth rate ranged from 38.33% to 100.82% in T_1, from 41.86% to 106.53% in T_2, from 37.01% to 129.61% in T_3 respectively (Appendix 5 & Figure 13). The monthly relative growth rate showed highly significant differences ($p < 0.001$) among three treatments in first and second months (Table 4). The highest relative growth rate was found 68.60% in T_1, while the lowest was 62.24% in T_3 (Table 3 & Figure 18). The relative growth rate exhibited significantly differences ($p < 0.001$) among the three treatments (Table 5).

Specific growth rate (SGR)

The monthly specific growth rate varied from 1.07%/day to 2.31%/day in $T_{1.}$ In case of T_2 it fluctuated from 1.16%/day to 2.41%/day, while in T_3 specific growth rate ranged from 1.04%/day to 2.76%/day (Appendix 5 & Figure 14). The monthly specific growth rate showed highly significant differences ($p < 0.001$) among the three treatments in first and second months (Table 4). Among the three treatments, highest specific growth rate 1.68%/day recorded in T_1 and lowest value 1.52%/day in T_3 (Table 3 & Figure 19). The specific growth rate expressed highly significant differences ($p < 0.001$) among the three treatments (Table 5).

Food conversion ratio (FCR)

The monthly food conversion ratio ranged from 1.26 to 1.65 in T_1, from 1.40 to 2.53 and from 1.15 to 3.86 in T_2 and T_3 respectively (Appendix 5 & Figure 15). The monthly food conversion ratio was found highly significant differences ($p < 0.001$) in first, third and fourth months among the three treatments and significantly difference ($p < 0.01$) in second month between T1 and T3, and T2 and T3 respectively (Table 4). Food conversion ratio was found 1.46, 2.01 and 2.89 in T_1, T_2 and T_3 respectively, where T_1 shown the lowest value and the T_3 was highest (Table 3 & Figure 20). The food conversion ratio showed highly significant differences ($p < 0.001$) among the three treatments (Table 5).

Survival rate

The survival rate of tilapia in cage was found ranged from 67.58% to 85.61%. The maximum survival rate was found in T_1 (85.61%) followed by T_2 (81.92%) and T_3 (67.58%) respectively (Table 3 & Figure 21). The survival rates of the three treatments were found highly significant differences ($p < 0.001$) among them (Table 5).

Gross production (GP)

Gross production of the tilapia was recorded in ranged from 114.29kg/cage to 172.24kg/cage. The gross production was recorded highest 172.24kg/cage in T_3 and the lowest 114.29kg/cage in T_1 (Table 3 & Figure 22). The gross production showed highly significant differences ($p < 0.001$) between T_1 and T_2, T_3 (Table 5).

Net production (NP)

The net production of the tilapia was recorded in ranged from 99.35kg/cage to 146.64kg/cage. Net production also was recorded highest 146.64kg/cage in T_3 and the lowest 99.35kg/cage in T_1 (Table 3 & Figure 23). Net production also showed highly significant differences ($p < 0.001$) between T_1 and T_2, T_3 (Table 5).

Net profit

The detail of net profit determination of this trial is shown in table (Appendix 9). Net profit of the different treatments of the stocking density trial-1 was found in ranged between

2263Tk/cage and 3151Tk/cage in T_1 and T_2 respectively, while no profit was earned from the T_3 due to loss (-2478Tk/cage) in this treatment (Table 3 & Figure 24). Net profit expressed highly significant differences ($p < 0.001$) among the three treatments (Table 5).

Benefit cost ratio (BCR)

The detail of benefit cost ratio determination of stocking density trial-1 is shown in table (Appendix 9). The benefit cost ratio determined in this trial was ranged from 0.88 to 1.20. The highest benefit cost ratio was achieved in T_1 (1.20) followed by T_2 (1.19) and T_3 (0.88) respectively (Table 3 & Figure 25). Benefit cost ratio exhibited the highly significant differences ($p < 0.001$) between T_1 and T_3, and T_2 and T_3 (Table 5).

Table 3. Growth performance of tilapia under different treatments of stocking density trial- 1 in Dakatia river, Echoli, Chandpur during 15 April - 13 August, 2010.

Parameters	**Treatments**				
	T_1-(30/m^3) 540/cage	T_2-(50/m^3) 900/cage	T_3-(70/m^3) 1260/cage	Range	Mean ± SD
Initial weight- IW (g)	32.31	32.31	32.31	32.31 - 32.31	32.31±0
Final weight- FW (g)	247.27	231.23	202.28	202.28 - 247.27	226.93±22.80
Weight gain- WG (g)	214.96	198.92	169.97	169.97 - 214.96	194.62±22.80
Relative growth rate- RGR (%)	68.60	65.61	62.24	62.24 - 68.60	65.48±3.18
Specific growth rate- SGR (%/day)	1.68	1.63	1.52	1.52 -1.68	1.61±0.08
Food conversion ratio- FCR	1.46	2.01	2.89	1.46 - 2.89	2.12±0.72
No. of fish harvested	462	737	852	462 - 852	683.67±200.40
Survival (%)	85.61	81.92	67.58	67.58 - 85.61	78.37±9.52
Gross production- GP (kg/cage)	114.29	170.47	172.24	114.29 - 172.24	142.38±39.72
Net production- NP (kg/cage)	99.35	146.64	144.72	99.35 - 146.64	130.23±26.77
Net profit (Tk/cage)	2263	3151	–2478	2263 - 3151	2707±627.91
Benefit cost ratio- BCR	1.20	1.19	0.88	0.88 – 1.20	1.09±0.18

Feeding: 5-3% body weight feed daily in each treatment

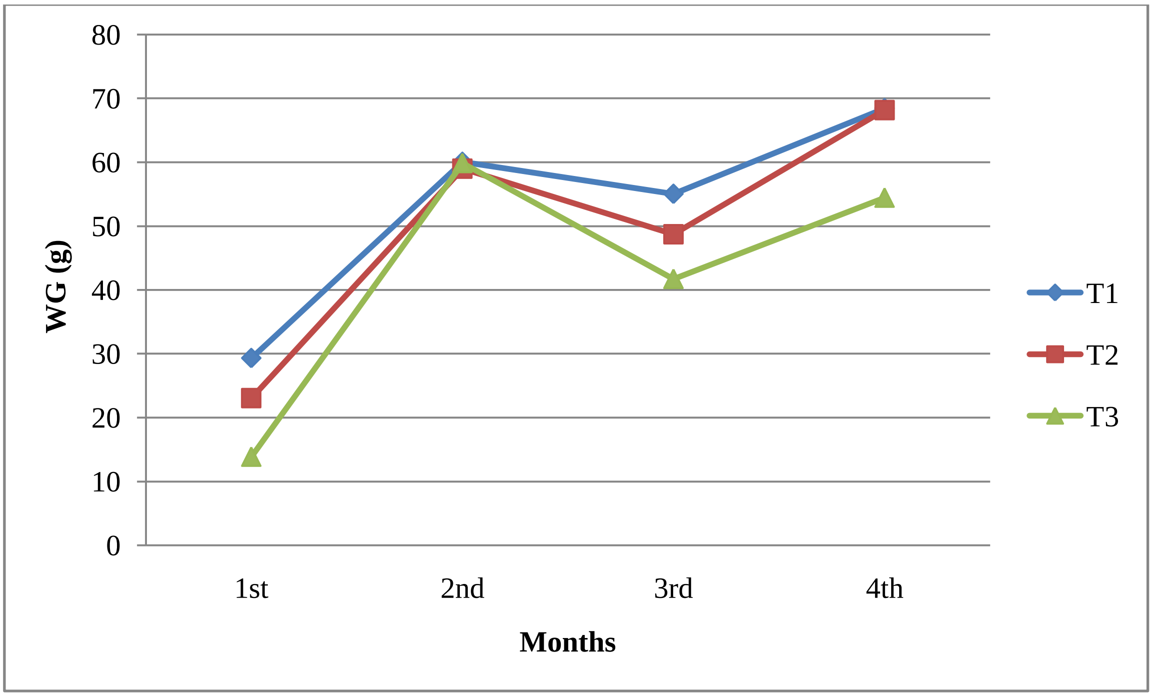

Figure 12. Monthly variations of weight gain in different treatments of stocking density trial-1

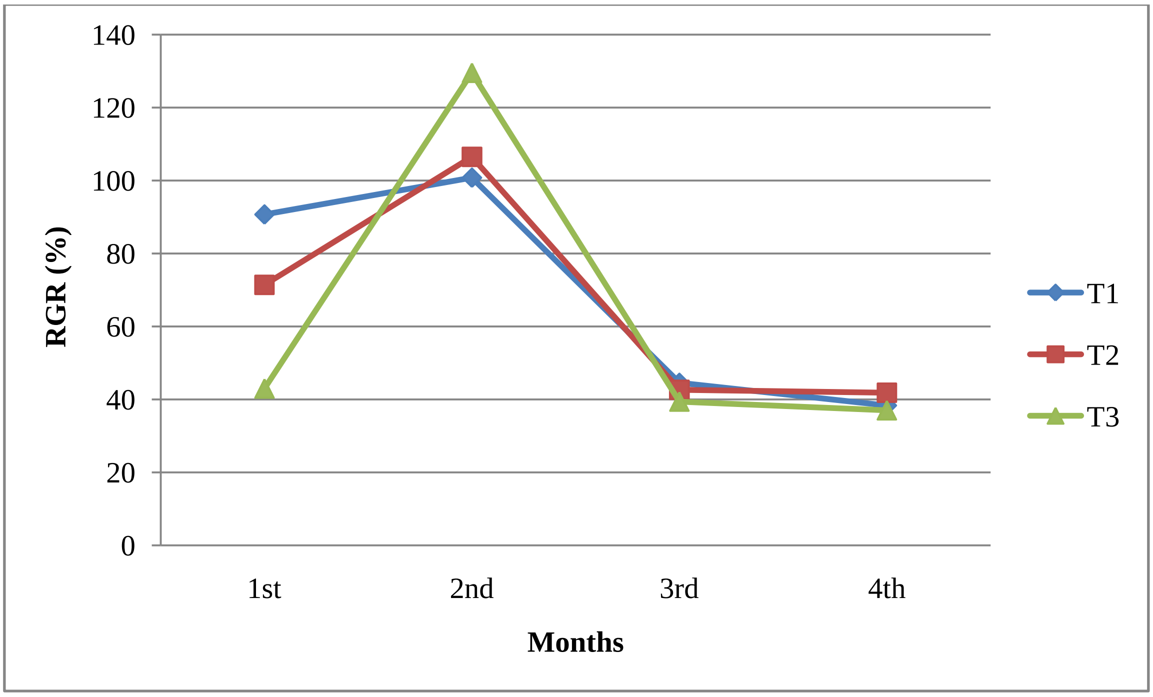

Figure 13. Monthly variations of relative growth rate in different treatments of stocking density trial- 1

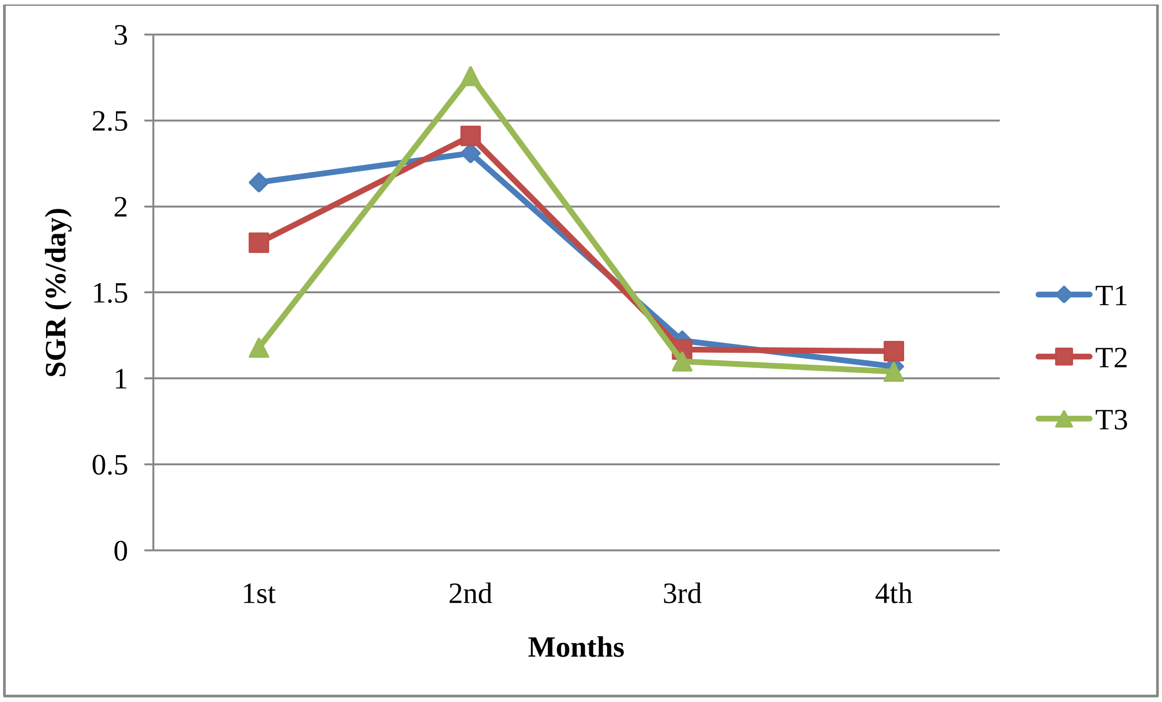

Figure 14. Monthly variations of specific growth rate in different treatments of stocking density trial-1

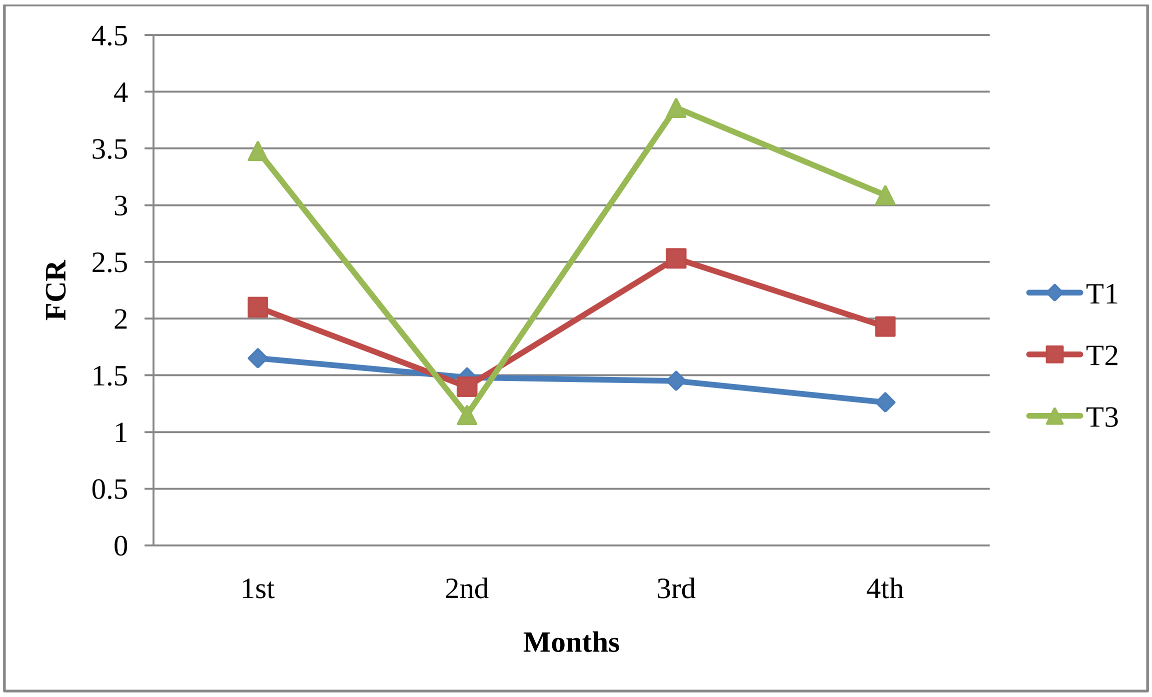

Figure 15. Monthly variations of feed conversion ratio in different treatments of stocking density trial-1

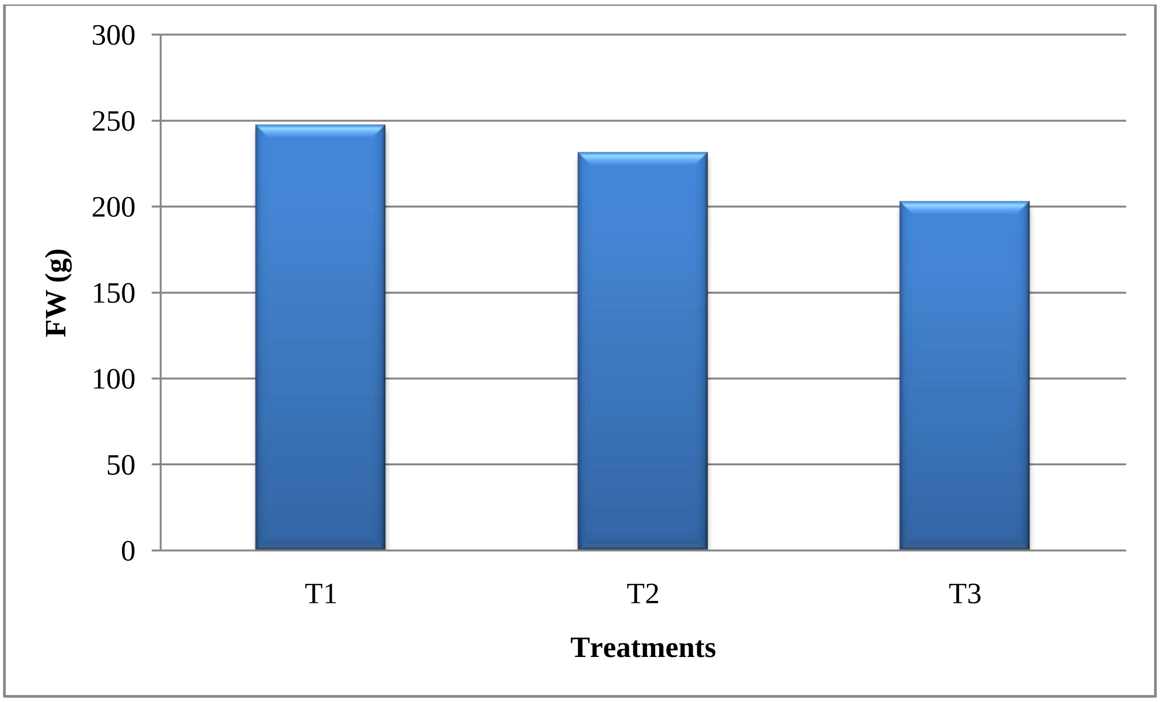

Figure 16. Final weight of tilapia in different treatments of stocking density trial-1

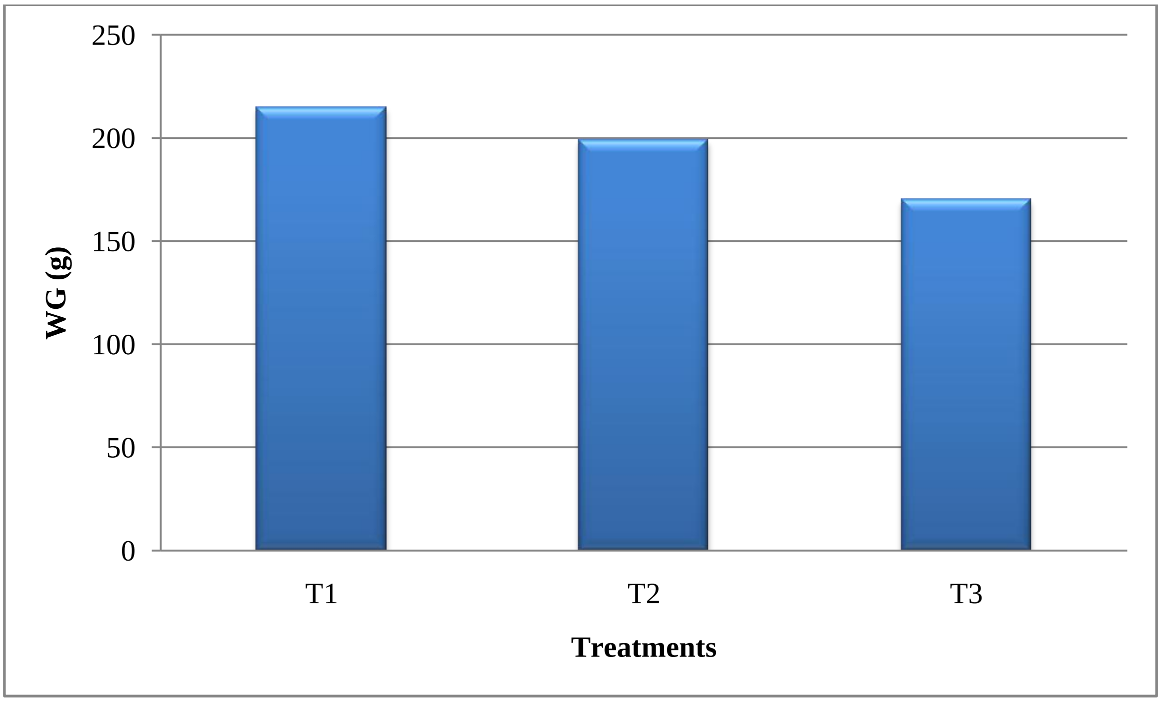

Figure 17. Weight gain of tilapia in different treatments of stocking density trial-1

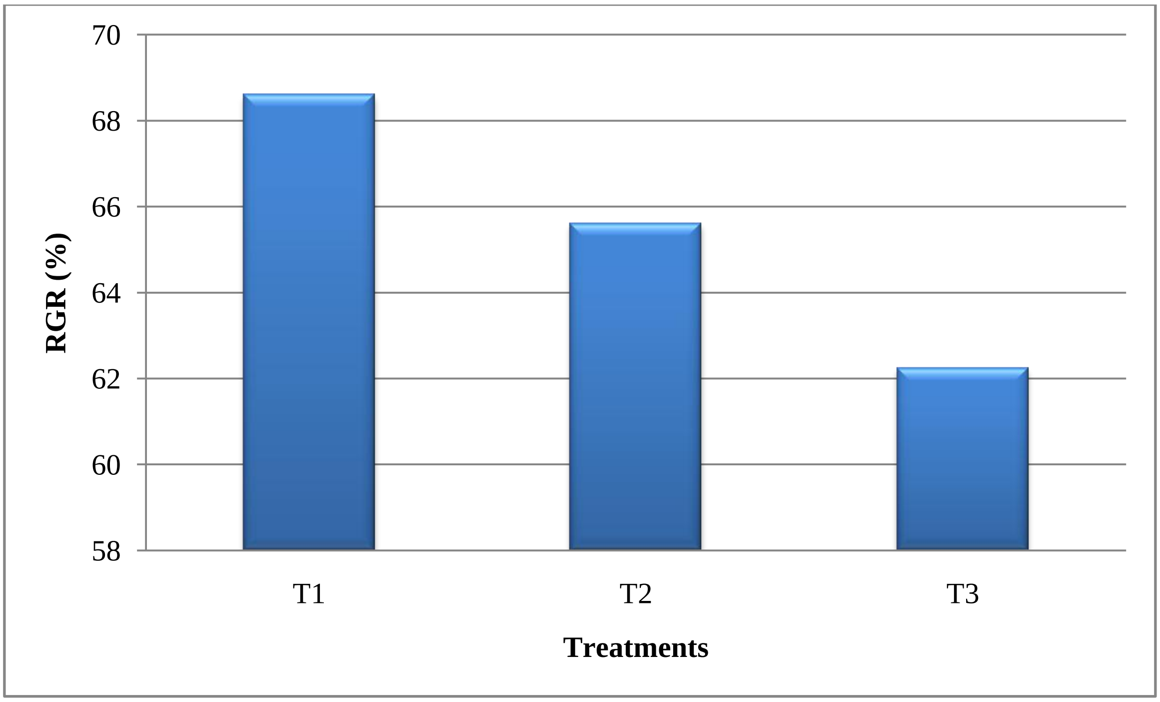

Figure 18. Relative growth rate of tilapia in different treatments of stocking density trial-1

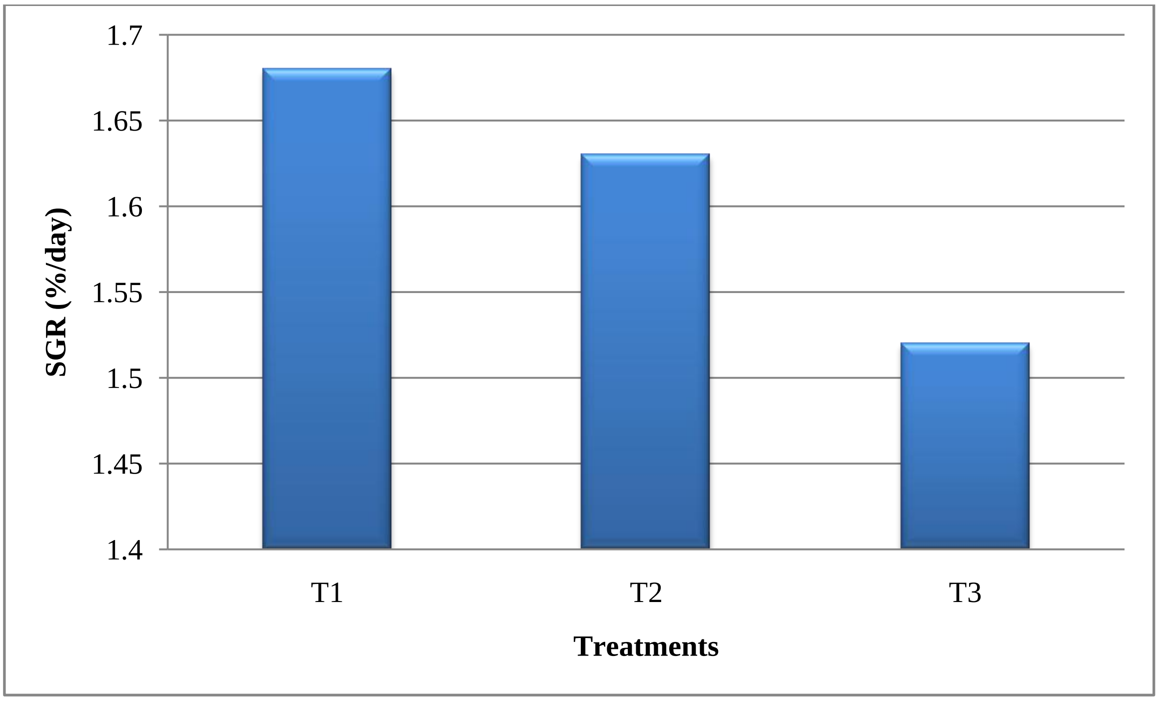

Figure 19. Specific growth rate of tilapia in different treatments of stocking density trial-1

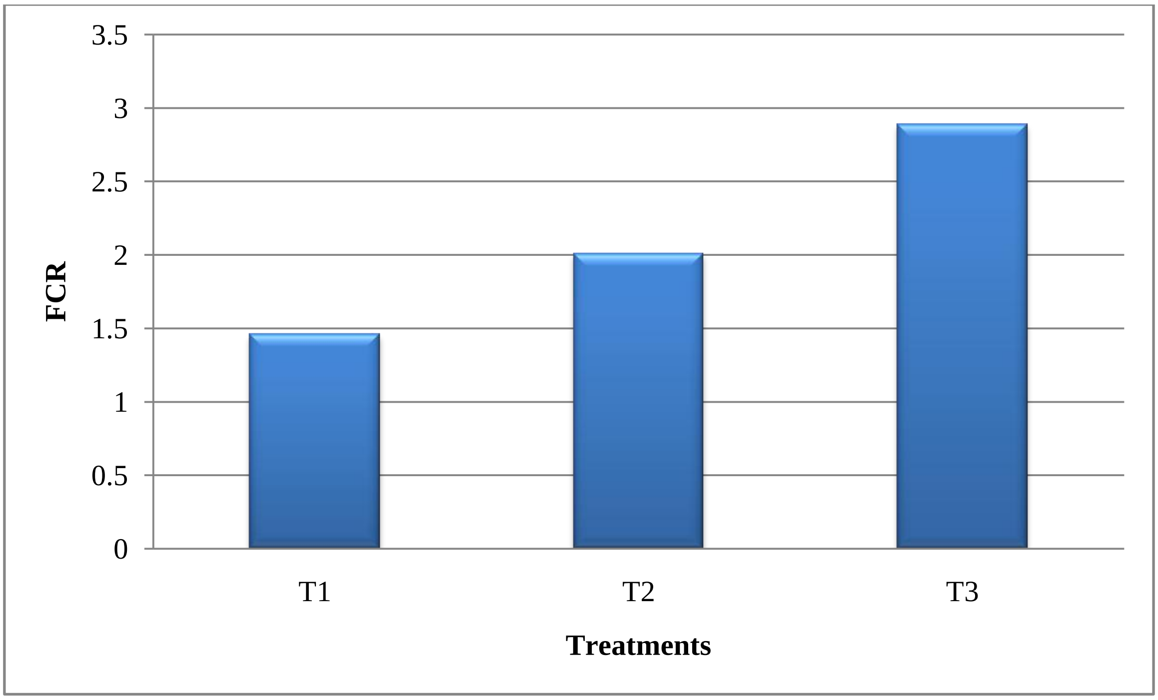

Figure 20. Food conversion ratio of tilapia in different treatments of stocking density trial-1

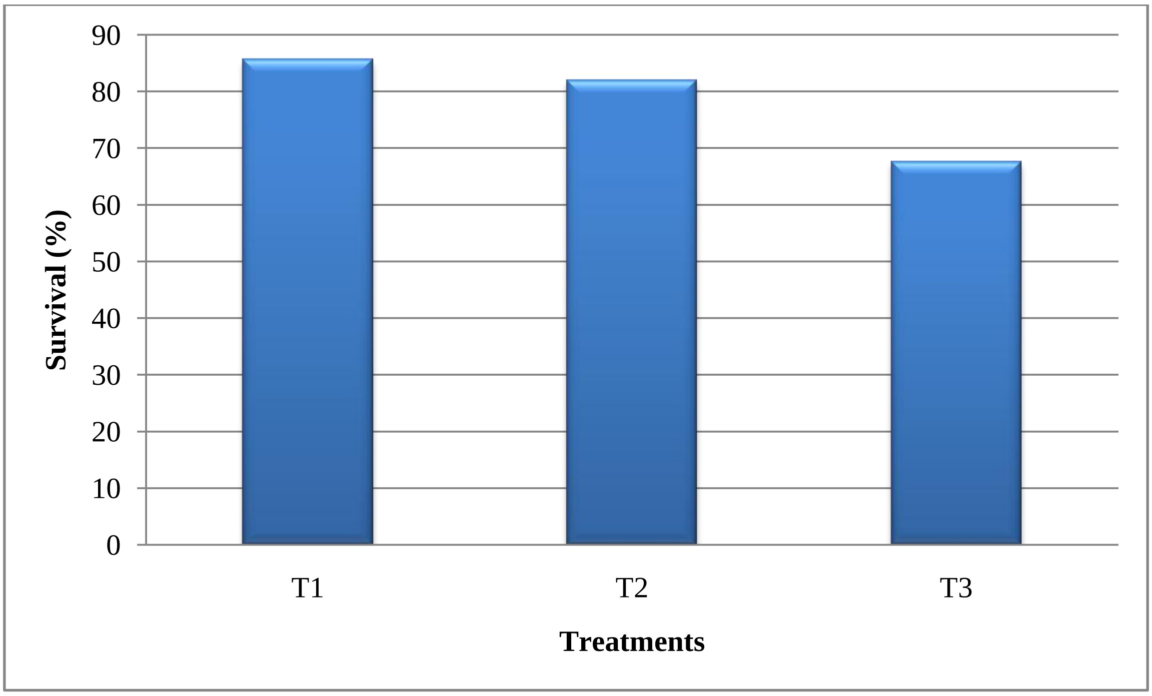

Figure 21. Survival rate of tilapia in different treatments of stocking density trial-1

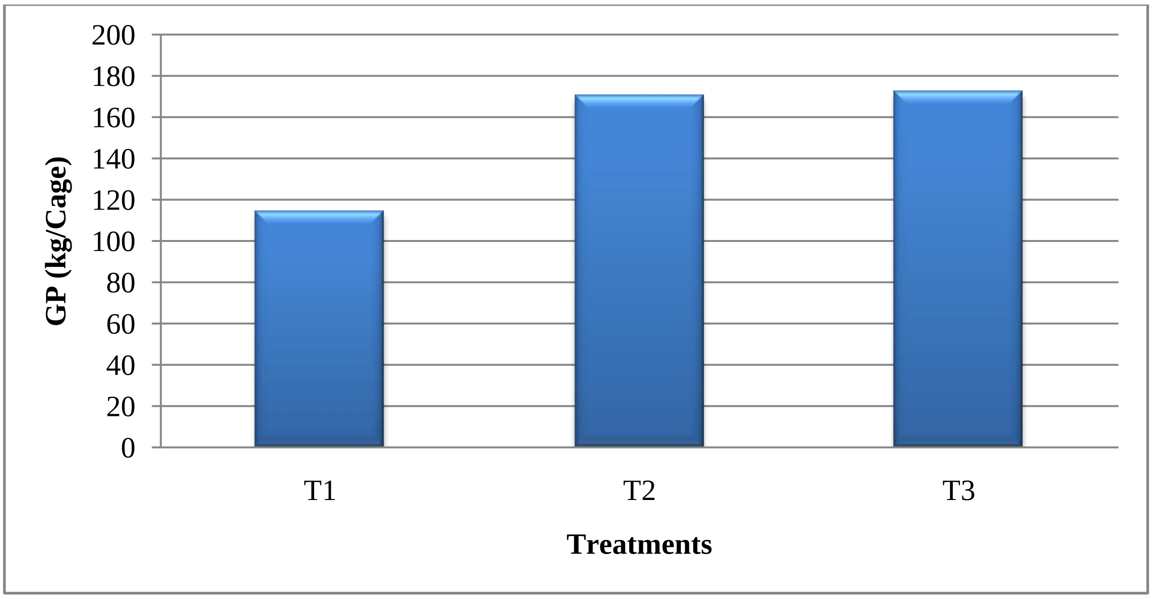

Figure 22. Gross production of tilapia in different treatments of stocking density trial-1

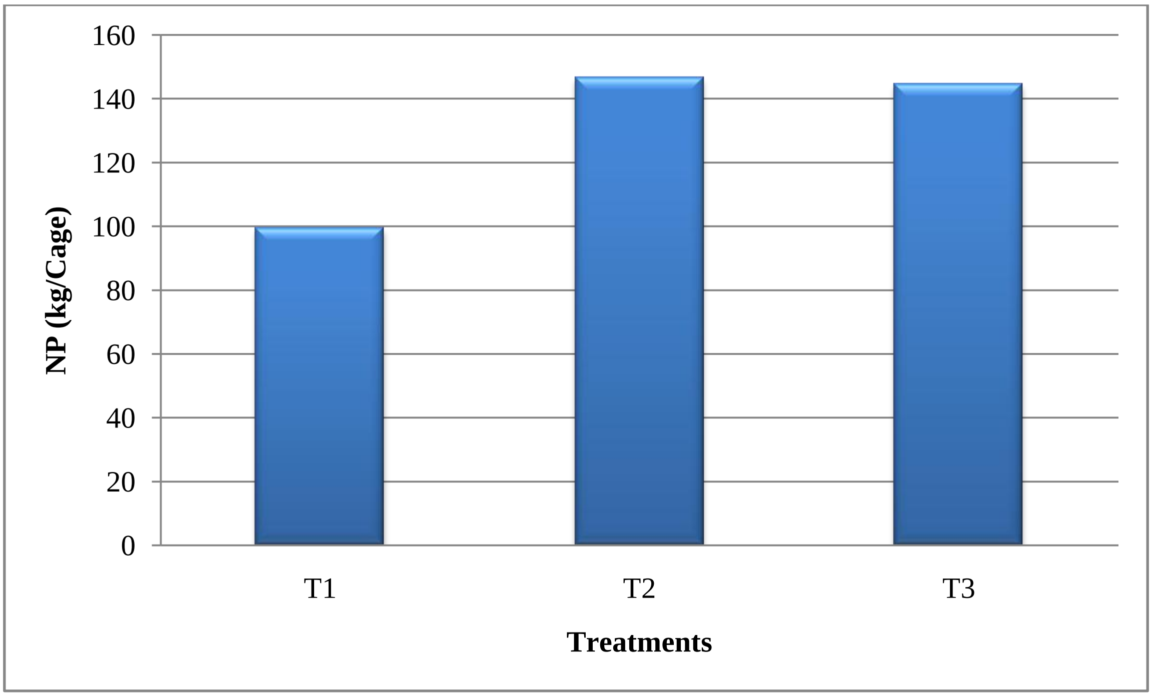

Figure 23. Net production of tilapia in different treatments of stocking density trial-1

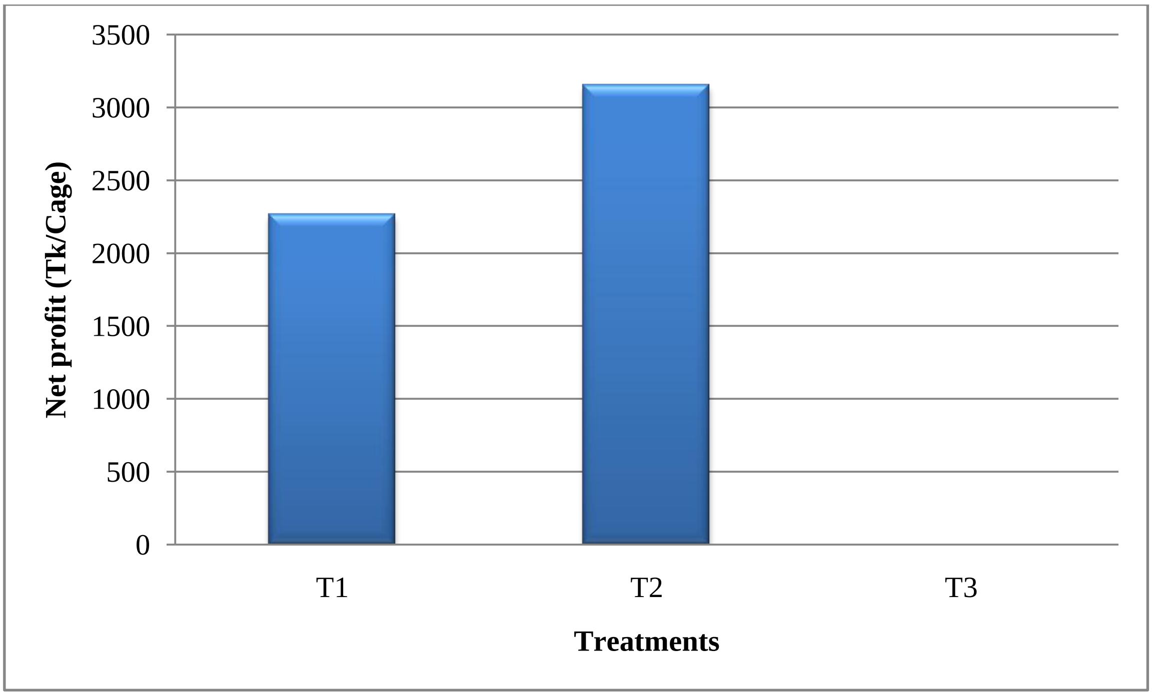

Figure 24. Net profit of tilapia in different treatments of stocking density trial-1

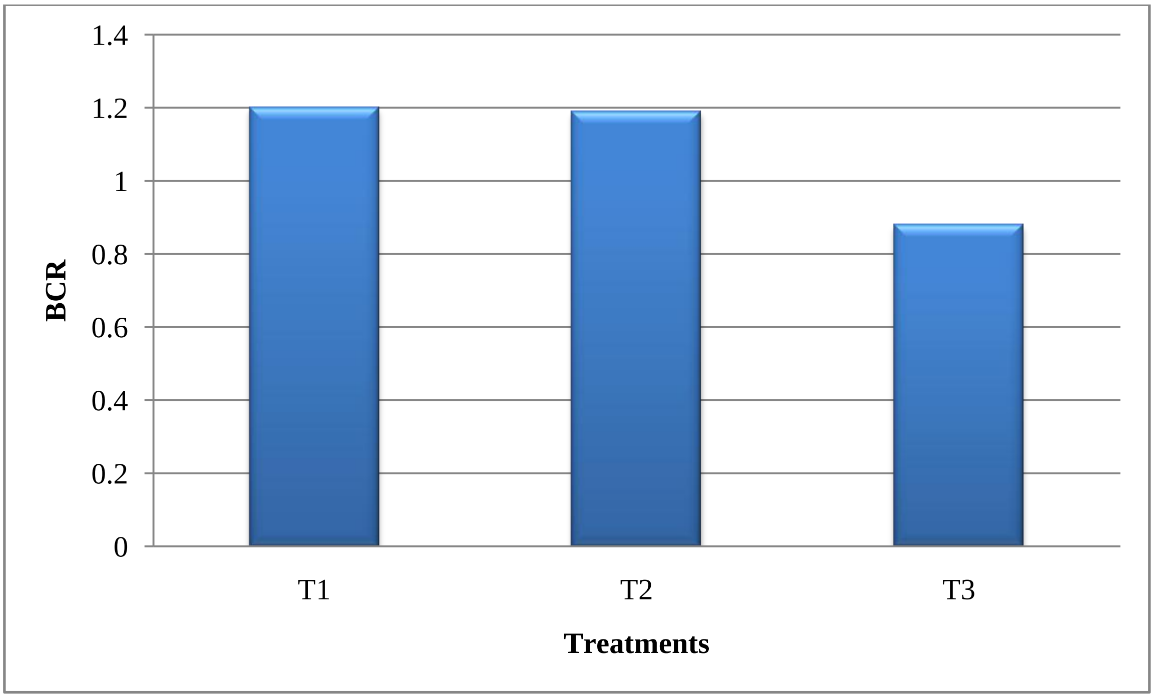

Figure 25. Benefit cost ratio of tilapia in different treatments of stocking density trial-1

Table 4. Effect of stocking density on monthly growth parameters of Tilapia cultured in net cage of Dakatia river, Echoli, Chandpur during 15 April- 13 August, 2010 at stocking density trial-1.

Treatments	**Monthly growth parameters**															
Stocking density (fish/m^3)	Mean weight gain - WG (g)				Mean relative growth rate - RGR (%)				Mean specific growth rate - SGR (%/day)				Mean food conversion ratio - FCR			
	1st month	2nd month	3rd month	4th month	1st month	2nd month	3rd month	4th month	1st month	2nd month	3rd month	4th month	1st month	2nd month	3rd month	4th month
30	29.32a	62.06a	55.05a	68.46a	90.74a	100.82c	44.53a	38.34a	2.14a	2.32b	1.22a	1.08a	1.65c	1.48a	1.45c	1.26c
50	23.08b	59.00a	48.74ab	68.18a	71.44b	106.53b	42.62a	41.86a	1.79b	2.41b	1.18a	1.16a	2.10b	1.41a	2.54b	1.94b
70	13.89 c	59.88a	41.75b	54.46a	42.98c	129.61a	39.40a	37.01a	1.19c	2.76a	1.10a	1.04a	3.48a	1.15b	3.86a	3.09a
LSD	3.73***	3.52	8.97*	14.12	11.54***	7.42***	9.45	10.84	0.22***	0.12***	0.22	0.26	0.30***	0.15**	0.56***	0.40***
CV (%)	8.45	2.92	9.25	11.10	8.44	3.31	11.21	13.89	6.43	2.40	9.60	11.97	6.26	5.40	10.76	9.55

Means bearing same letter(s) in a column do not differ significantly
*** indicates P < 0.001, ** indicates P < 0.01; * indicates P < 0.05

Table 5. Effect of stocking density on different parameters of Tilapia cultured in net cage of Dakatia river, Echoli, Chandpur during 15 April-13 August, 2010 at stocking density trial-1.

Treatments	Parameters									
Stocking density (fish/m^3)	Mean final weight (g)	Mean weight gain (g)	Mean relative growth rate (%)	Mean specific growth rate (%/day)	Mean food conversion ratio	Mean survival rate (%)	Mean gross production (kg)	Mean net production (kg)	Mean benefit cost ratio	Mean net profit (Tk)
30	247.27a	214.96a	68.61a	1.69a	1.47c	85.61a	114.30b	99.29b	1.20a	2263b
50	231.23b	198.92b	65.61b	1.63b	2.00b	81.92b	170.47a	146.66a	1.19a	3151a
70	202.29c	169.98c	62.25c	1.52c	2.90a	67.59c	172.24a	144.72a	0.88b	-2478 c
LSD	9.36***	9.36***	1.59***	0.04***	0.15***	2.07***	4.17***	4.51***	0.03***	430.36***
CV (%)	2.06	2.40	1.22	1.15	3.56	1.32	1.37	1.73	1.19	22.01

Means bearing same letter(s) in a column do not differ significantly
*** indicates $P < 0.001$

4.2. Stocking density trial -2

4.2.1. Physicochemical parameters of cage water

The physicochemical parameters in cage water of stocking density trial-2 were monitored fortnightly throughout the experimental period in Dakatia river, Roghunathpur, Chandpur during 5 June to 3 October, 2010. The monthly variations of recorded different physicochemical parameters in cage water are shown in Appendix 2 and graphically presented in Figure 26-36. In this trial, water depth ranged from 5.0 m in June to 5.5 m in October. Current velocity of water varied from 25 cm/sec in June to 37 cm/sec in October. The secchi-disk transparency varied from 38 cm in June to 71 cm in October. Secchi disk transparency showed a positive correlation with water current velocity ($p < 0.05$; $r = 0.951$) (Table 6). The highest water temperature was recorded 32.1°C in October and the lowest was 31.1°C in July. Total dissolved solids fluctuated from 4 mg/l in June, July to 6 mg/l in the month of September and October respectively. Total dissolved solids showed a positive correlation with secchi-disk transparency ($p < 0.05$; $r = 0.925$) (Table 6). Dissolved oxygen ranged from 5.68 mg/l in July to 7.2 mg/l in June. Free CO_2 varied from 4.2 mg/l in October to 4.6 mg/l in August. The water pH value ranged from 7.0 in July to 8.4 in October. The pH value showed positive correlation with water current velocity, ($p < 0.05$; $r = 0.916$) water temperature ($p < 0.05$; $r = 0.927$) and total dissolved solids ($p < 0.05$; $r = 0.885$) (Table 6). The total hardness of cage water was recorded lowest 46.32 mg/l in September and the highest 54.28 mg/l in June. Total alkalinity also found lowest 52.62 mg/l in September and the highest 68.62 mg/l in June. Total alkalinity showed positive correlation with dissolved oxygen ($p < 0.01$; $r = 0.967$) and total hardness ($p < 0.05$; $r = 0.944$) (Table 6). Ammonia-NH_3 was determined lowest 0.002 mg/l in September and the highest 0.006 mg/l in June. There is no salinity and Nitrite-NO_2 was found during the study period (Appendix 2).

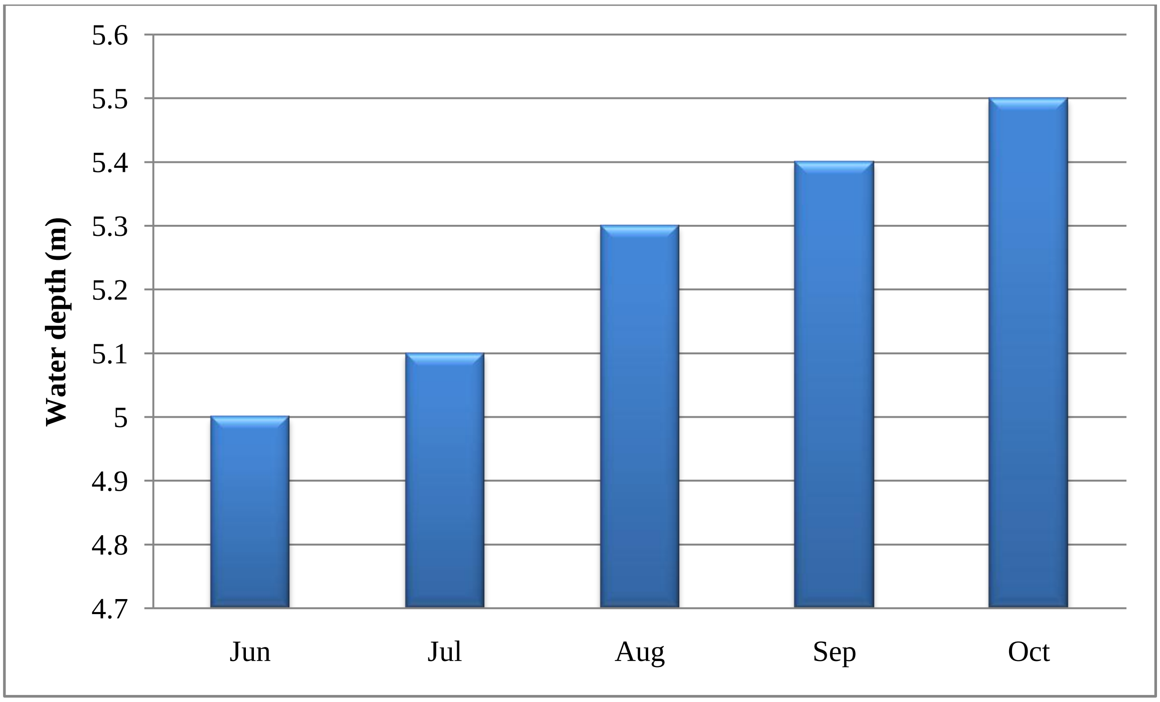

Figure 26. Monthly variations of water depth of Dakatia river, Roghunathpur, Chandpur during stocking density trial-2 of cage culture

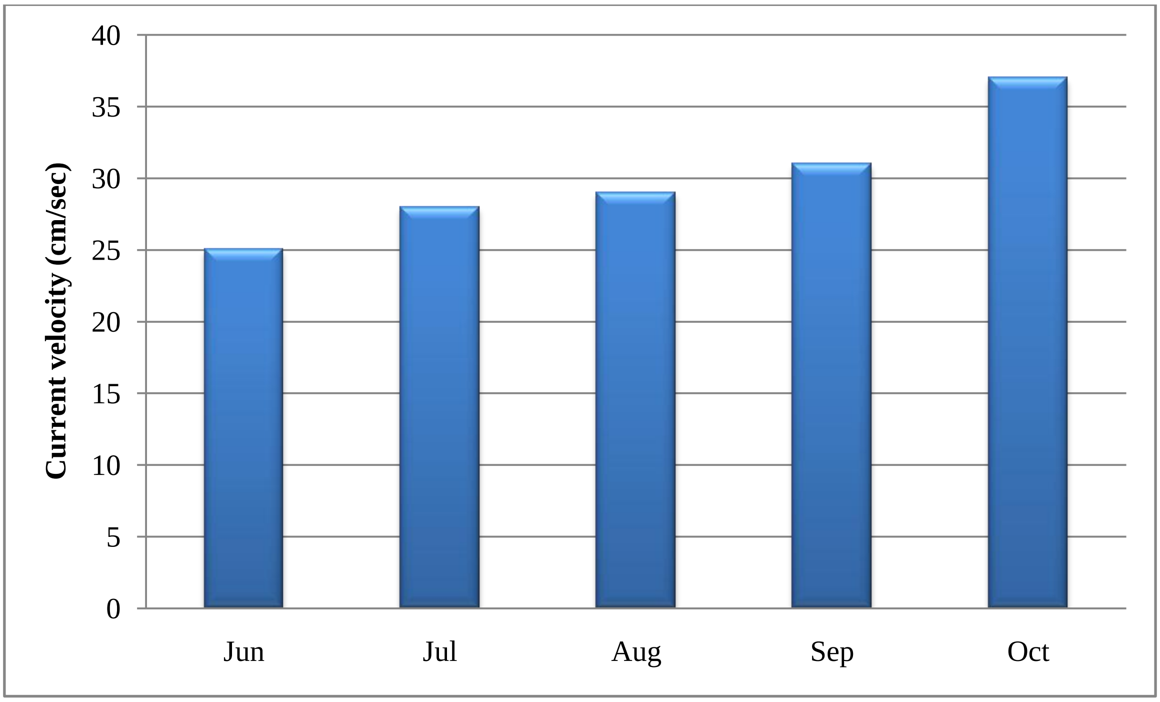

Figure 27. Monthly variations of water current velocity of Dakatia river, Roghunathpur, Chandpur during stocking density trial-2 of cage culture

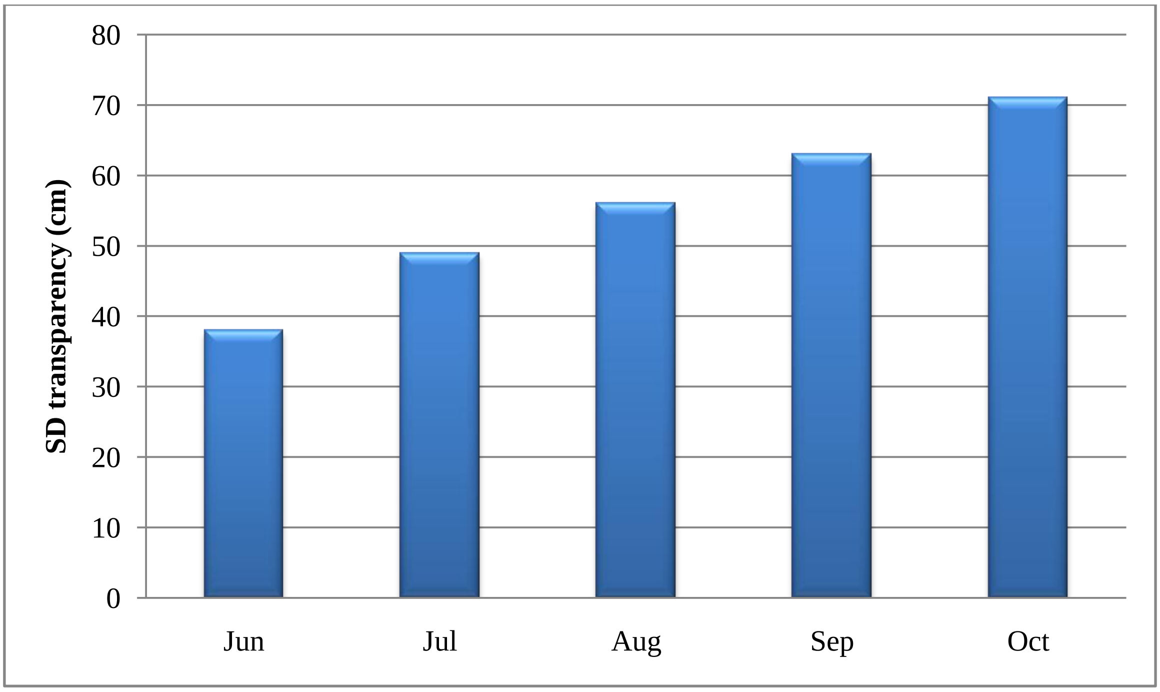

Figure 28. Monthly variations of Secchi disk transparency of water in Dakatia river, Roghunathpur, Chandpur during stocking density trial-2 of cage culture

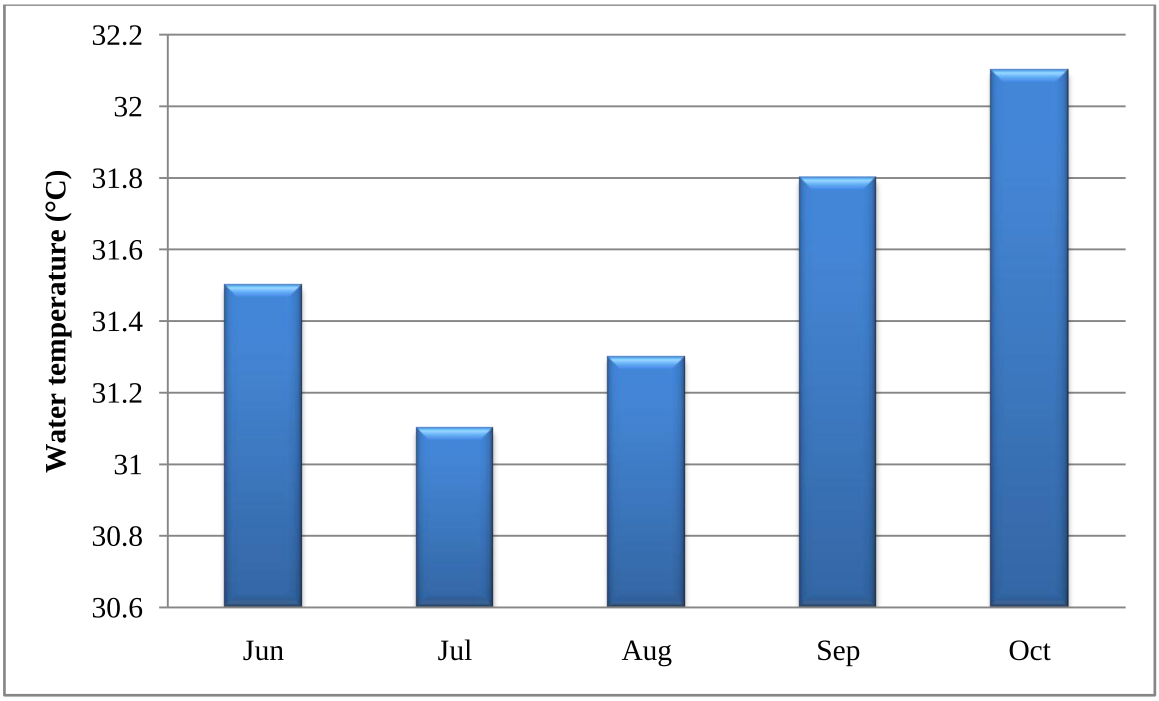

Figure 29. Monthly variations of water temperature in Dakatia river, Roghunathpur, Chandpur during stocking density trial-2 of cage culture

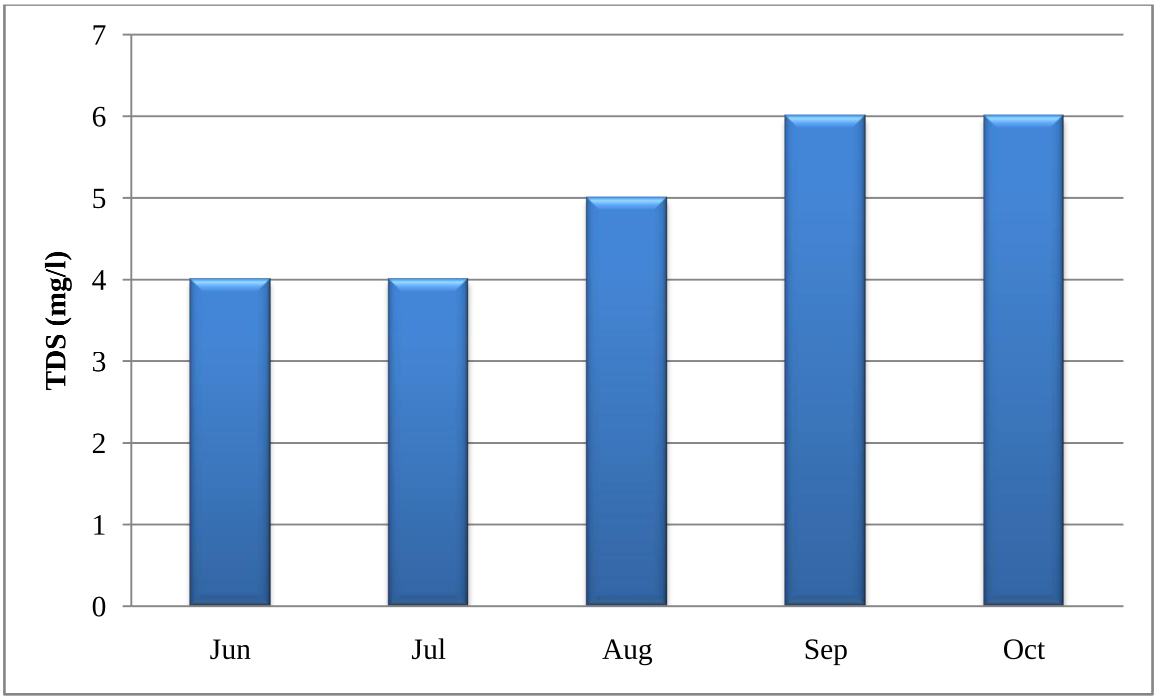

Figure 30. Monthly variations of total dissolved solids of water in Dakatia river, Roghunathpur, Chandpur during stocking density trial-2 of cage culture

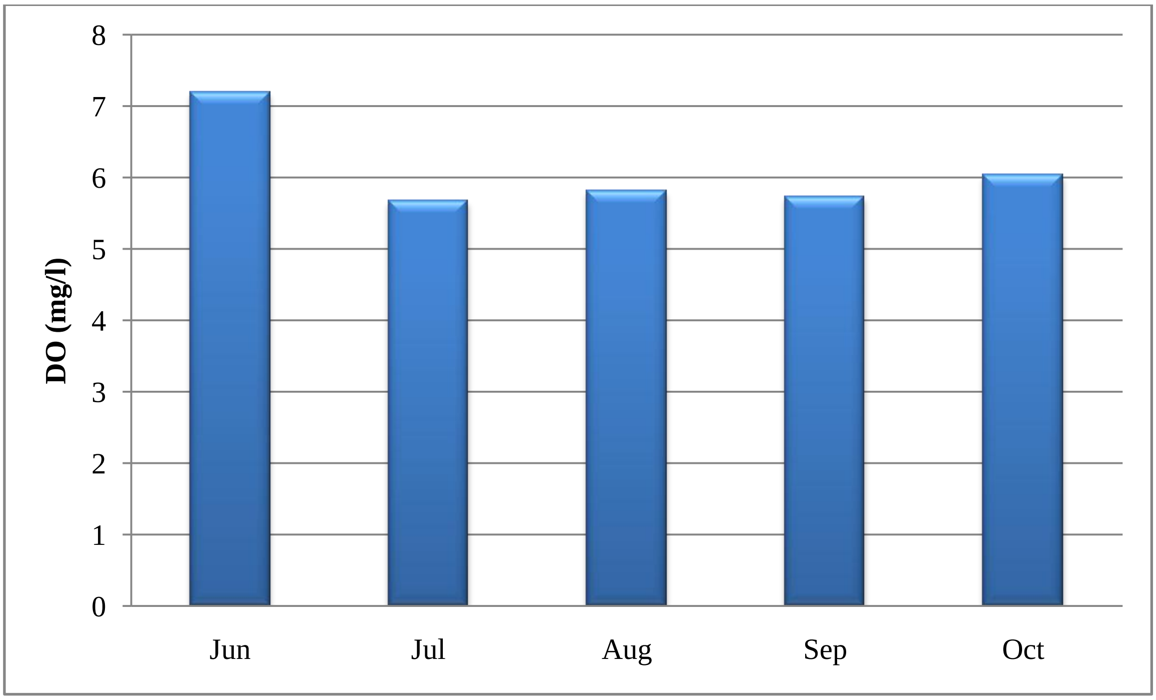

Figure 31. Monthly variations of dissolved oxygen of water in Dakatia river, Roghunathpur, Chandpur during stocking density trial-2 of cage culture

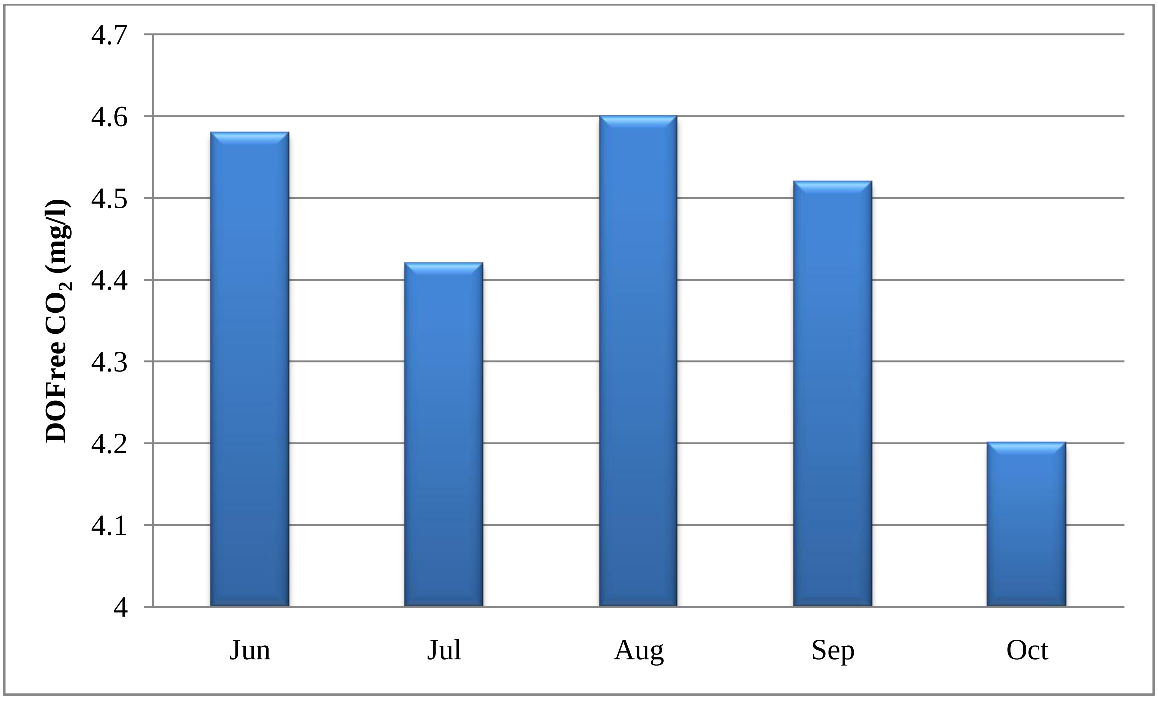

Figure 32. Monthly variations of free carbon dioxide of water in Dakatia river, Roghunathpur, Chandpur during stocking density trial-2 of cage culture

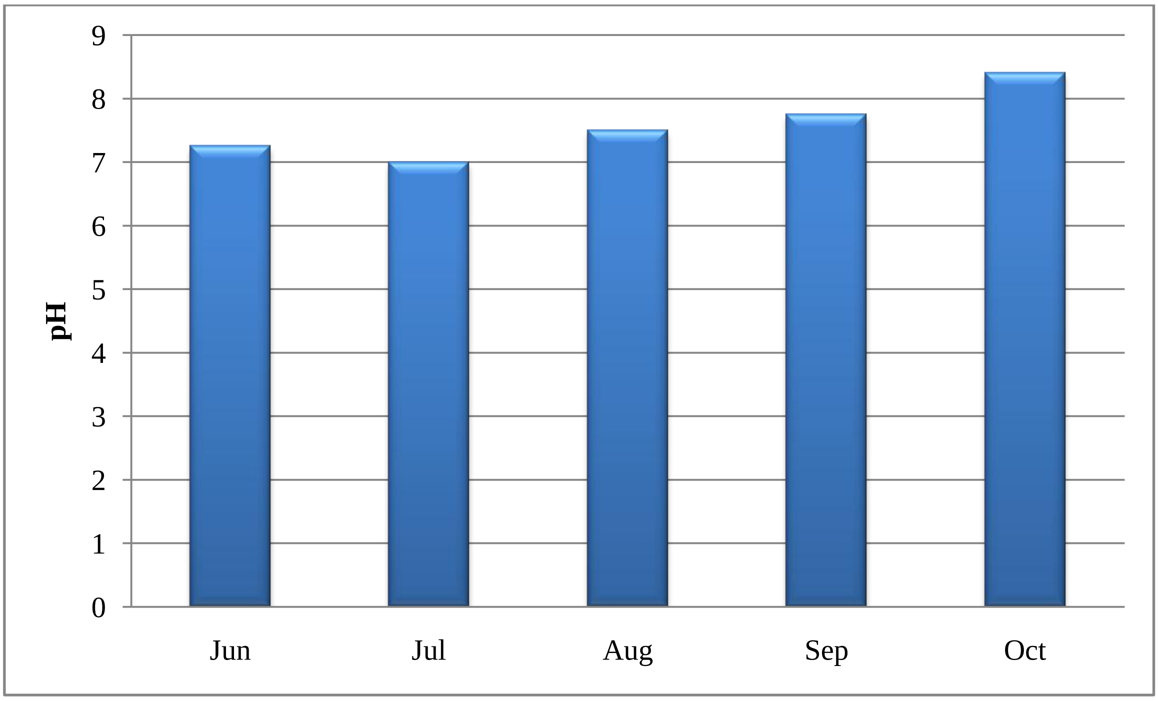

Figure 33. Monthly variations of water pH in Dakatia river, Roghunathpur, Chandpur during stocking density trial-2 of cage culture

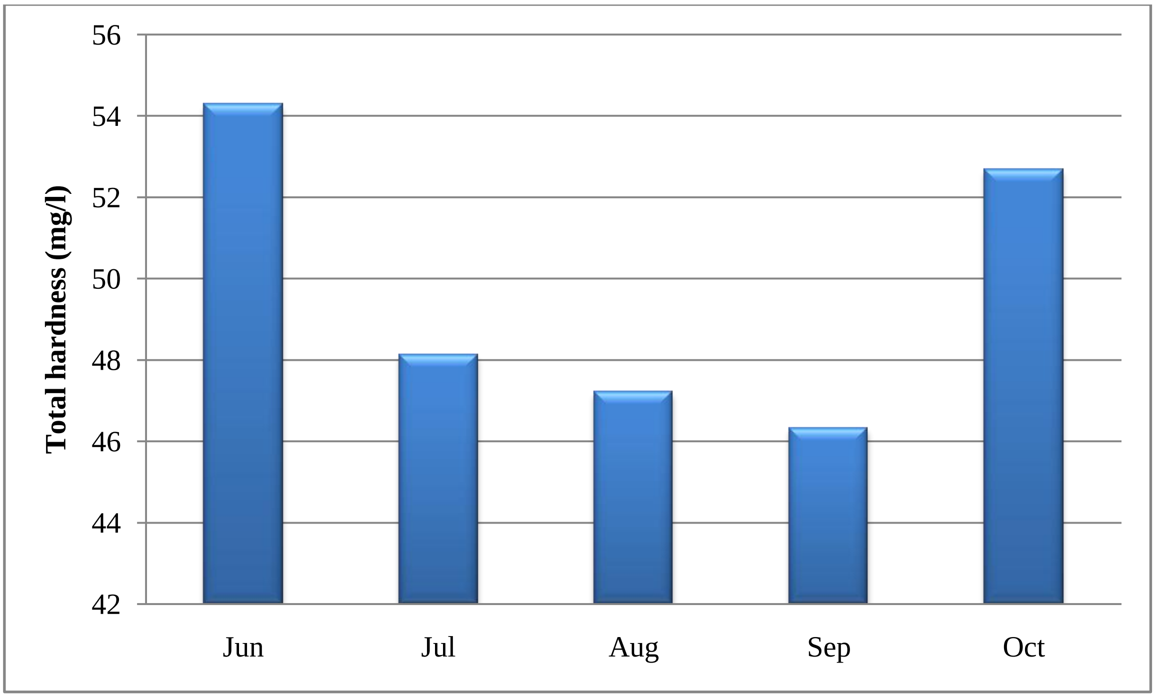

Figure 34. Monthly variations of total hardness of water in Dakatia river, Roghunathpur, Chandpur during stocking density trial-2 of cage culture

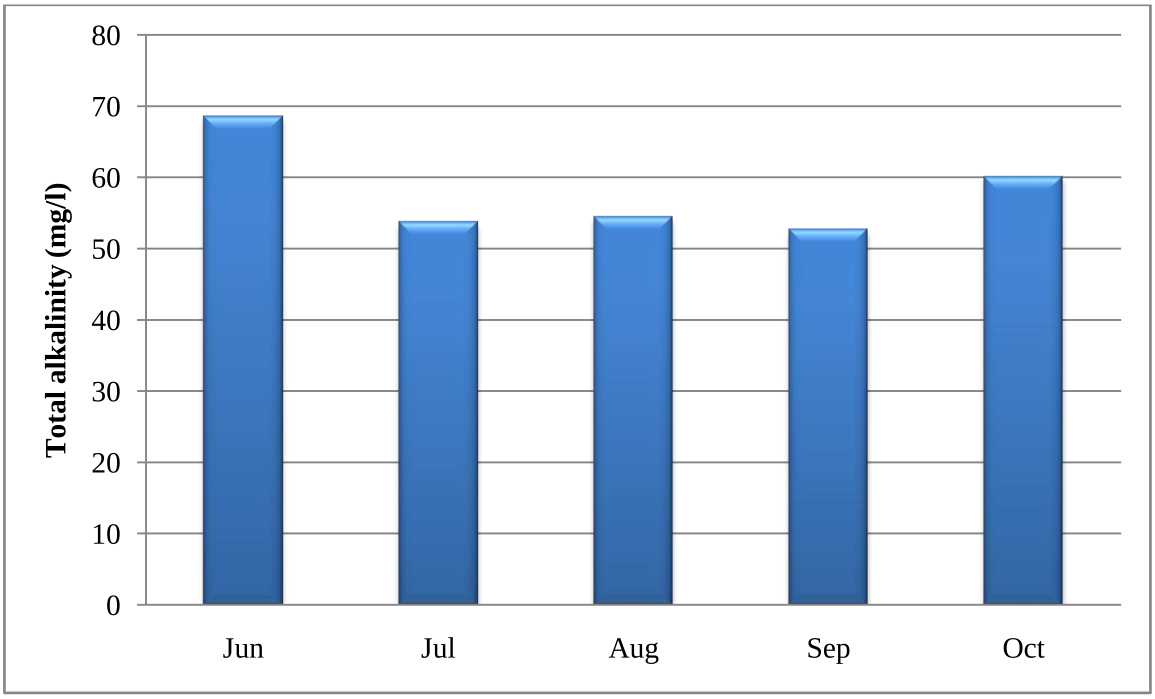

Figure 35. Monthly variations of total alkalinity of water in Dakatia river, Roghunathpur, Chandpur during stocking density trial-2 of cage culture

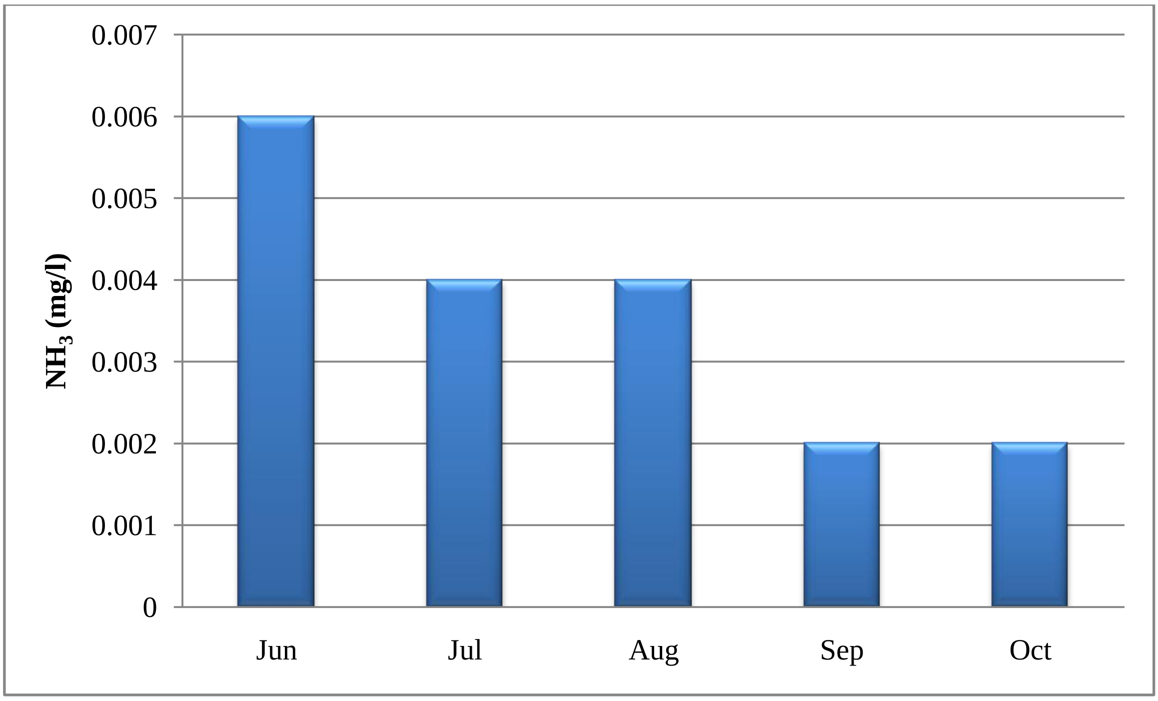

Figure 36. Monthly variations of ammonia of water in Dakatia river, Roghunathpur, Chandpur during stocking density trial-2 of cage culture

Table 6. Correlation Matrix of Water Quality parameters during culture period in stocking density trial-2

	WCV	SDT	WT	TDS	DO	CO_2	pH	TH	TA
WCV	1								
SDT	.951*	1							
WT	.773	.697	1						
TDS	.839	.925*	.818	1					
DO	-.456	-.632	.081	-.435	1				
CO_2	-.828	-.644	-.582	-.429	.251	1			
PH	.916*	.861	.927*	.885*	-.153	-.657	1		
TH	.004	-.280	.338	-.240	.832	-.310	.194	1	
TA	-.263	-.493	.202	-.359	.967**	.014	.008	.944*	1

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

WCV = Water Current Velocity, SDT = Secchi Disk Transparency, WT = Water Temperature, TDS =Total Dissolved Solids, DO = Dissolved Oxygen, CO_2 = Carbon Di-oxide, pH = Hydrogen Ion Concentration, TH =Total Hardness, TA =Total Alkalinity

4.2.2. Growth parameters of stocking density trial-2

Final weight (FW)

After 120 days the mean final weight of the tilapia of different treatments in cage ranged from 201.15g to 376.72g, while the initial average weight was 28.92g for each treatment. The highest final weight attained in T_1 (376.72g) followed by T_2 (276.64g) and T_3 (201.15g) respectively (Table 7 & Figure 41). The final weight expressed highly significant differences ($p < 0.001$) among the three treatments (Table 9).

Weight gain (WG)

The monthly weight gain in stocking density trial-2 fluctuated from 40.55g to 125.56g in T_1, it ranged from 24.92g to 76.83g in $T_{2,}$ whereas, it ranged from 22.40g to 63.61g in T_3 (Appendix- 6 & Figure 37). The monthly weight gain was found significantly differences among three treatments in all the first to fourth month ($p < 0.001$) (Table 8). All the three treatments, the highest weight gain observed 347.80g in T_1 and followed by T_2 (247.72g) and T_3 (172.23g) respectively (Table 7 & Figure 42). The weight gain was showed highly significant differences ($p < 0.001$) among the three treatments (Table 9).

Relative growth rate (RGR)

The monthly relative growth rate fluctuated from 34.51% to 140.23% in T_1, from 33.98% to 141.09% in T_2, from 24.47% to 123.97% in T_3 respectively (Appendix 6 & Figure 38). The monthly relative growth rate found highly significant differences ($p < 0.001$) among three treatments in first and third months whereas, significant differences ($p < 0.05$) in second and fourth months (Table 8). The highest relative growth rate was found 94.63% in T_1 followed by T_2 (80.14%) and T_3 (66.62%), respectively (Table 7 & Figure 43). The relative growth rate found significantly differences ($p < 0.001$) among the three treatments (Table 9).

Specific growth rate (SGR)

The monthly specific growth rate fluctuated from 0.98%/day to 2.91%/day in $T_{1.}$ In case of T_2 it ranged from 0.97%/day to 2.92%/day, while in T_3 specific growth rate varied from 0.72%/day to 2.68%/day (Appendix 6 & Figure 39). The monthly specific growth rate found highly significant differences ($p < 0.001$) among the three treatments in first and third months whereas, significant differences ($p < 0.05$) in second and fourth months (Table 8). Among the three treatments, highest specific growth rate 2.13%/day recorded in T_1 followed by T_2 (1.87%/day) and T_3 (1.61%/day), respectively (Table 7 & Figure 44). The specific growth rate found highly significant differences ($p < 0.001$) among the three treatments (Table 9).

Food conversion ratio (FCR)

The monthly food conversion ratio of stocking density trial-2 fluctuated from 1.06 to 2.63 in T_1, from 1.06 to 2.65 in T_2 and from 1.20 to 3.67 in $T_{3,}$ respectively (Appendix 6 & Figure 40). The monthly food conversion ratio was found highly significant differences ($p < 0.001$) in first and third months while significantly differences ($p < 0.01$) found in second and fourth months among the three treatments (Table 8). Food conversion ratio was found 1.59, 1.87 and 2.43 in T_1, T_2 and T_3 respectively, where T_3 shown the highest value and T_1 was the lowest (Table 7 & Figure 45). The food conversion ratio was found highly significant differences ($p < 0.001$) among the three treatments (Table 9).

Survival rate

The survival rate of tilapia in cage was found varied from 84.38% to 97.92%. The highest survival rate was found in T_1 (97.92%) followed by T_2 (86.73%) and T_3 (84.38%) respectively (Table 7 & Figure 46). The survival rate was found highly significant differences ($p < 0.001$) among the three treatments (Table 9).

Gross production (GP)

Gross production of the tilapia was varied from 305.54 kg/cage to 331.96 kg/cage in different treatments of the stocking density trial-2. The gross production was recorded highest 331.96 kg/cage in T_1 followed by T_2 (323.92 kg/cage) and T_3 (305.54 kg/cage) respectively (Table 7 & Figure 47). The gross production was found significantly different ($p < 0.01$) between T_1 and T_3, and T_2 and T_3 (Table 9).

Net production (NP)

Net production of the tilapia was recorded from 261.60 kg/cage to 306.48 kg/cage in different treatments of the stocking density trial-2. The net production also was recorded highest 306.48 kg/cage in T_1 followed by T_2 (290.05 kg/cage) and T_3 (261.60 kg/cage) respectively

(Table 7 & Figure 48). Net production was found highly significant differences ($p < 0.001$) among the three treatments (Table 9).

Net profit

The detail of net profit determination of this trial is shown in table (Appendix 10). Net profit of the different treatments of the stocking density trial-2 was found in ranged from 2211Tk/cage to 17215Tk/cage. The net profit was recorded highest in T_1 (17215Tk/cage) followed by T_2 (9740Tk/cage) and T_3 (2211Tk/cage) respectively (Table 7 & Figure 49). Net profit showed highly significant differences ($p < 0.001$) among the three treatments (Table 9).

Benefit cost ratio (BCR)

The detail of benefit cost ratio determination of stocking density trial-2 is shown in table (Appendix 10). The benefit cost ratio was calculated ranged from 1.07 to 1.81 in different treatments in this trial. The highest benefit cost ratio was achieved in T_1 (1.81) followed by T_2 (1.37) and T_3 (1.07) respectively (Table 7 & Figure 50). Benefit cost ratio expressed the highly significant differences ($p < 0.001$) among the three treatments (Table 9).

Table 7. Growth performance of tilapia under different treatments of stocking density trial- 2 in Dakatia river, Roghunathpur, Chandpur during 05 June - 03 October, 2010.

Parameters	**Treatments**				
	T_1-(50/m^3) 900/cage	T_2- (75/m^3) 1350/cage	T_3-(100/m^3) 1800/cage	Range	Mean ± SD
Initial weight- IW (g)	28.92	28.92	28.92	28.92 - 28.92	28.92±0
Final weight- FW (g)	376.72	276.64	201.15	201.15 - 376.72	284.84±88.07
Weight gain- WG (g)	347.80	247.72	172.23	172.23 - 347.80	255.92±88.07
Relative growth rate- RGR (%)	94.63	80.14	66.62	66.62 - 94.63	80.46±14.00
Specific growth rate- SGR(%/day)	2.13	1.87	1.61	1.61- 2.13	1.87±0.26
Food conversion ratio- FCR	1.59	1.87	2.43	1.59 - 2.43	1.96±0.43
No. of fish harvested	881	1171	1519	881 - 1519	1190.33±319.44
Survival (%)	97.92	86.73	84.38	84.38 - 97.92	89.68±7.23
Gross production- GP (kg/cage)	331.96	323.92	305.54	305.54 - 331.96	320.47±13.54
Net production- NP (kg/cage)	306.48	290.05	261.60	261.60 - 306.48	286.04±22.71
Net profit (Tk/cage)	17215	9740	2211	2211 - 17215	9722±7502.01
Benefit cost ratio- BCR	1.81	1.37	1.07	1.07 - 1.81	1.42±0.37

Feeding: 5-3% body weight feed daily in each treatment

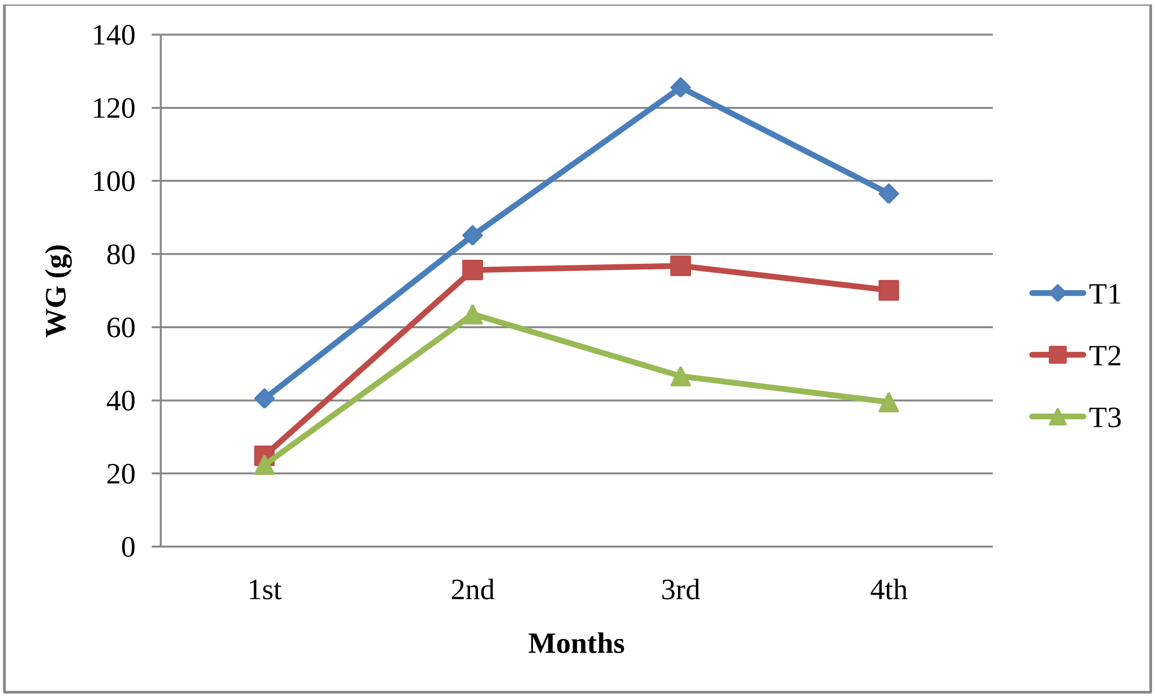

Figure 37. Monthly variations of weight gain in different treatments of stocking density trial-2

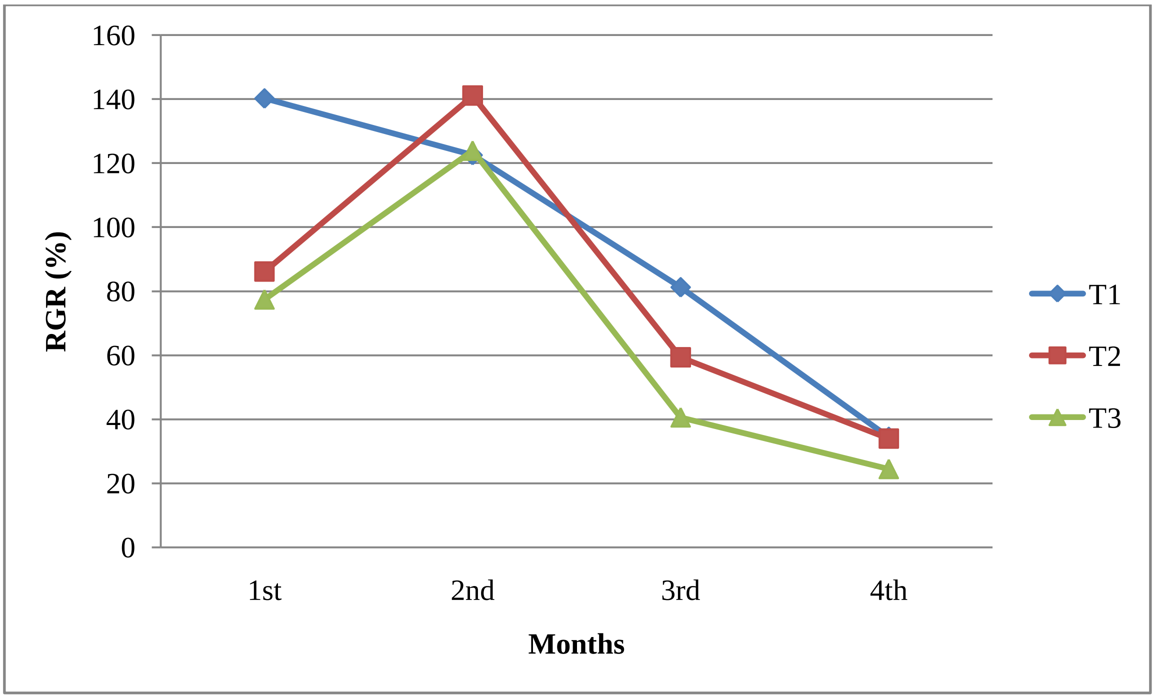

Figure 38. Monthly variations of relative growth rate in different treatments of stocking density trial-2

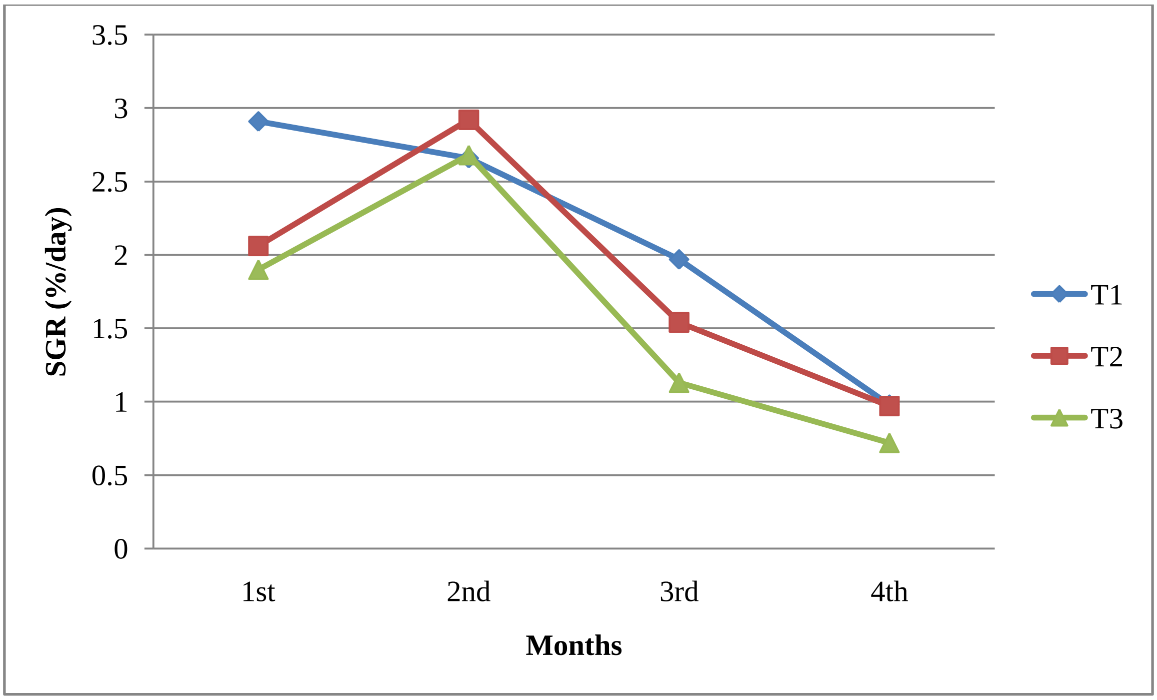

Figure 39. Monthly variations of specific growth rate in different treatments of stocking density trial-2

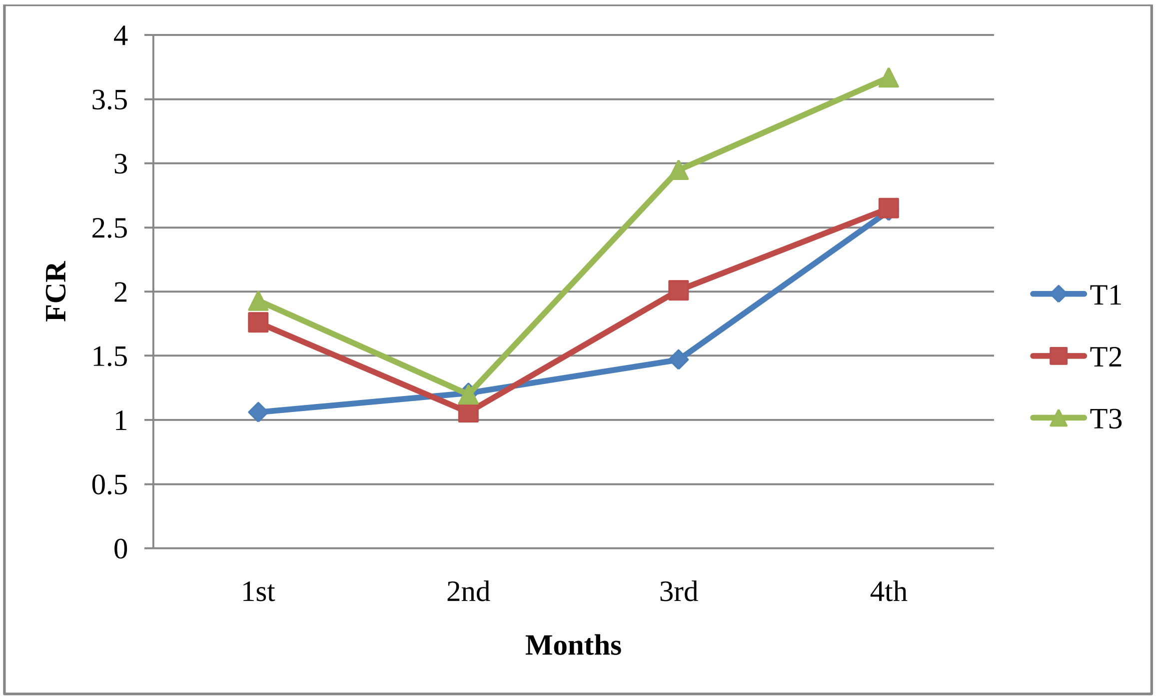

Figure 40. Monthly variations of feed conversion ratio in different treatments of stocking density trial-2

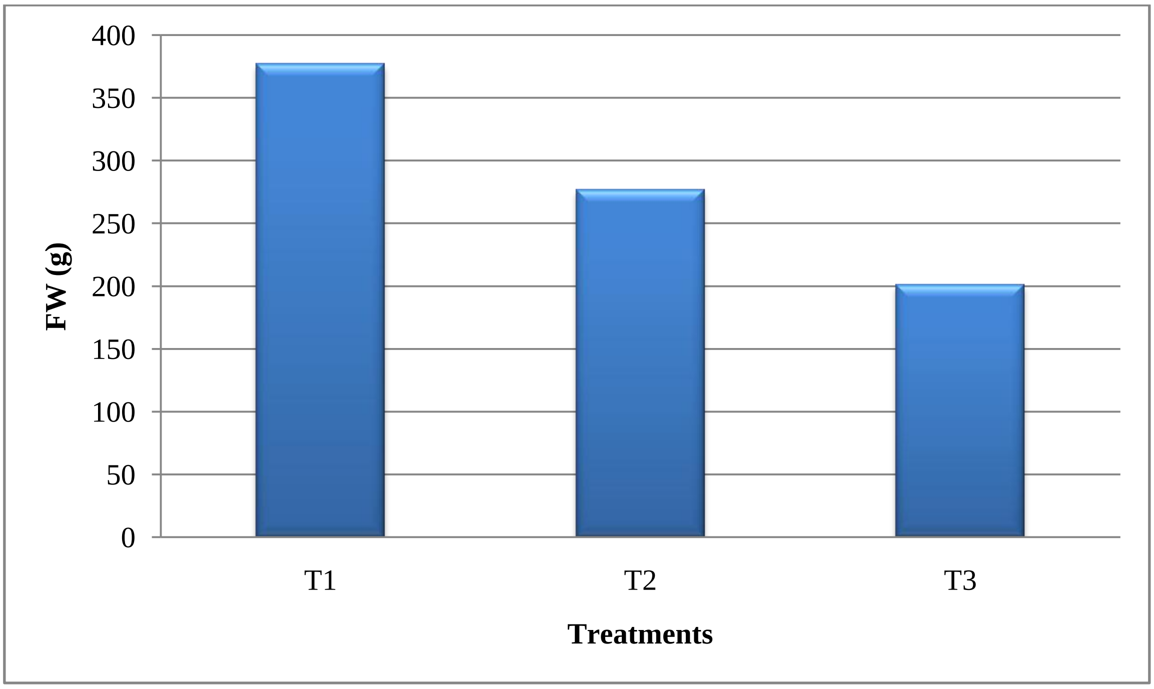

Figure 41. Final weight of tilapia in different treatments of stocking density trial-2

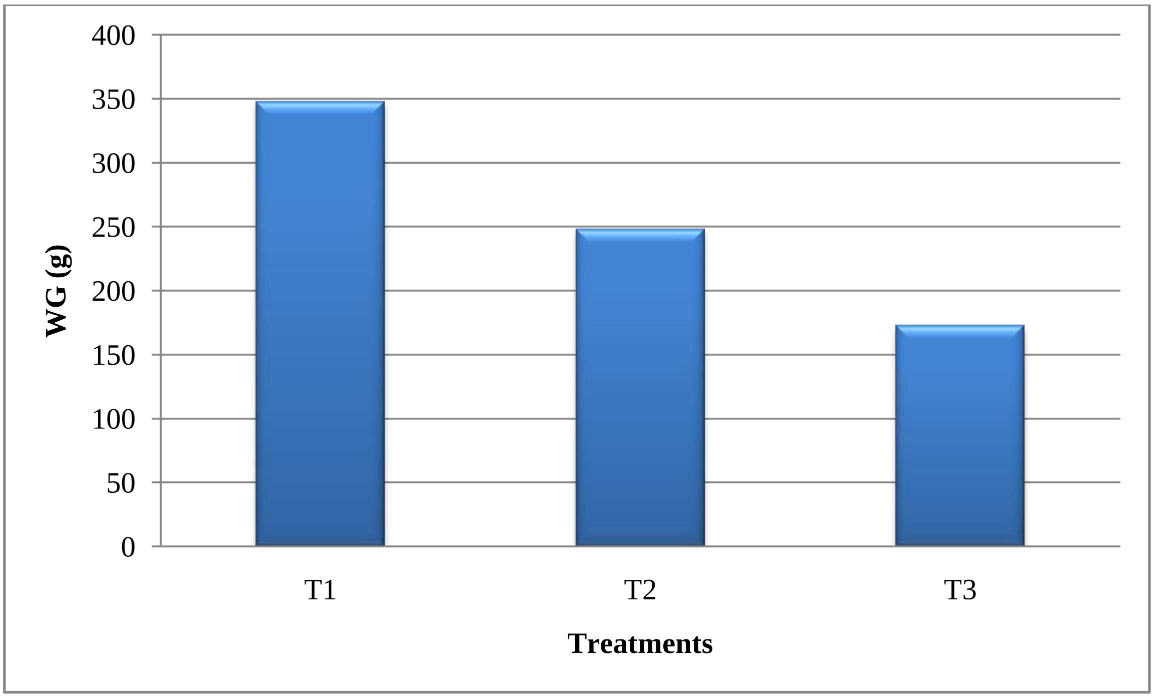

Figure 42. Weight gain of tilapia in different treatments of stocking density trial-2

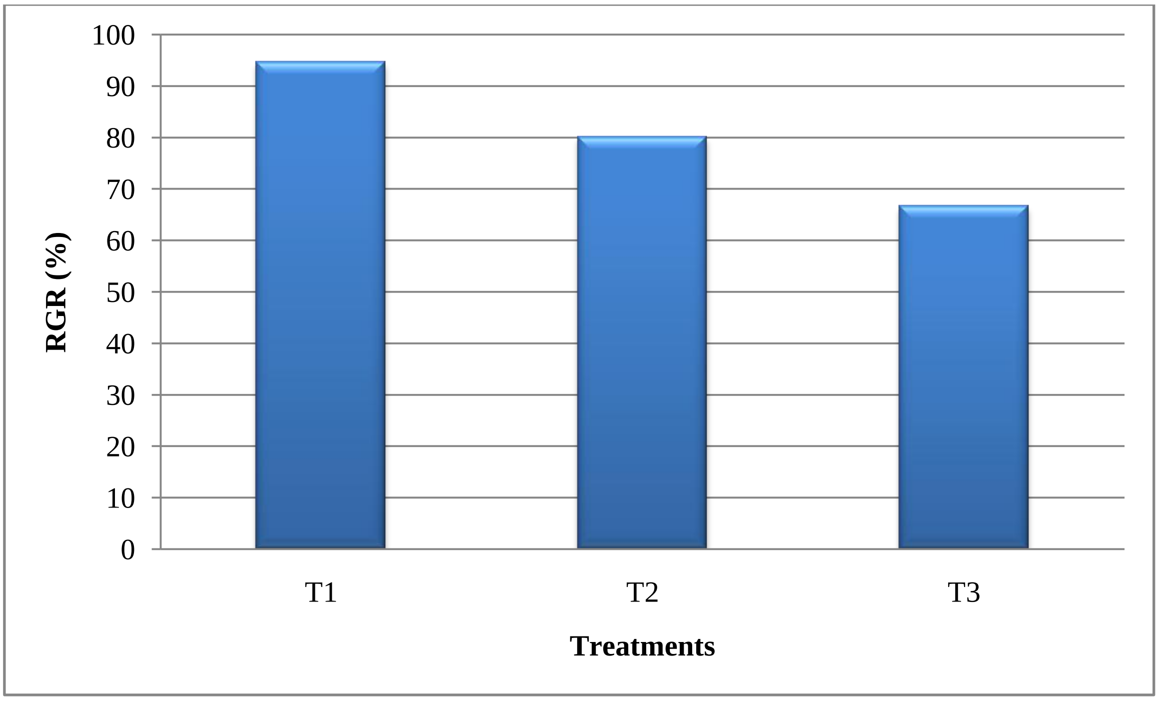

Figure 43. Relative growth rate of tilapia in different treatments of stocking density trial-2

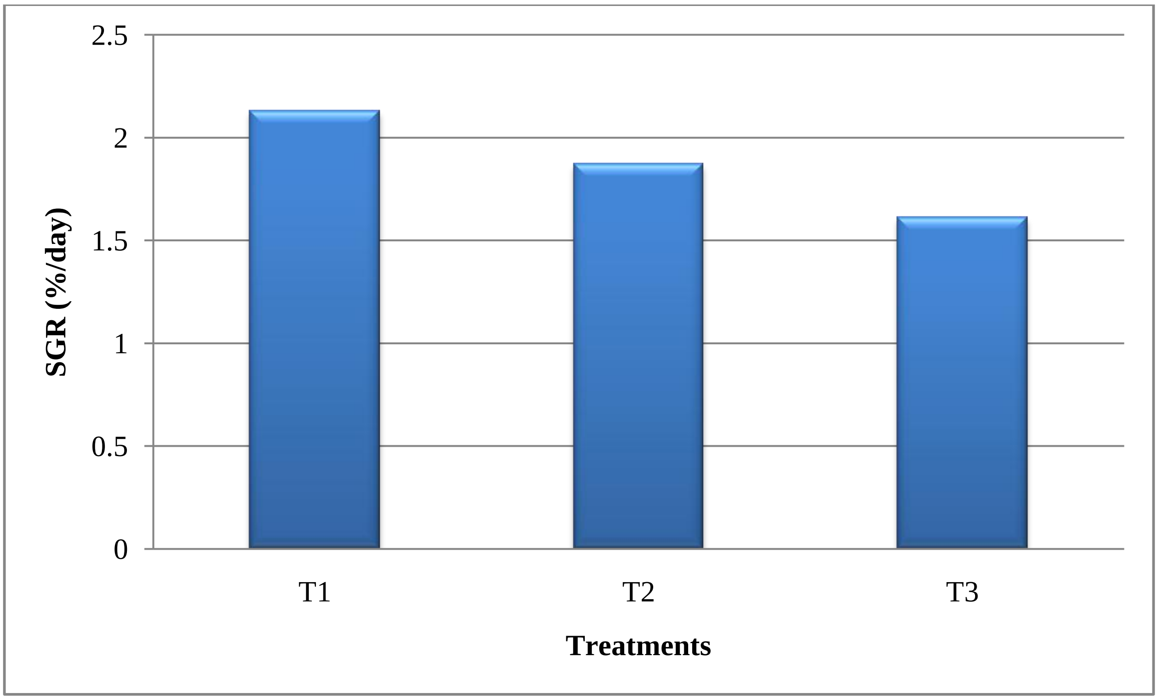

Figure 44. Specific growth rate of tilapia in different treatments of stocking density trial-2

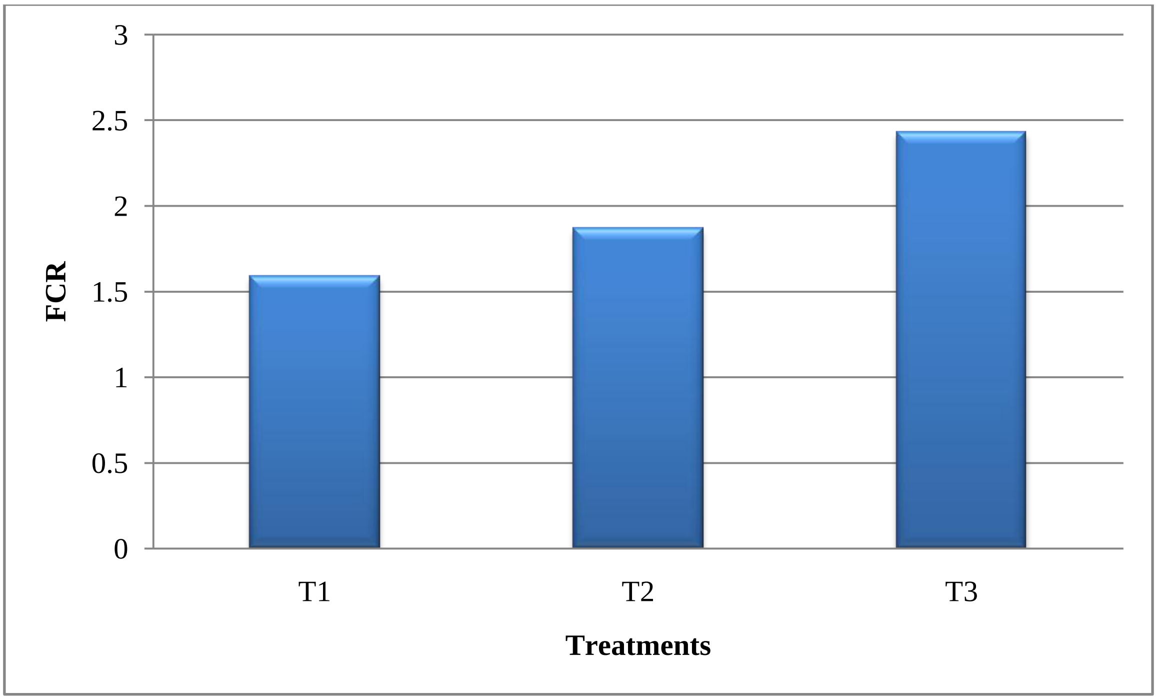

Figure 45. Food conversion ratio of tilapia in different treatments of stocking density trial-2

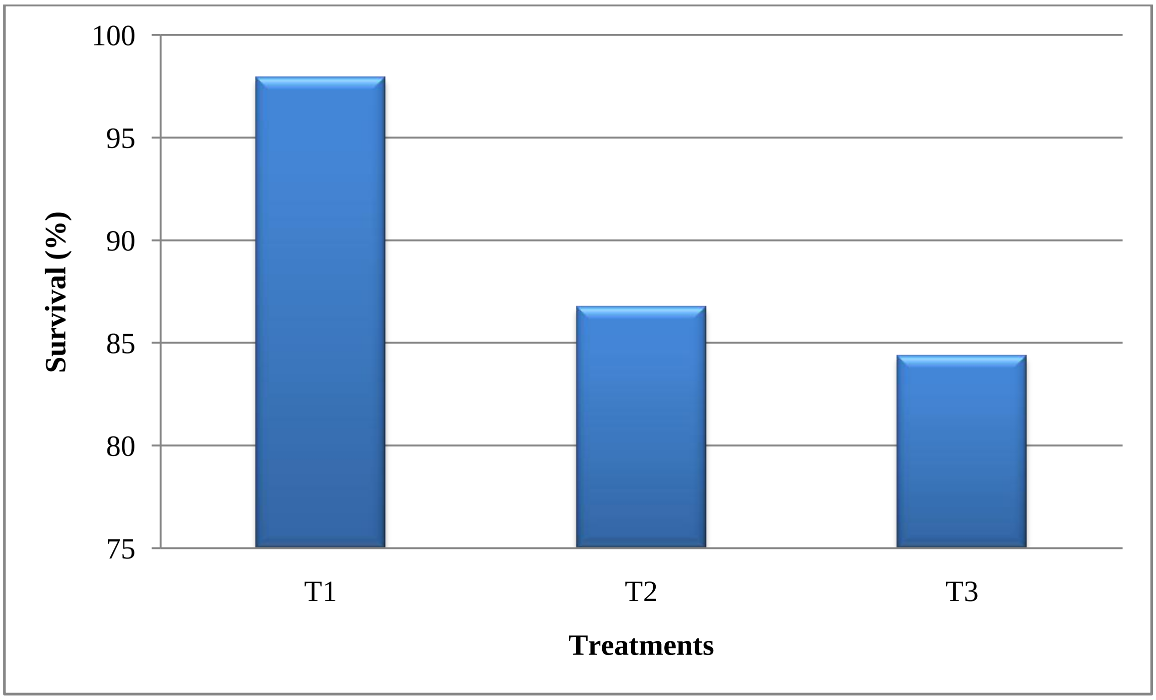

Figure 46. Survival rate of tilapia in different treatments of stocking density trial-2

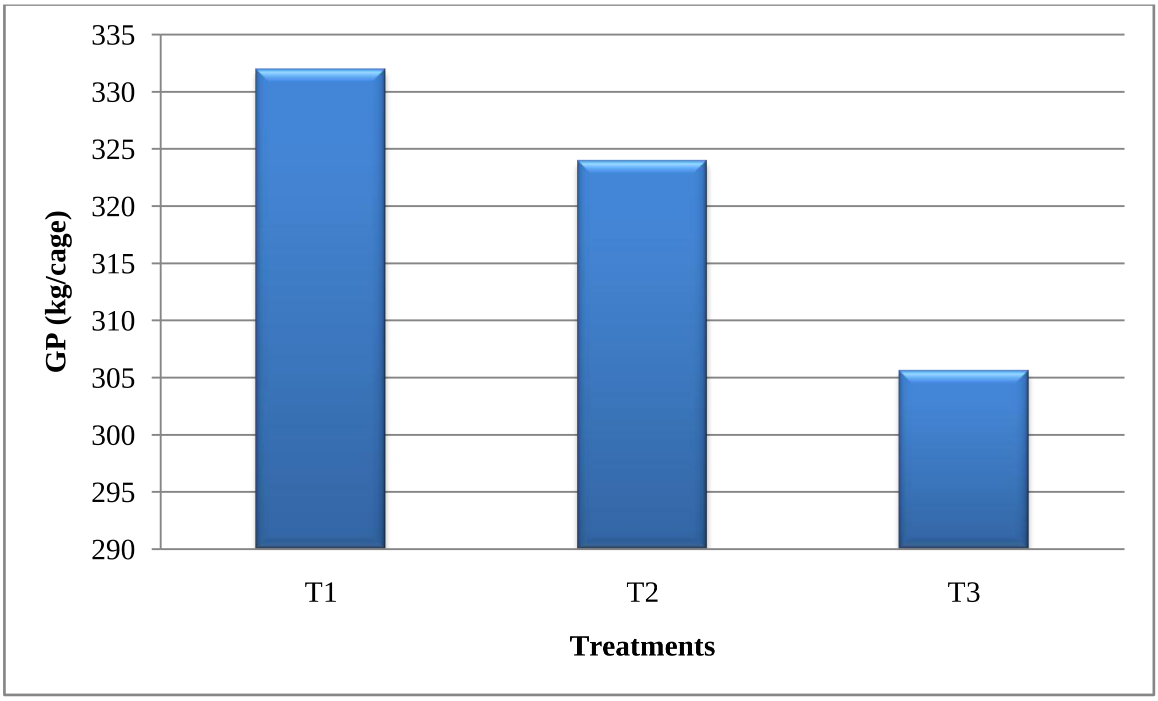

Figure 47. Gross production of tilapia in different treatments of stocking density trial-2

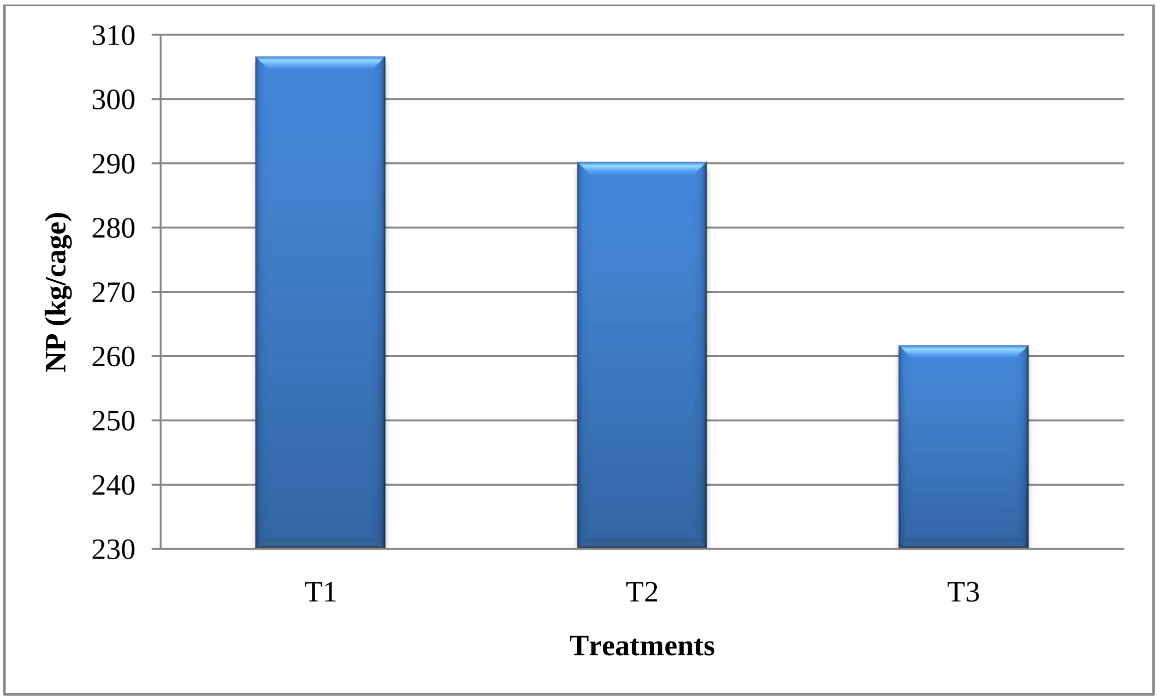

Figure 48. Net production of tilapia in different treatments of stocking density trial-2

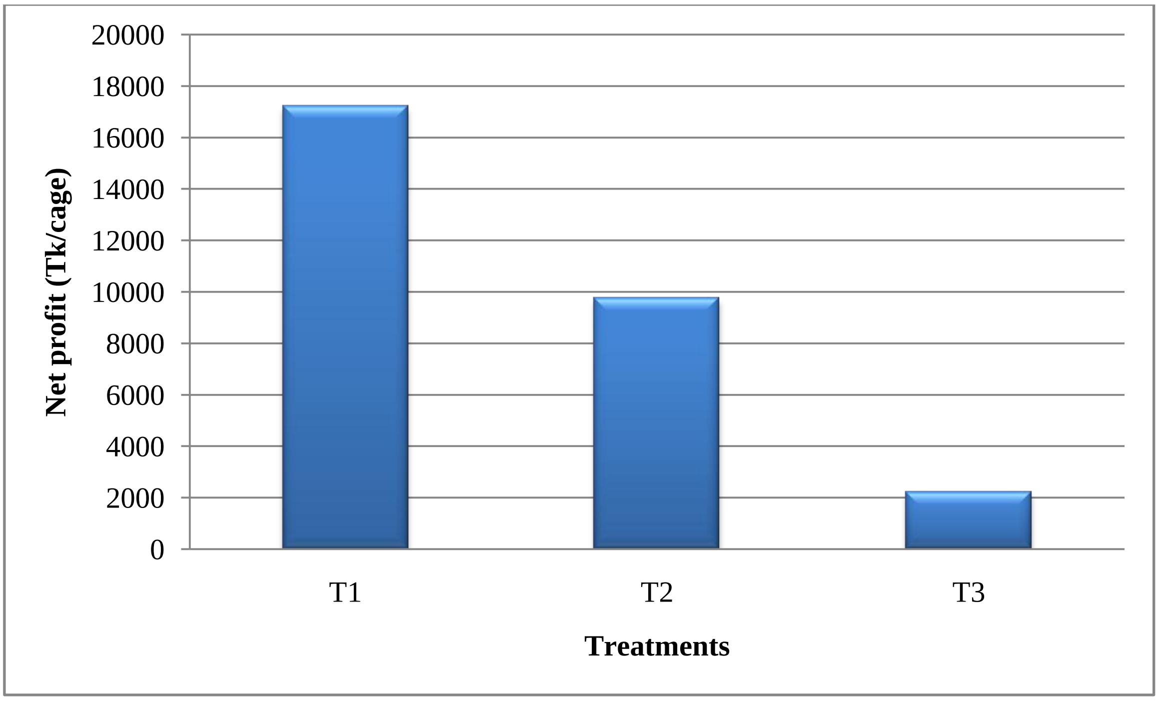

Figure 49. Net profit of tilapia in different treatments of stocking density trial-2

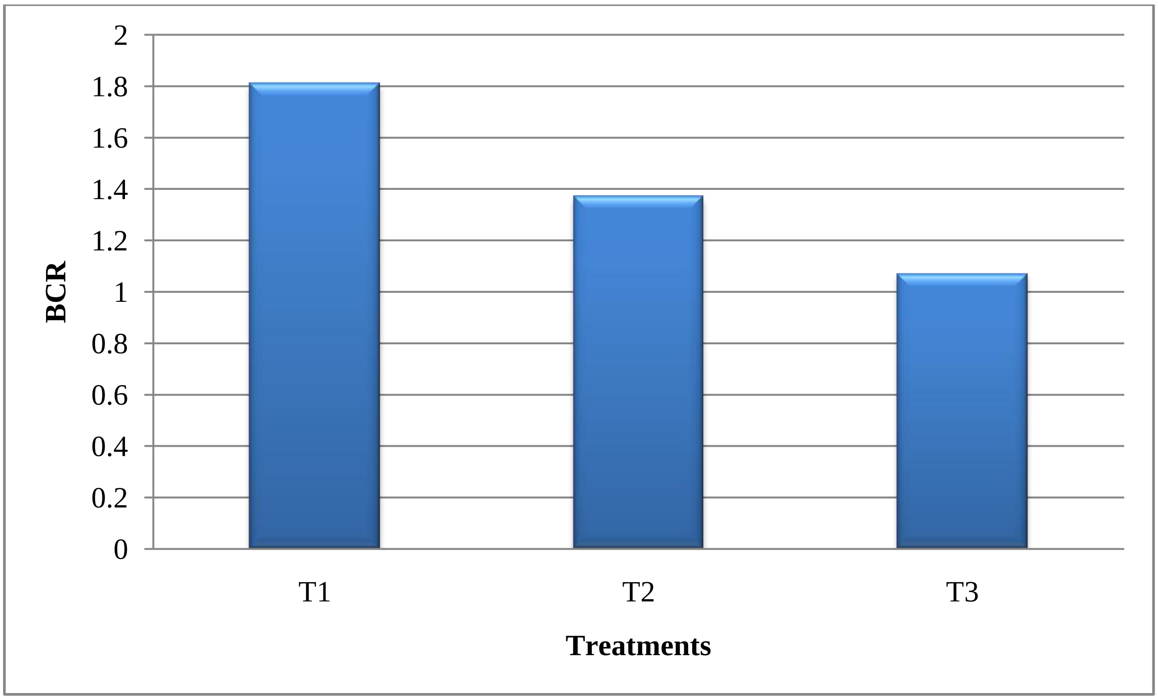

Figure 50. Benefit cost ratio of tilapia in different treatments of stocking density trial-2

Table 8. Effect of stocking density on monthly growth parameters of Tilapia cultured in net cage of Dakatia river, Roghunathpur, Chandpur during 05 June -03 October, 2010 at stocking density trial-2.

Treatments	Monthly growth parameters															
Stocking density ($fish/m^3$)	Mean weight gain - WG (g)				Mean relative growth rate - RGR (%)				Mean specific growth rate - SGR (%/day)				Mean food conversion ratio - FCR			
	1st month	2nd month	3rd month	4th month	1st month	2nd month	3rd month	4th month	1st month	2nd month	3rd month	4th month	1st month	2nd month	3rd month	4th month
50	40.56a	85.15a	125.56a	96.54a	140.23a	122.54b	81.25a	34.52a	2.92a	2.66b	1.98a	0.98a	1.06b	1.22a	1.47c	2.64b
75	24.92b	75.74b	76.83b	70.18b	86.16b	141.09a	59.45b	33.98a	2.06b	2.93a	1.55b	0.97a	1.76a	1.06b	2.02b	2.65b
100	22.40b	63.61c	46.66c	39.56c	77.46b	123.97b	40.60c	24.47b	1.91b	2.68b	1.13c	0.73b	1.93a	1.20a	2.95a	3.67a
LSD	4.45***	4.36***	7.84***	15.11***	15.39***	13.49*	6.81***	6.31*	0.27***	0.19*	0.14***	0.16*	0.30***	0.07**	0.12***	0.52**
CV (%)	7.61	2.92	4.72	11.00	7.60	5.22	5.64	10.20	5.90	3.42	4.46	8.81	9.41	2.81	2.76	8.74

Means bearing same letter(s) in a column do not differ significantly
*** indicates P < 0.001, ** indicates P < 0.01; * indicates P < 0.05

Table 9. Effect of stocking density on different parameters of Tilapia cultured in net cage of Dakatia river, Roghunathpur, Chandpur during 05 June -03 October, 2010 at stocking density trial-2.

Treatments	Parameters									
Stocking density (fish/m^3)	Mean final weight (g)	Mean weight gain (g)	Mean relative growth rate (%)	Mean specific growth rate (%/day)	Mean food conversion ratio	Mean survival rate (%)	Mean gross production (kg)	Mean net production (kg)	Mean benefit cost ratio	Mean net profit (Tk)
50	376.72a	347.80a	94.63a	2.13a	1.60c	97.92a	331.96a	306.48a	1.81a	17215a
75	276.65b	247.73b	80.17b	1.87b	1.87b	86.74b	323.92a	290.06b	1.37b	9740b
100	201.15c	172.23c	66.63c	1.61c	2.44a	84.39c	305.54b	261.61c	1.07c	2211c
LSD	12.95***	12.95***	2.17***	0.03***	0.14***	1.25***	10.43**	10.72***	0.05***	1282.55***
CV (%)	2.28	2.53	1.35	0.85	3.53	0.70	1.63	1.88	1.81	6.60

Means bearing same letter(s) in a column do not differ significantly
*** indicates P < 0.001, ** indicates P < 0.01;

4.3. Feeding regime trial -1

4.3.1. Physicochemical parameters of cage water

The physicochemical parameters in cage water of feeding regime trial-1 were monitored fortnightly throughout the experimental period in Dakatia river, Roghunathpur, Chandpur during 15 April to 13 August, 2011. The recorded monthly variations of different physicochemical parameters in cage water are shown in Appendix 3 and graphically presented in Figure 51-60. During this trial, water depth ranged from 4.2 m in April to 5.6 m in August. The water current velocity ranged from 20 cm/sec in April to 31 cm/sec in August. The highest secchi-disk transparency found 53 cm in April and the lowest in 40 cm in July. Secchi disk transparency showed a negative correlation with water current velocity ($p < 0.05$; $r = - 0. 953$) (Table 10). The highest water temperature was 32.6°C in July and the lowest was recorded 31.4°C in April. Water temperature had a positive correlation with water current velocity ($p < 0.05$; $r = 0. 946$) and a negative correlation with secchi-disk transparency ($p < 0.01$; $r = - 0. 993$) (Table 10). Total dissolved solids varied from 8 mg/l in May, June, to 10 mg/l in the month of April, July and August respectively. Dissolved oxygen ranged from 4.4 mg/l in August to 5.62 mg/l in June. Free CO_2 ranged from 5.92 mg/l in August to 8.04 mg/l in July. The water pH value varied from 7.5 in May, July and August to 7.75 in April and June respectively. The recorded total hardness of cage water was varied from 42.98 mg/l in July to 94.12 mg/l in April. Total hardness found inversely correlated with water current velocity ($p < 0.01$; $r = - 0. 965$) and positively correlated with secchi-disk transparency ($p < 0.05$; $r = 0. 890$) (Table 10). The total alkalinity also recorded lowest 40.56 mg/l in July and the highest 116.3 mg/l in April. Total alkalinity showed negative correlation with water current velocity ($p < 0.05$; $r = - 0. 921$) and water temperature ($p < 0.05$; $r = - 0. 913$), whereas positively correlated with secchi-disk transparency ($p < 0.05$; $r = 0. 955$) and total hardness ($p < 0.05$; $r = 0. 912$) of cage water (Table 10). There is no salinity; ammonia-$NH_3$and nitrite-NO_2 was found during the period of this trial (Appendix 3).

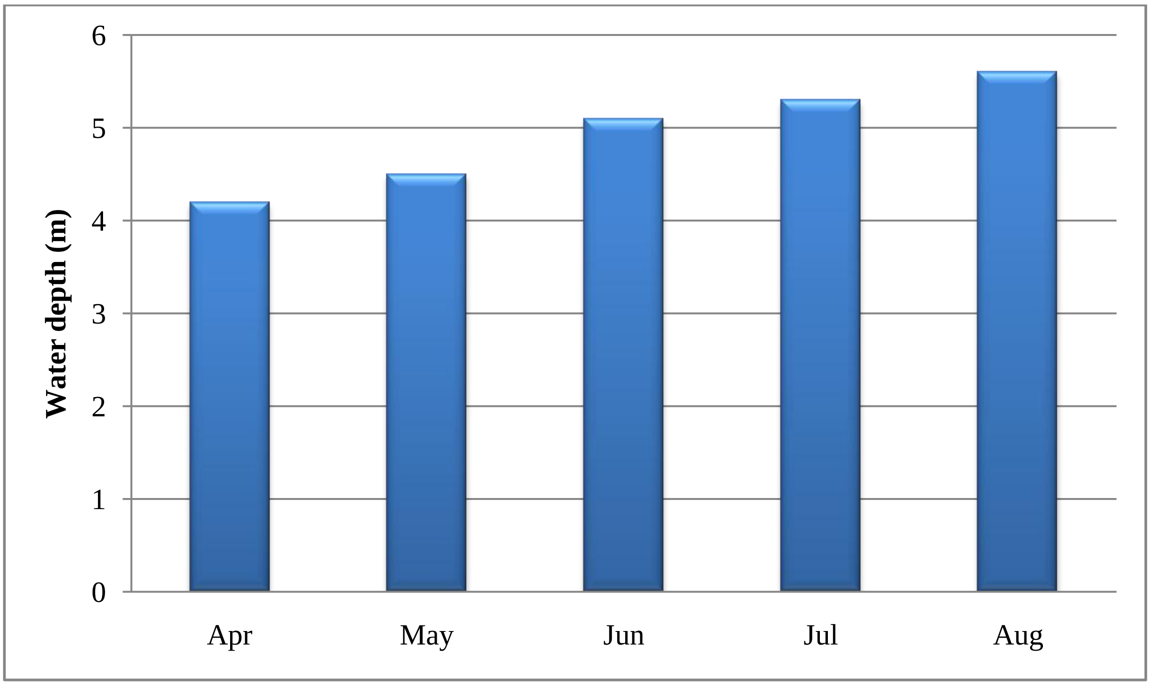

Figure 51. Monthly variations of water depth of Dakatia river, Roghunathpur, Chandpur during feeding regime trial-1 of cage culture

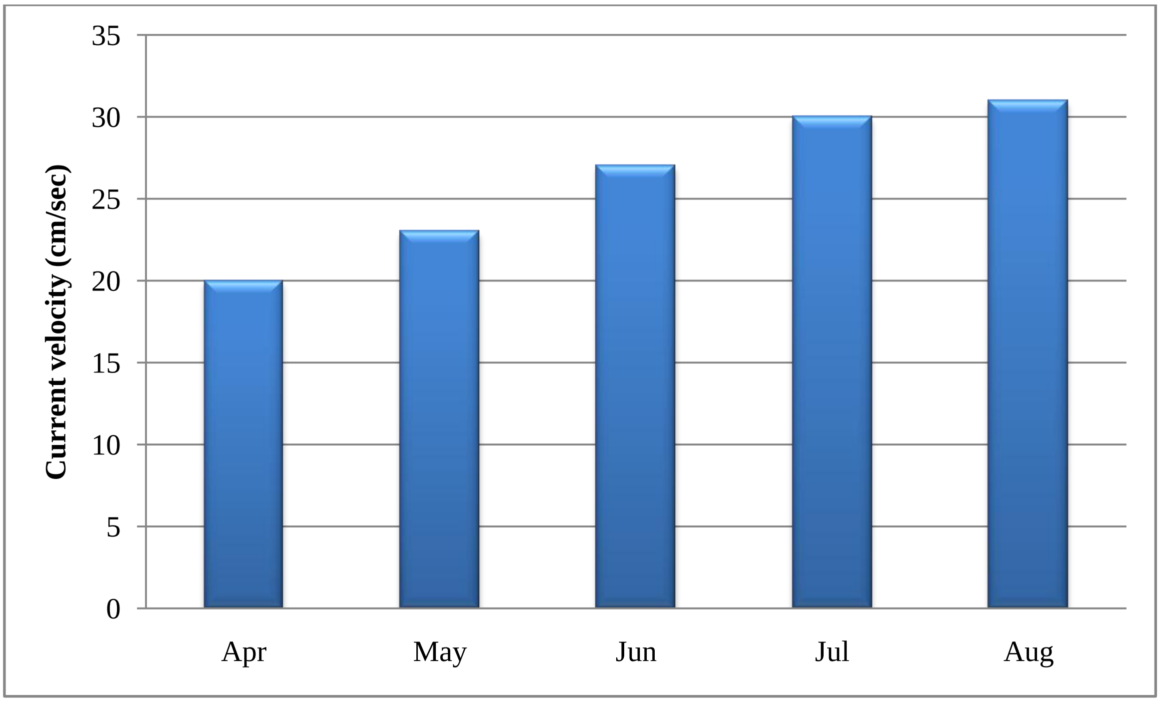

Figure 52. Monthly variations of water current velocity of Dakatia river, Roghunathpur, Chandpur during feeding regime trial-1 of cage culture

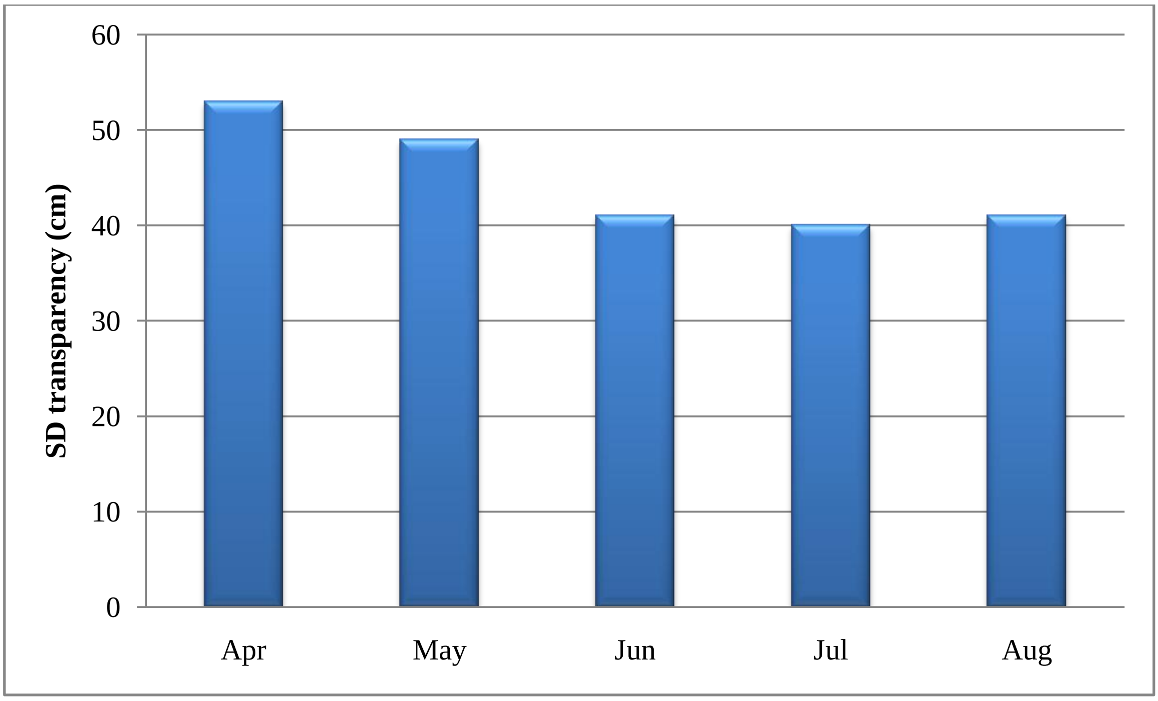

Figure 53. Monthly variations of Secchi disk transparency of water in Dakatia river, Roghunathpur, Chandpur during feeding regime trial-1 of cage culture

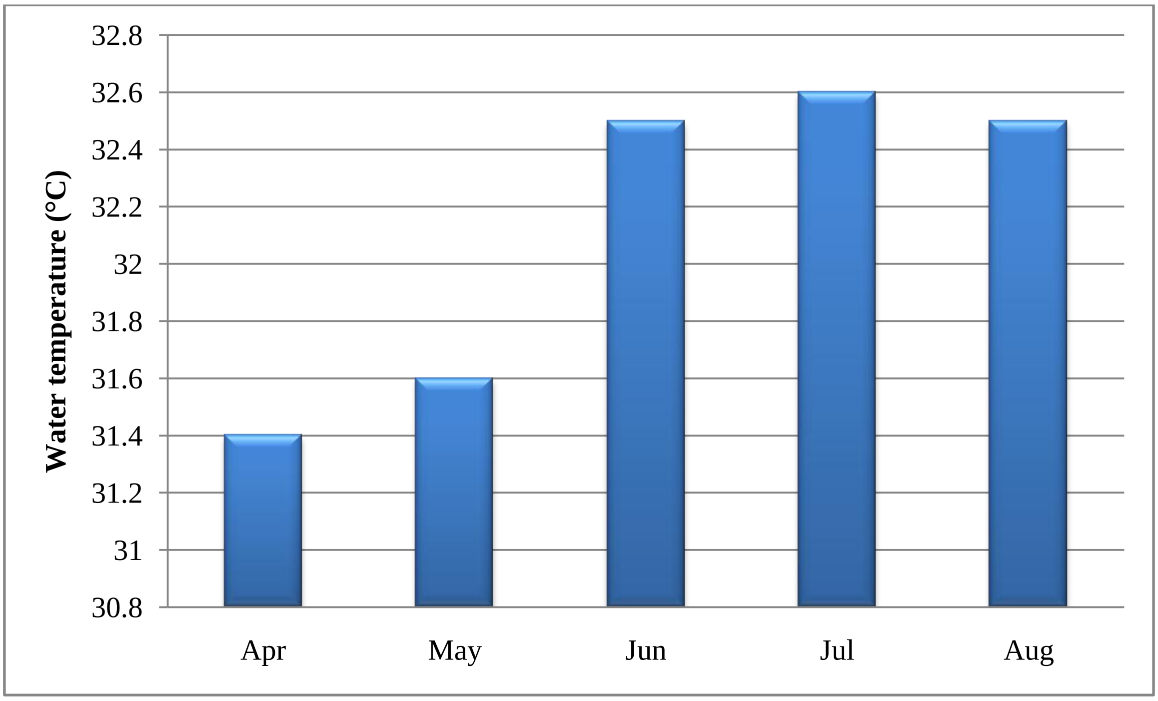

Figure 54. Monthly variations of water temperature in Dakatia river, Roghunathpur, Chandpur during feeding regime trial-1 of cage culture

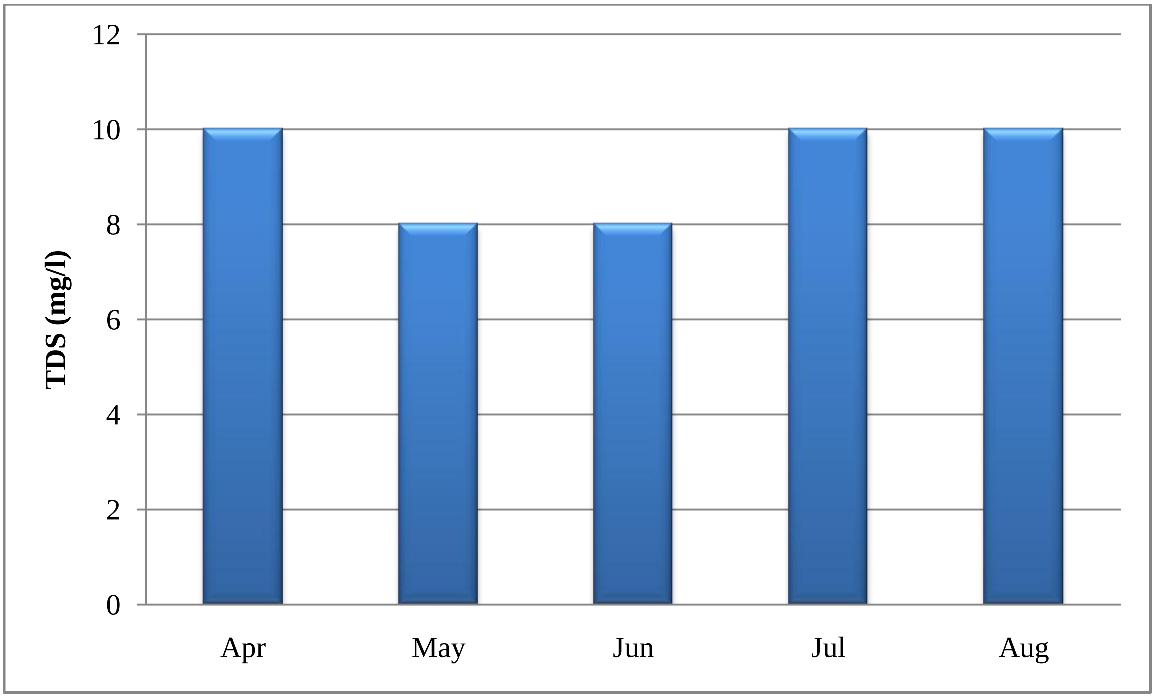

Figure 55. Monthly variations of total dissolved solids of water in Dakatia river, Roghunathpur, Chandpur during feeding regime trial-1 of cage culture

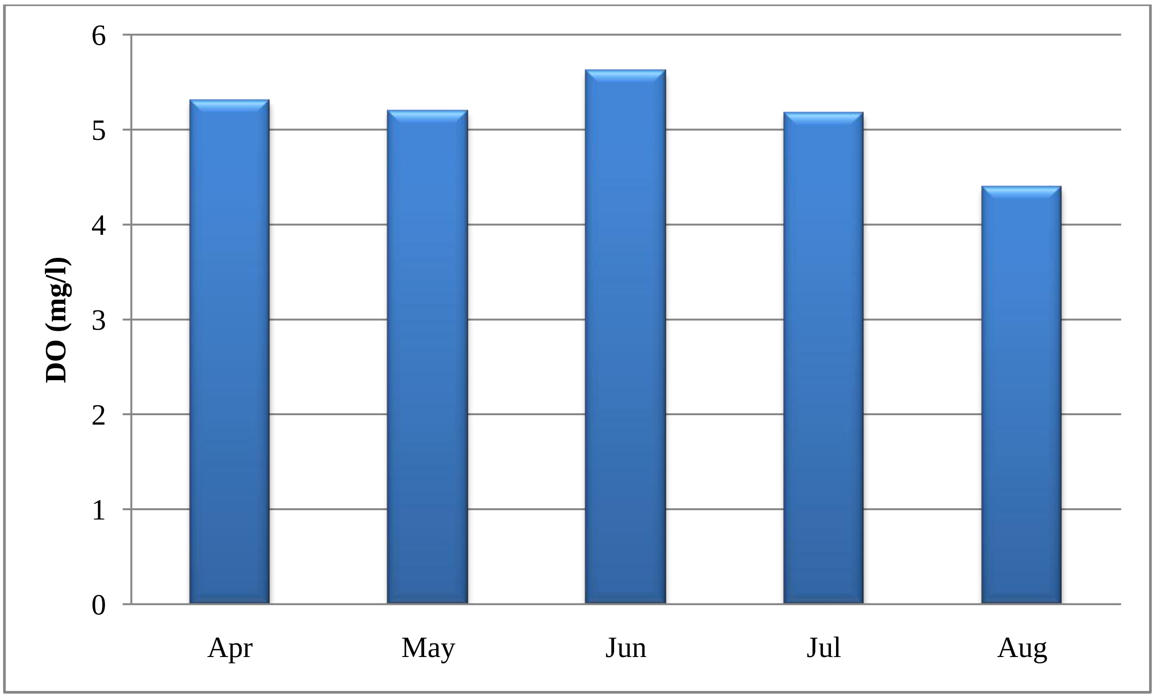

Figure 56. Monthly variations of dissolved oxygen of water in Dakatia river, Roghunathpur, Chandpur during feeding regime trial-1 of cage culture

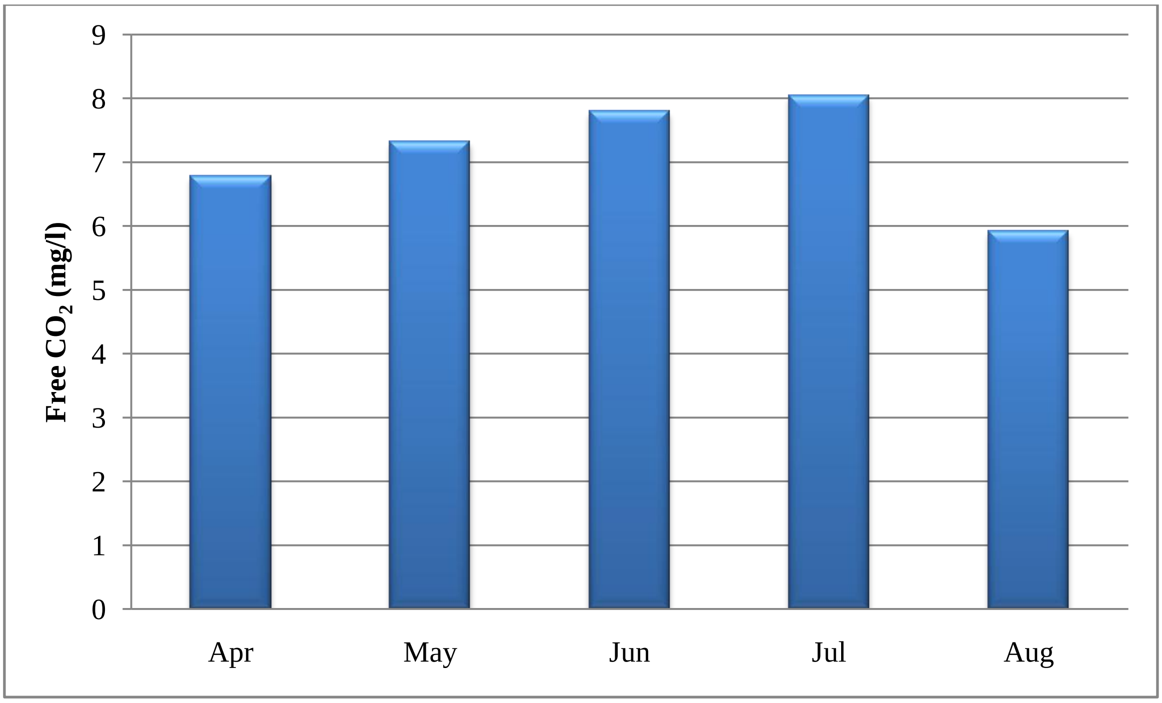

Figure 57. Monthly variations of free carbon dioxide of water in Dakatia river, Roghunathpur, Chandpur during feeding regime trial-1 of cage culture

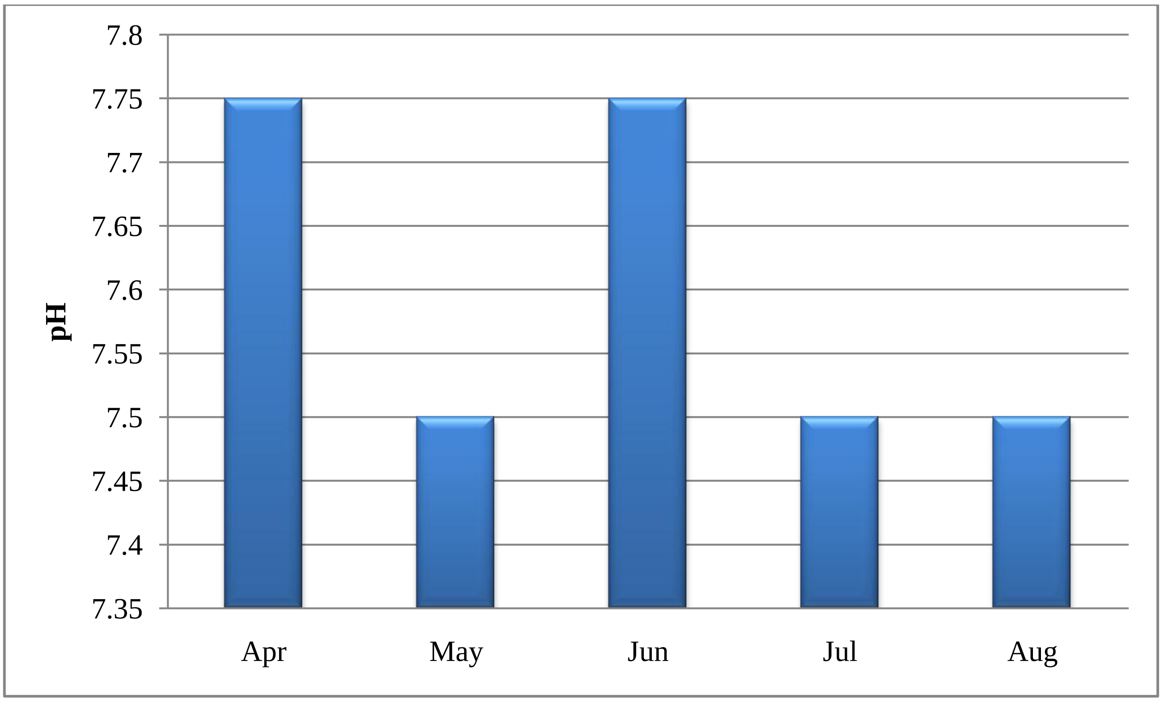

Figure 58. Monthly variations of water pH in Dakatia river, Roghunathpur, Chandpur during feeding regime trial-1 of cage culture

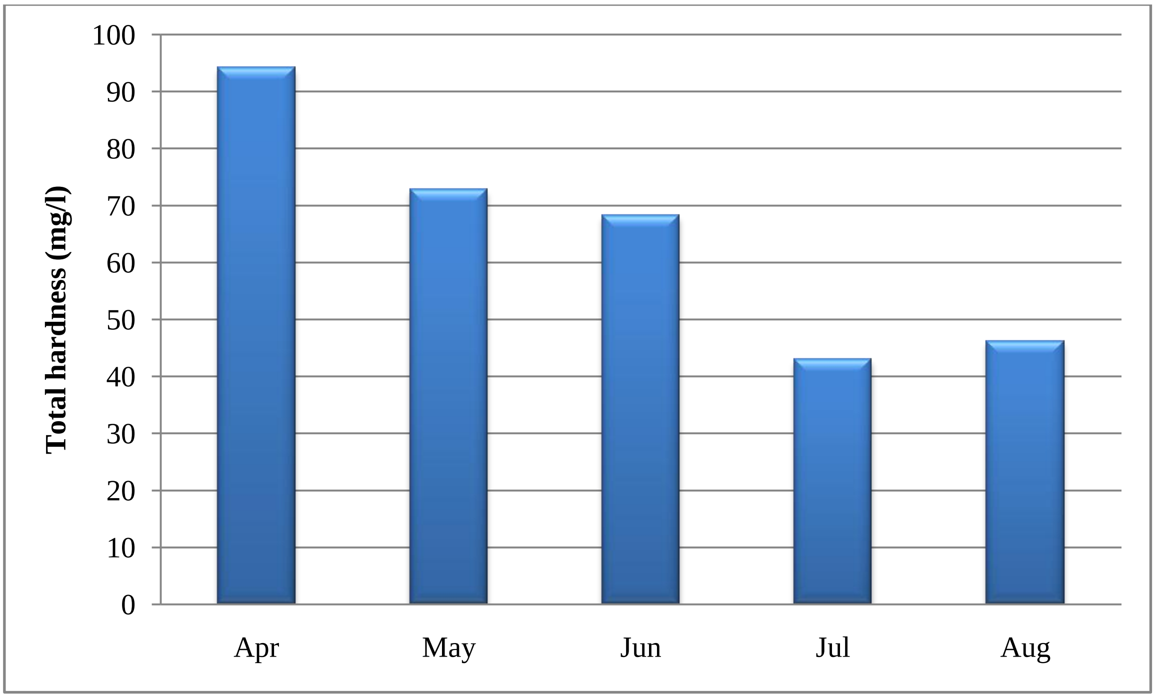

Figure 59. Monthly variations of total hardness of water in Dakatia river, Roghunathpur, Chandpur during feeding regime trial-1 of cage culture

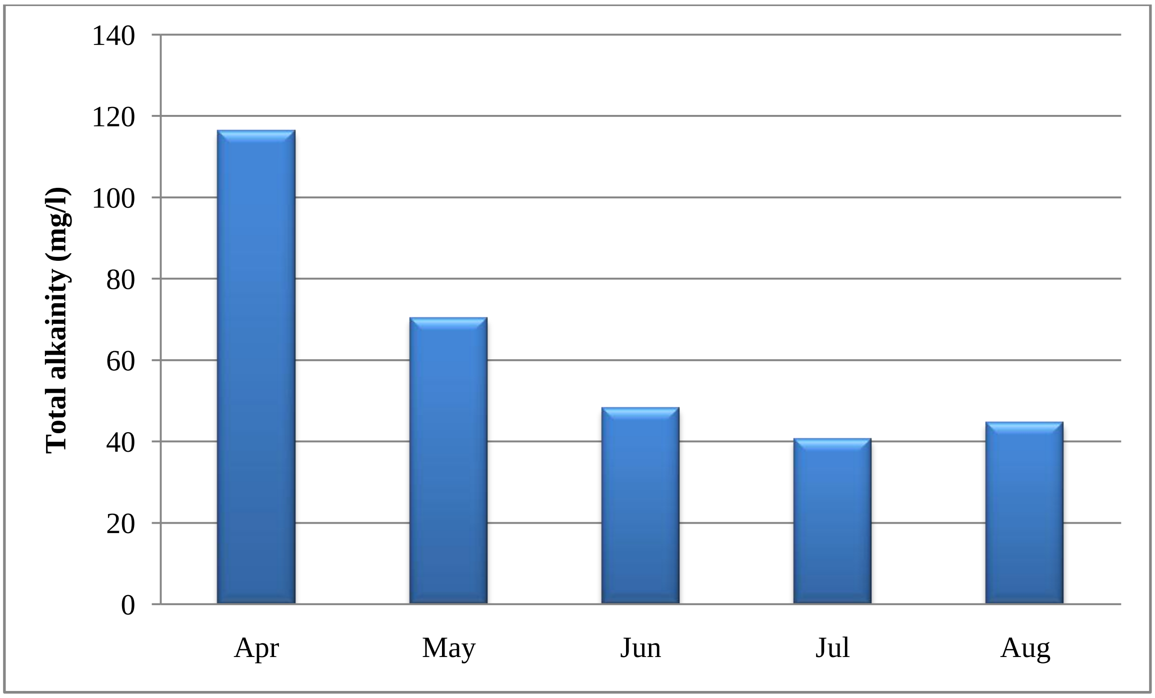

Figure 60. Monthly variations of total alkalinity of water in Dakatia river, Roghunathpur, Chandpur during feeding regime trial-1 of cage culture

Table 10. Correlation Matrix of Water Quality parameters during culture period in feeding regime trial-1

	WCV	SDT	WT	TDS	DO	CO_2	pH	TH	TA
WCV	1								
SDT	-.953*	1							
WT	.946*	-.993**	1						
TDS	.235	-.031	.112	1					
DO	-.508	.232	-.226	-.543	1				
CO_2	-.016	-.221	.198	-.417	.786	1			
PH	-.529	.343	-.271	-.167	.654	.127	1		
TH	-.965**	.890*	-.866	-.245	.529	-.054	.710	1	
TA	-.921*	.955*	-.913*	.137	.266	-.240	.530	.912*	1

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

WCV = Water Current Velocity, SDT = Secchi Disk Transparency, WT = Water Temperature, TDS =Total Dissolved Solids, DO = Dissolved Oxygen, CO_2 = Carbon Di-oxide, pH = Hydrogen Ion Concentration, TH =Total Hardness, TA =Total Alkalinity

4.3.2. Growth parameters of feeding regime trial-1

Final weight (FW)

After completion of the experimental period (120 days), the mean final weight of the tilapia in cage of different treatments of feeding regime trial-1 was ranged between 314.48g to 328.91g, from the initial average weight of 36.20g for each treatment. The highest final weight attained in T_3 (328.91g) followed by T_2 (319.76g) and T_1 (314.48g) respectively (Table 11 & Figure 65). The final weight of the three treatments expressed significant differences ($p < 0.05$) between T_1 and T_3, and T_2 and T_3 (Table 13).

Weight gain (WG)

The monthly weight gain of feeding regime trial-1 fluctuated from 45.47g to 87.89g in T_1, it varied from 50.99g to 85.51g in T_2 and from 57.14g to 95.96g in T_3 (Appendix 7 Figure 61). The monthly weight gain was found significantly differences ($p < 0.001$) among three treatments in the first month only (Table 12). Among the three treatments, the highest weight gain observed 292.71g in T_3 and followed by T_2 (283.56g) and T_1 (278.28g) respectively (Table 11 & Figure 66). The weight gain of the three treatments showed significant differences ($p < 0.05$) between T_1 and T_3, and T_2 and T_3 (Table 13).

Relative growth rate (RGR)

The monthly relative growth rate of the different treatments in this trial varied from 38.85% to 125.62% in T_1, from 36.51% to 140.86% in T_2, and from 41.27% to 157.84% in T_3 respectively (Appendix 7 & Figure 62). The monthly relative growth rate showed highly significant differences ($p < 0.001$) among three treatments only in the first month (Table 12). The highest relative growth rate was found 79.06% in T_3 followed by T_2 (76.69%) and T_1 (74.91%), respectively (Table 11 & Figure 67). The relative growth rate showed highly significant differences ($p < 0.001$) among the three treatments (Table 13).

Specific growth rate (SGR)

The monthly specific growth rate of the different treatments in this trial fluctuated from 1.08%/day to 2.70%/day in T_1, while in T_2 it varied from 1.03%/day to 2.92%/day and in T_3 specific growth rate ranged from 1.15%/day to 3.15%/day (Appendix 7& Figure 63). The monthly specific growth rate found also highly significant differences ($p < 0.001$) among the three treatments only in the first month (Table 12). The highest specific growth rate was found 1.83%/day in T_3 followed by T_2 (1.80%/day) and T_1 (1.79%/day), respectively (Table 11 & Figure 68). The specific growth rate of this trial was found significantly different ($p < 0.05$) between the T_1 and T_3 (Table 13).

Food conversion ratio (FCR)

The monthly food conversion ratio of different treatments in this trial varied from 1.18 to 2.32 in T_1, while from 1.27 to 3.28 in T_2 and from 1.32 to 3.65 in $T_{3,}$ respectively (Appendix 7 & Figure 64). The monthly food conversion ratio was found significantly different ($p < 0.05$) between the T_1 and T_3 in first month, but highly significant differences ($p < 0.001$) found in second and third months among the three treatments while highly significant differences ($p < 0.001$) found between T_1 and T_2, and T_1 and T_3 in fourth month (Table 12). Food conversion ratio was found 1.68, 2.21 and 2.69 in T_1, T_2 and T_3 respectively, where T_1 shown the lowest value and T_3 was the highest (Table 11 & Figure 69). The food conversion ratio was found highly significant differences ($p < 0.001$) among the three treatments in this trial (Table 13).

Survival rate

The survival rate of the tilapia in different treatments was varied from 96.44% to 97.33% in this trial. The highest survival rate was found in T_1 (97.33%) followed by T_3 (96.88%) and T_2 (96.44%) respectively (Table 11 & Figure 70). No significant differences were found in survival rates of different treatments in this trial (Table 13).

Gross production (GP)

The gross production of the tilapia in different treatments was varied from 275.45 kg/cage to 286.78 kg/cage of the feeding regime trial-1. Gross production was recorded highest 286.78 kg/cage in T_3 followed by T_2 (277.51 kg/cage) and T_1 (275.45 kg/cage) respectively (Table 11 & Figure 71). The gross production was found highly significant differences ($p < 0.001$) between T_1 and T_3, and T_2 and T_3 (Table 13).

Net production (NP)

The net production of the tilapia in different treatments was varied from 243.73 kg/cage to 255.21 kg/cage of the feeding regime trial-1. Net production was also recorded highest 255.21 kg/cage in T_3 followed by T_2 (246.09 kg/cage) and T_1 (243.73 kg/cage) respectively (Table 11 & Figure 72). Net production was found highly significant differences ($p < 0.001$) between T_1 and T_3, and T_2 and T_3 (Table 13).

Net profit

The detail of net profit determination of this trial is shown in table (Appendix 11). The net profit achieved from the different treatments of the feeding regime trial-1 was ranged from 4907Tk/cage to 13376Tk/cage. Net profit was found highest in T_1 (13376Tk/cage) followed by T_2 (8605Tk/cage) and T_3 (4907Tk/cage) respectively (Table 11 & Figure 73). Net profit was found highly significant differences ($p < 0.001$) among the three treatments (Table 13).

Benefit cost ratio (BCR)

The detail of benefit cost ratio determination of this trial is shown in table (Appendix 11). The benefit cost ratio was determined varied from 1.17 to 1.71 in different treatments in feeding regime trial-1. The maximum benefit cost ratio was achieved in T_1 (1.71) followed by T_2 (1.36) and T_3 (1.17) respectively (Table 11 & Figure 74). Benefit cost ratio exhibited the highly significant differences ($p < 0.001$) among the three treatments (Table 13).

Table 11. Growth performance of tilapia under different treatments of feeding regime trial- 1 in Dakatia river, Roghunathpur, Chandpur during 15 April - 13 August, 2011.

Parameters	**Treatments**				
	T_1- (5-3% bw feed)	T_2- (6-4% bw feed)	T_3- (7-5% bw feed)	Range	Mean ± SD
Initial weight- IW (g)	36.20	36.20	36.20	36.20 - 36.20	36.20±0
Final weight- FW (g)	314.48	319.76	328.91	314.48 - 328.91	321.05±7.30
Weight gain- WG (g)	278.28	283.56	292.71	278.28 - 292.71	284.85±7.30
Relative growth rate- RGR (%)	74.91	76.69	79.06	74.91 - 79.06	76.89±2.08
Specific growth rate- SGR (%/day)	1.79	1.80	1.83	1.79 - 1.83	1.81±0.02
Food conversion ratio- FCR	1.68	2.21	2.69	1.68 - 2.69	2.19±0.51
No. of fish harvested	876	868	872	868 - 876	872±4
Survival (%)	97.33	96.44	96.88	96.44 - 97.33	96.88±0.45
Gross production- GP (kg/cage)	275.45	277.51	286.78	275.45 - 286.78	279.91±6.04
Net production- NP (kg/cage)	243.73	246.09	255.21	243.73 - 255.21	248.34±6.06
Net profit (Tk/cage)	13376	8605	4907	4907 - 13376	8962.67±4245.81
Benefit cost ratio- BCR	1.71	1.36	1.17	1.17 - 1.71	1.41±0.27

Stocking density: 50/m^3 (900/cage) in each treatment

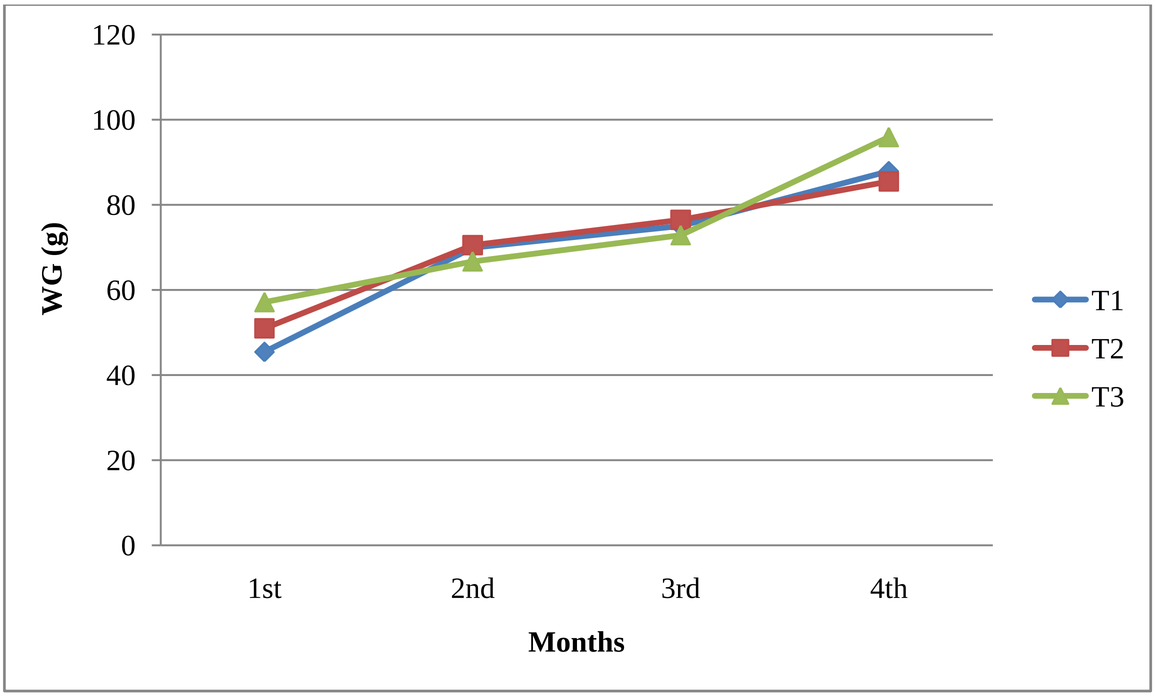

Figure 61. Monthly variations of weight gain in different treatments of feeding regime trial-1

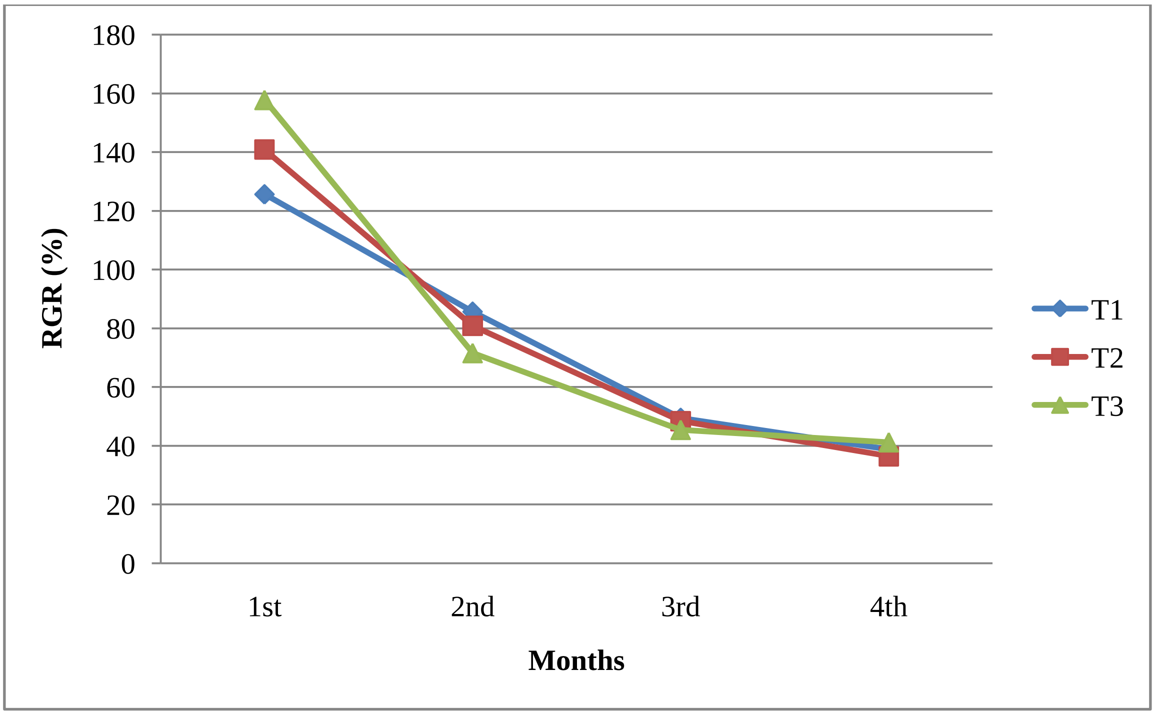

Figure 62. Monthly variations of relative growth rate in different treatments of feeding regime trial-1

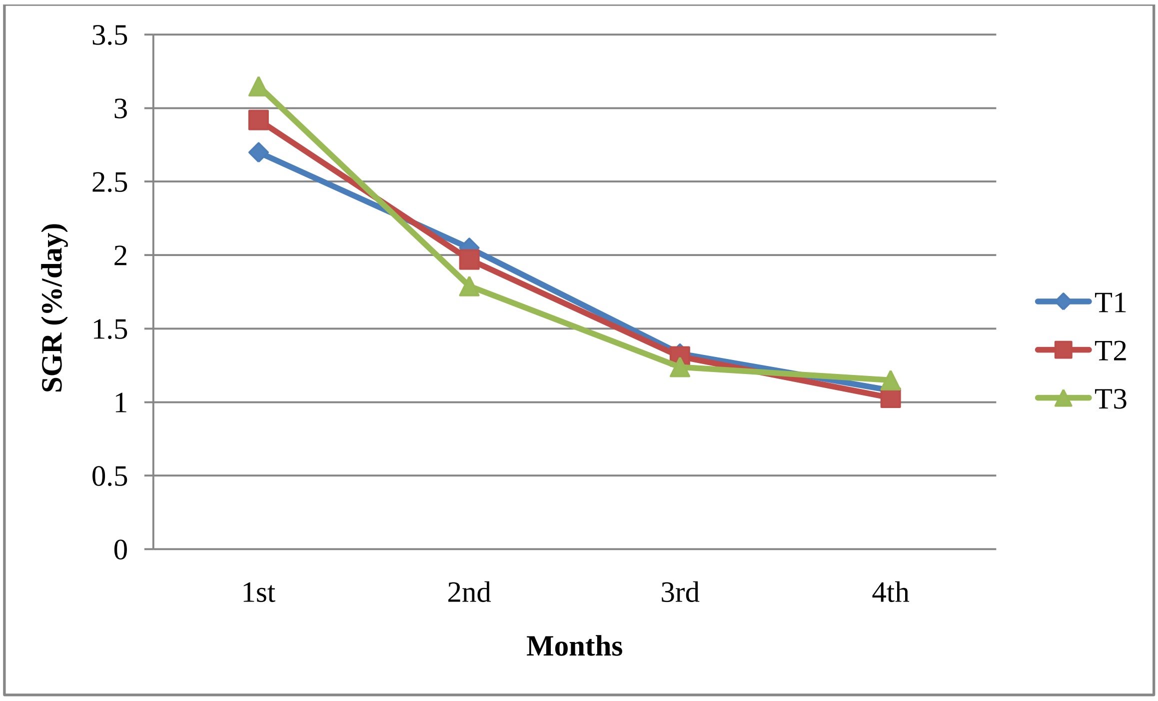

Figure 63. Monthly variations of specific growth rate in different treatments of feeding regime trial-1

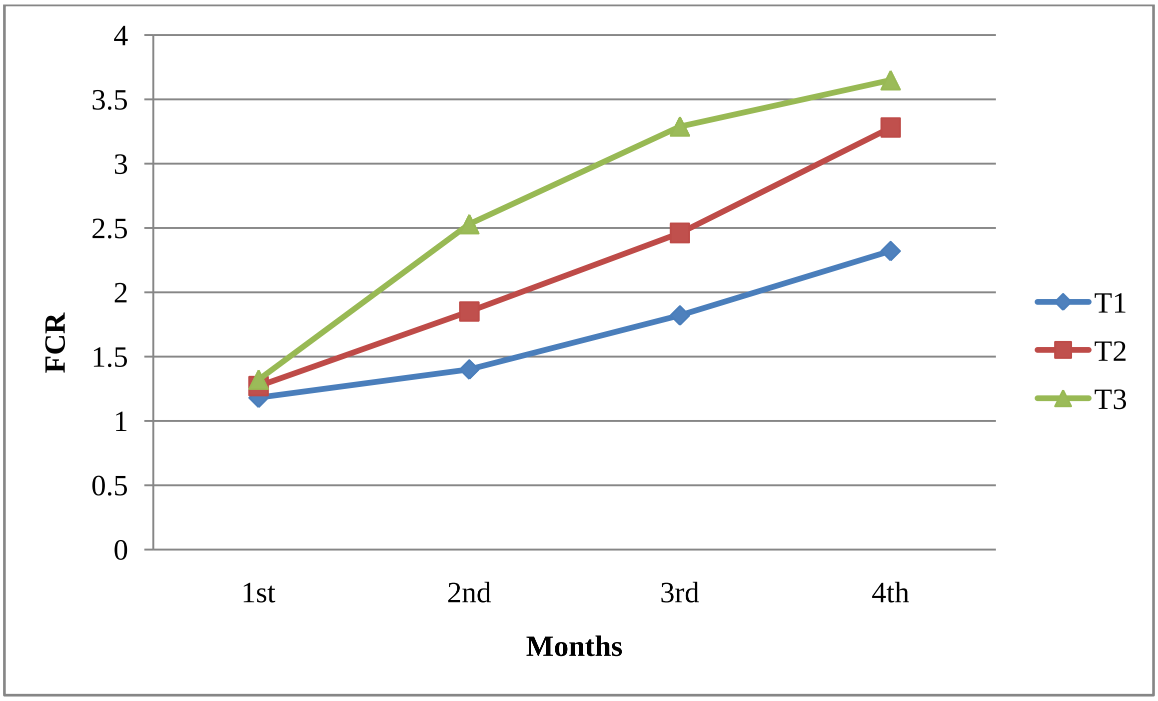

Figure 64. Monthly variations of food conversion ratio in different treatments of feeding regime trial-1

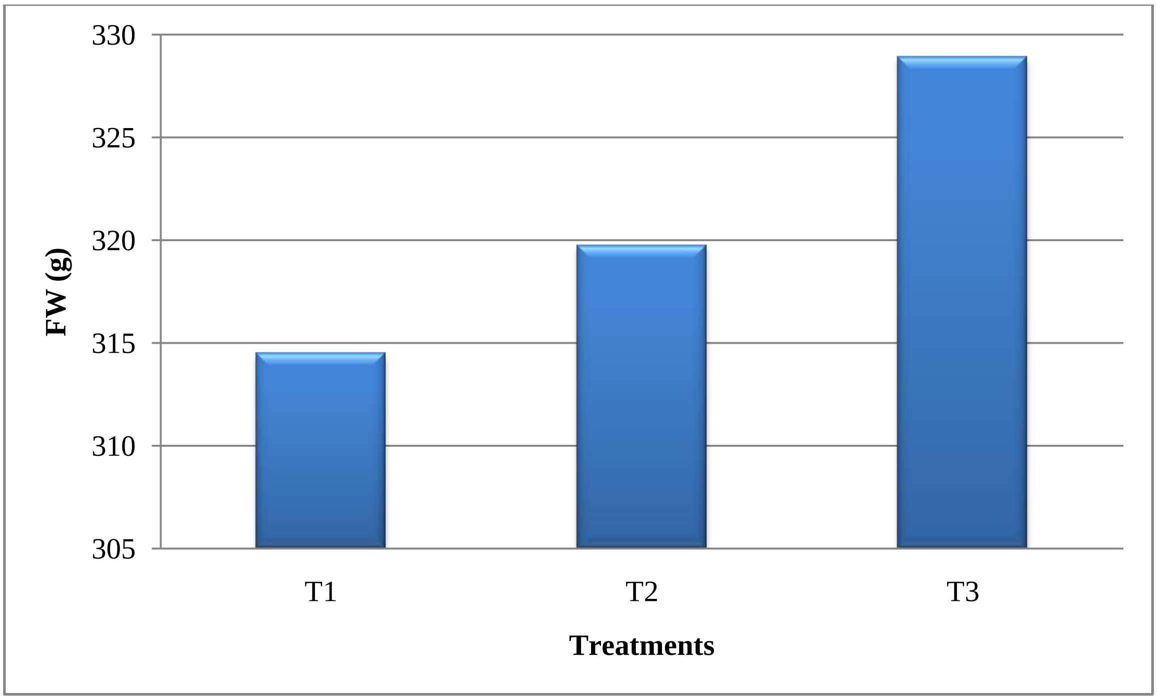

Figure 65. Final weight of tilapia in different treatments of feeding regime trial-1

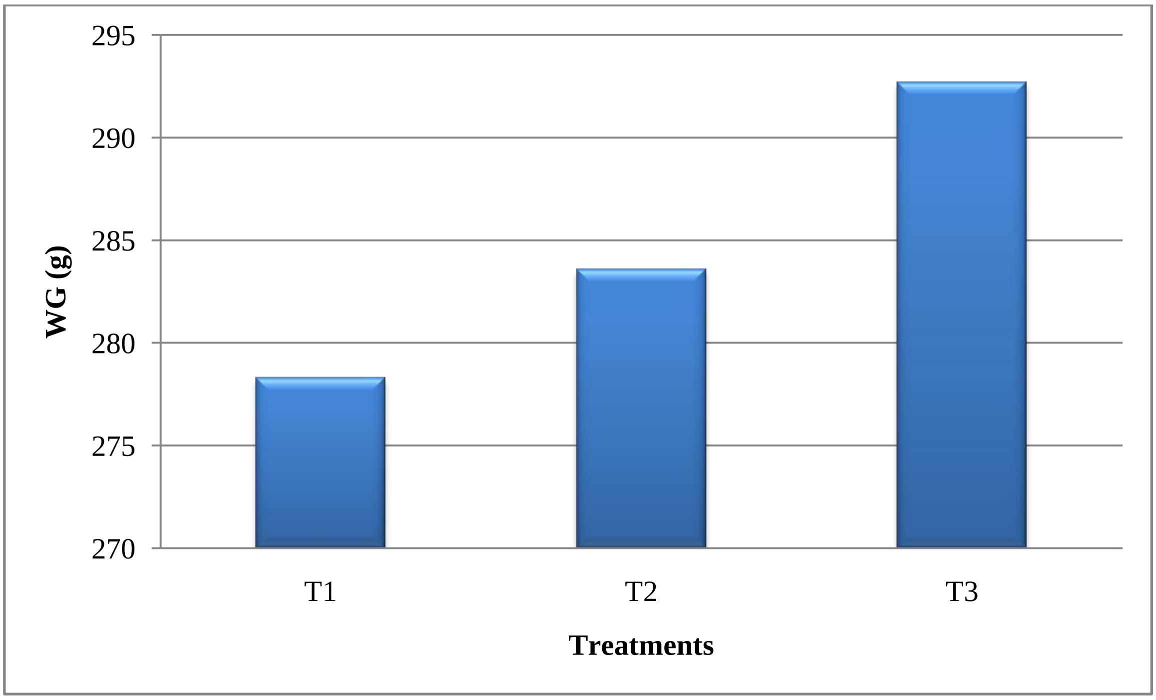

Figure 66. Weight gain of tilapia in different treatments of feeding regime trial-1

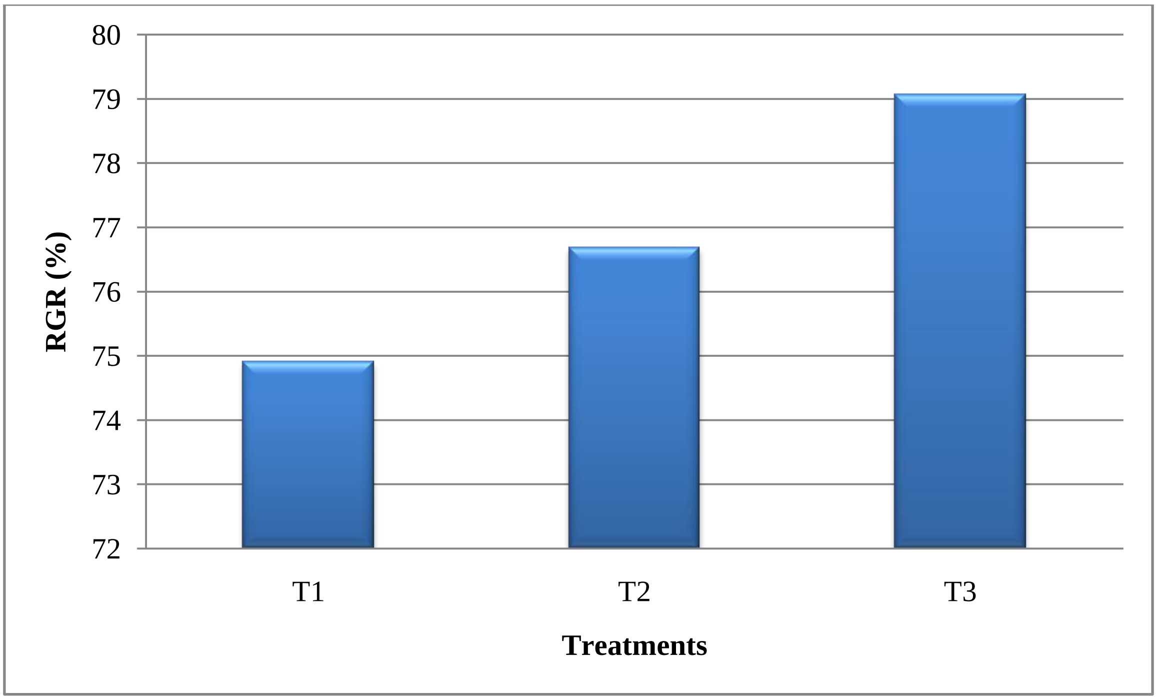

Figure 67. Relative growth rate of tilapia in different treatments of feeding regime trial-1

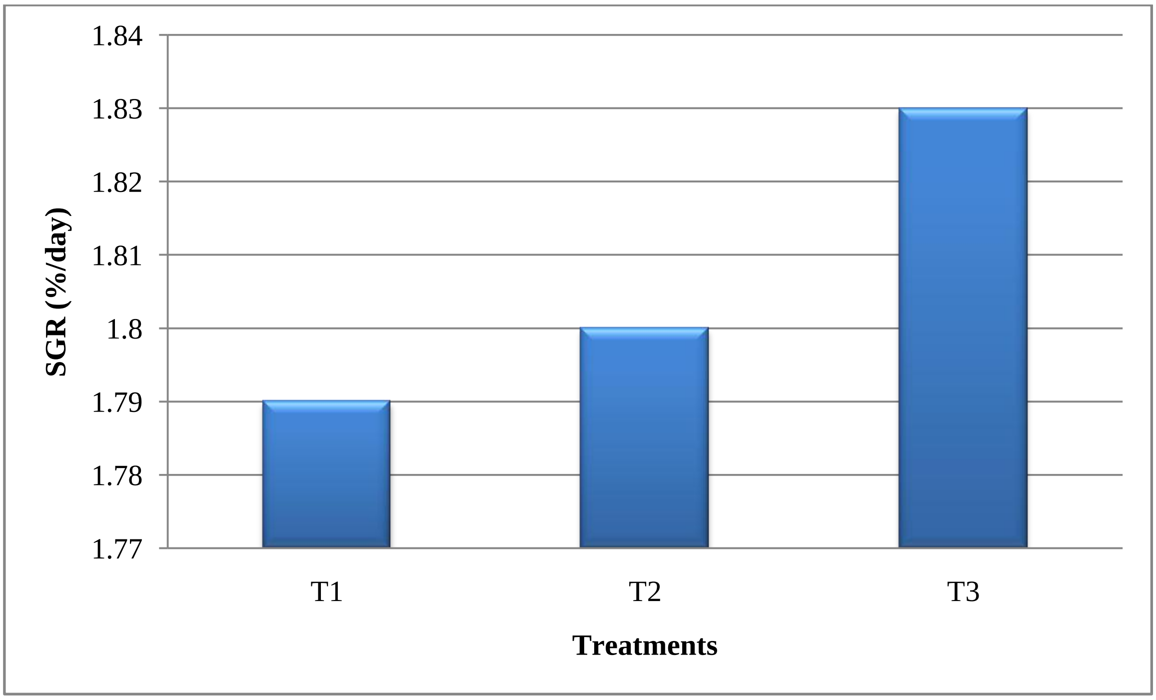

Figure 68. Specific growth rate of tilapia in different treatments of feeding regime trial-1

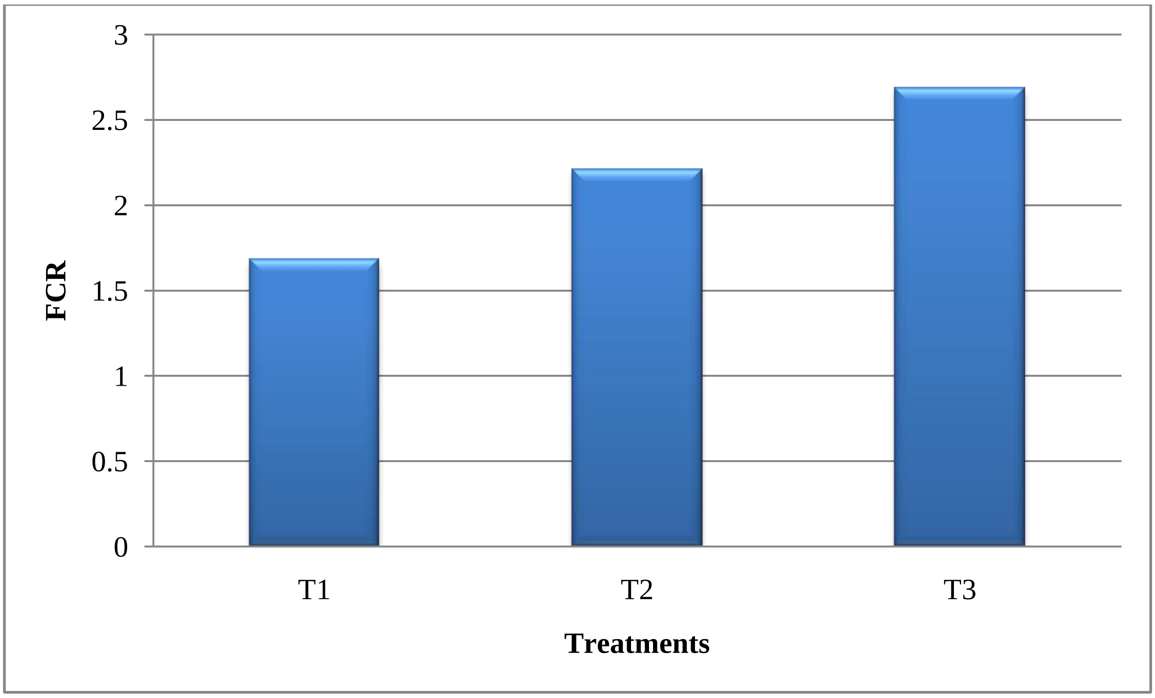

Figure 69. Food conversion ratio of tilapia in different treatments of feeding regime trial-1

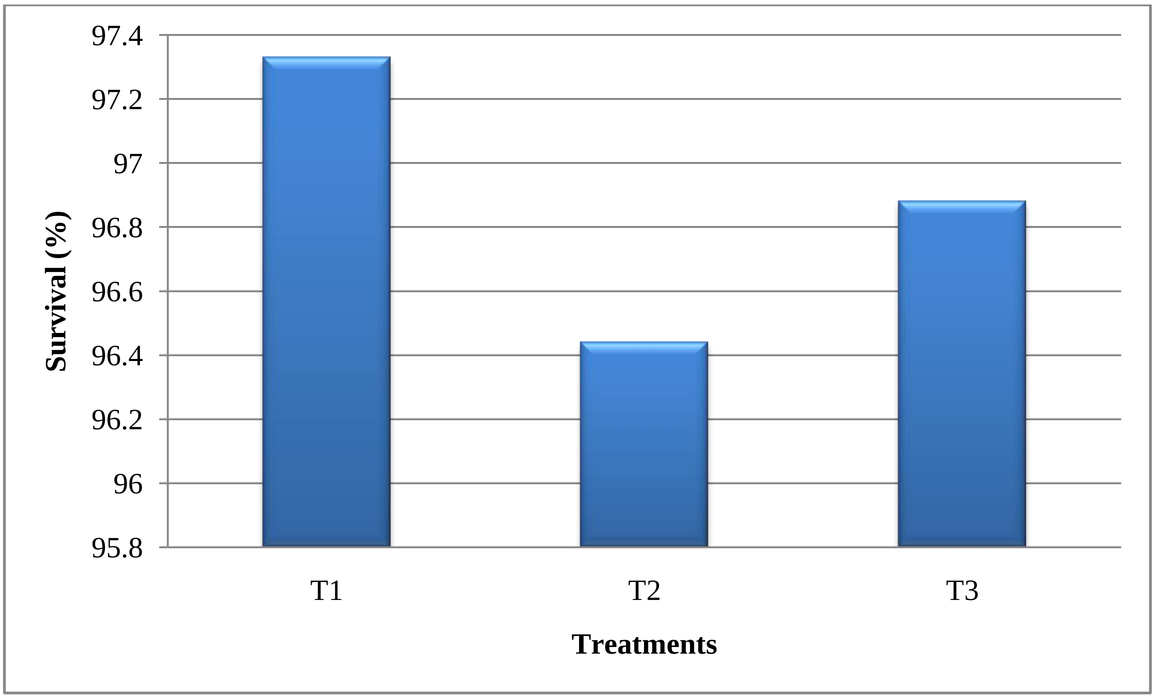

Figure 70. Survival rate of tilapia in different treatments of feeding regime trial-1

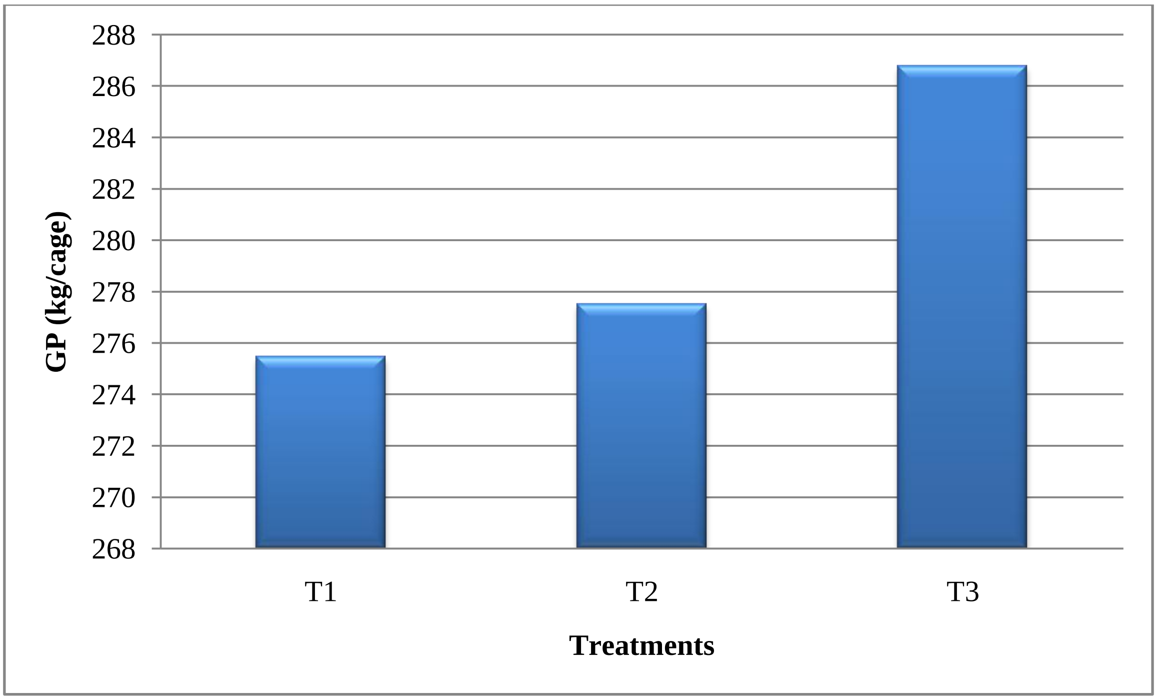

Figure 71. Gross production of tilapia in different treatments of feeding regime trial-1

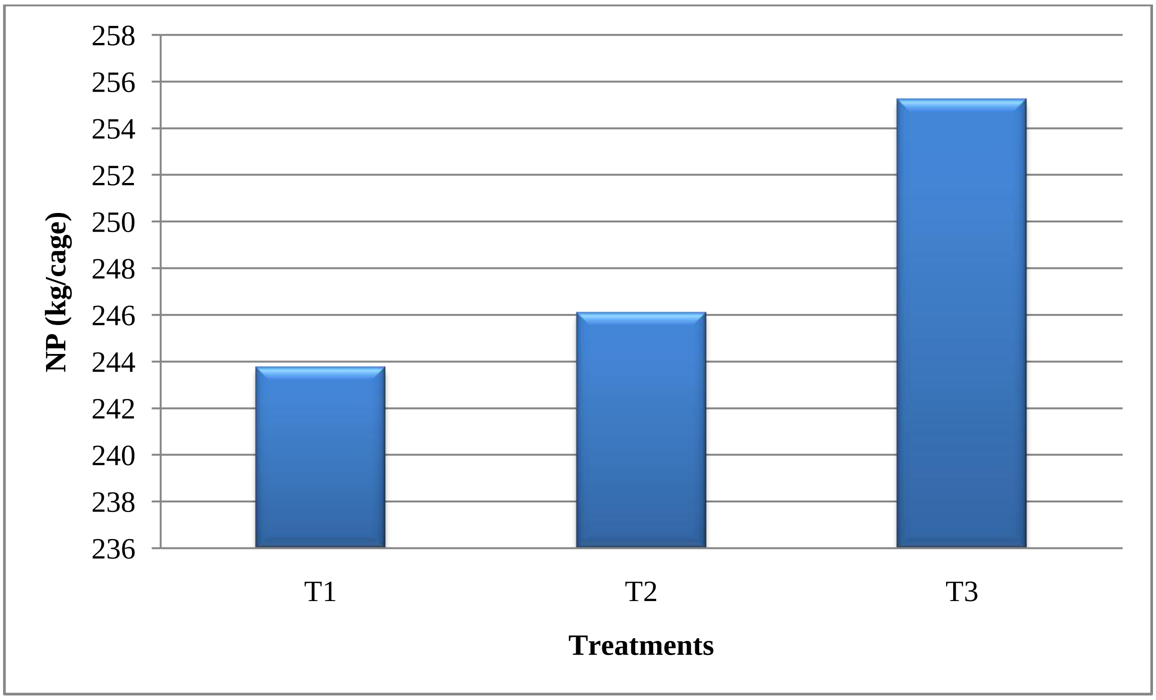

Figure 72. Net production of tilapia in different treatments of feeding regime trial-1

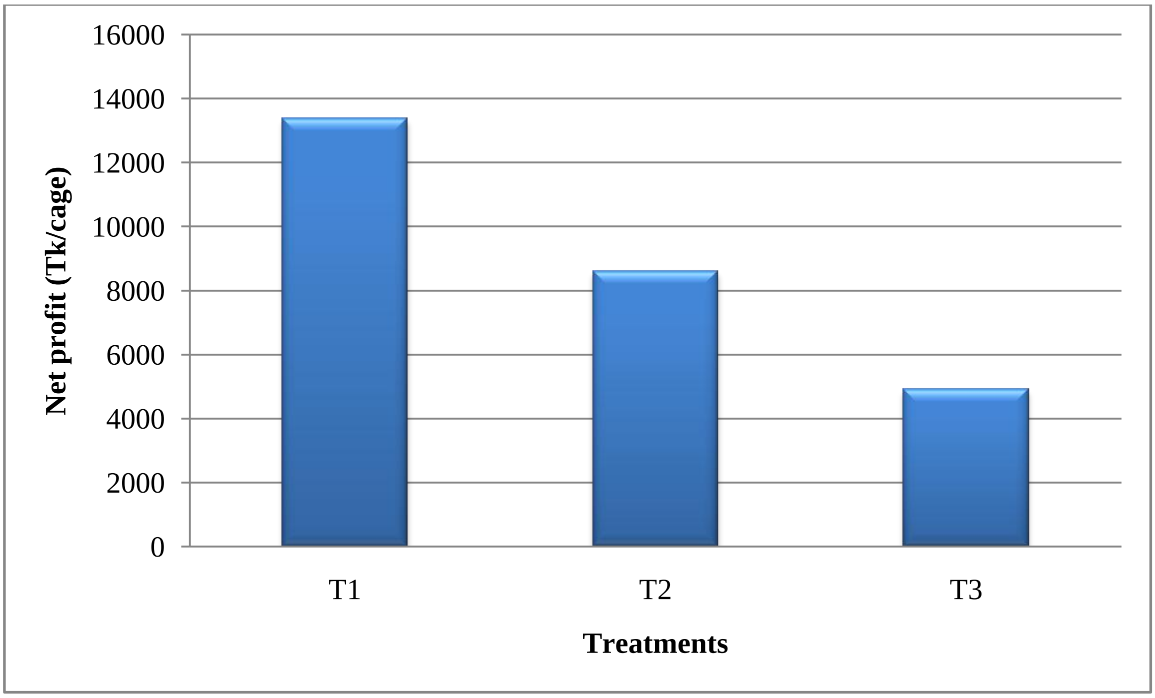

Figure 73. Net profit of tilapia in different treatments of feeding regime trial-1

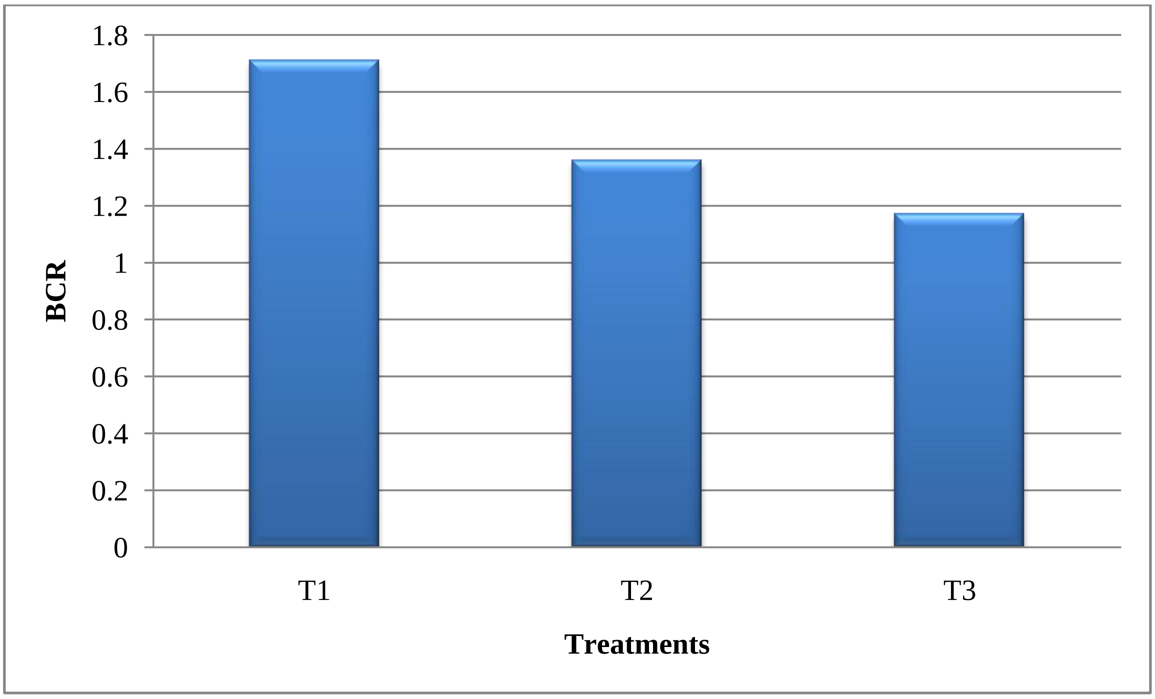

Figure 74. Benefit cost ratio of tilapia in different treatments of feeding regime trial-1

Table 12. Effect of different amount of feed supplements on monthly growth parameters of Tilapia cultured in net cage of Dakatia river, Roghunathpur, Chandpur during 15 April-13 August, 2011 at feeding regime trial-1.

Treatments	**Monthly growth parameters**															
Feed supplement (% body weight)	Mean weight gain - WG (g)				Mean relative growth rate - RGR (%)				Mean specific growth rate - SGR (%/day)				Mean food conversion ratio - FCR			
	1st month	2nd month	3rd month	4th month	1st month	2nd month	3rd month	4th month	1st month	2nd month	3rd month	4th month	1st month	2nd month	3rd month	4th month
5 - 3	45.48c	69.89a	75.02a	87.89a	125.62c	85.67a	49.53a	38.85a	2.71c	2.06a	1.34a	1.09a	1.18b	1.40c	1.83c	2.33b
6 - 4	50.99b	70.57a	76.48a	85.52a	140.86b	80.93ab	48.48a	36.52a	2.93b	1.97ab	1.31a	1.03a	1.27ab	1.85b	2.47b	3.28a
7 - 5	57.14a	66.73a	72.89a	95.96a	157.84a	71.65b	45.51a	41.28a	3.15a	1.79b	1.24a	1.15a	1.32a	2.53a	3.30a	3.65a
LSD	3.79***	9.74	9.92	12.88	10.46***	13.84	6.43	7.34	0.14***	0.26	0.14	0.18	0.09*	0.32***	0.31***	0.41***
CV (%)	3.70	7.06	6.64	7.18	3.79	8.73	6.73	9.45	2.42	6.71	5.54	8.06	3.66	8.21	6.20	6.73

Means bearing same letter(s) in a column do not differ significantly
*** indicates $P < 0.001$, * indicates $P < 0.05$

Table 13. Effect of different amount of feed supplements on different parameters of Tilapia cultured in net cage of Dakatia river, Roghunathpur, Chandpur during 15 April-13 August, 2011 at feeding regime trial-1.

Treatments	**Parameters**									
Feed supplement (% body weight)	Mean final weight (g)	Mean weight gain (g)	Mean relative growth rate (%)	Mean specific growth rate (%/day)	Mean food conversion ratio	Mean survival rate (%)	Mean gross production (kg)	Mean net production (kg)	Mean benefit cost ratio	Mean net profit (Tk)
5 - 3	314.48b	278.28b	74.91c	1.79b	1.68c	97.33a	275.45b	243.74b	1.71a	13376a
6 - 4	319.76ab	283.56ab	76.69b	1.81ab	2.21b	96.44a	277.52b	246.10b	1.36b	8605b
7 - 5	328.92a	292.72a	79.06a	1.83a	2.70a	96.89a	286.78a	255.22a	1.17c	4907c
LSD	9.67*	9.67*	1.35***	0.02*	0.08***	2.06	2.76***	3.35***	0.02***	337.58***
CV (%)	1.51	1.70	0.88	0.69	1.81	1.06	0.49	0.67	0.67	1.88

Means bearing same letter(s) in a column do not differ significantly
*** indicates $P < 0.001$, * indicates $P < 0.05$

4.4. Feeding regime trial -2

4.4.1. Physicochemical parameters of cage water

The physicochemical parameters in cage water of feeding regime trial-2 were monitored fortnightly throughout the experimental period in Dakatia river, Roghunathpur, Chandpur during 03 June to 01 October, 2011. The monthly variations recorded of different physicochemical parameters in cage water are shown in Appendix 4 and graphically presented in Figure 75-84. During this study, the water depth Fluctuated from 4.9 m in June to 5.6 m in September. Current velocity of water varied from 26 cm/sec in June to 38 cm/sec in October. Secchi-disk transparency ranged 40 cm in July and October to 44 cm in September. The highest water temperature was 32.8°C in September, October and the lowest was recorded 32.6°C in June, July and August respectively. Total dissolved solids ranged from 8 mg/l in June, July to 11 mg/l in the month of August. Dissolved oxygen varied from 4.28 mg/l in September to 5.6 mg/l in June. Free CO_2 varied from 5.38 mg/l in September to 8.18 mg/l in July. Free CO_2 had a positive correlation with dissolved oxygen ($p < 0.05$; r = 0. 914) (Table 14). The water pH ranged from 7.25 in September, October to 7.62 in July. The pH value showed a positive correlation with free CO_2 ($p < 0.05$; r = 0. 957) (Table 14). The total hardness of cage water was ranged from 44.62 mg/l in July to 78.6 mg/l in October. The total alkalinity recorded lowest 38.76 mg/l in October and the highest 49.3 mg/l in July. Total alkalinity showed negative correlation with total hardness ($p < 0.01$; r = - 0. 996) (Table 14). There is no salinity; ammonia-NH_3 and nitrite-NO_2 was found during the period of this study (Appendix 4).

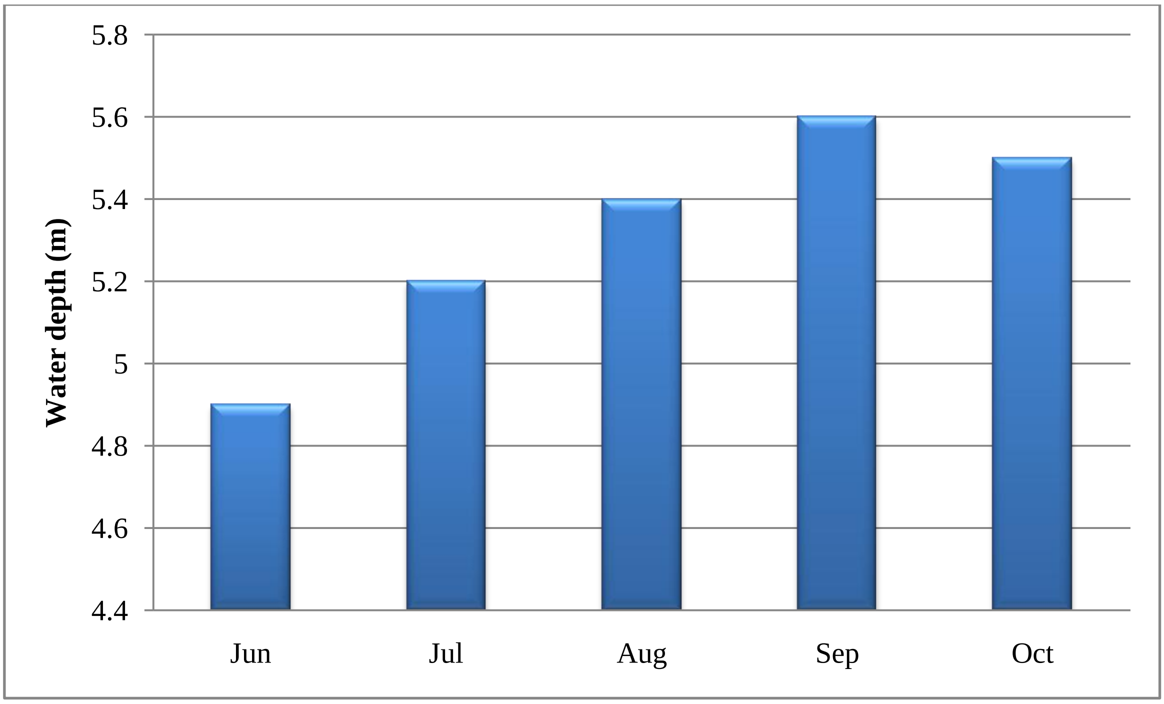

Figure 75. Monthly variations of water depth of Dakatia river, Roghunathpur, Chandpur during feeding regime trial-2 of cage culture

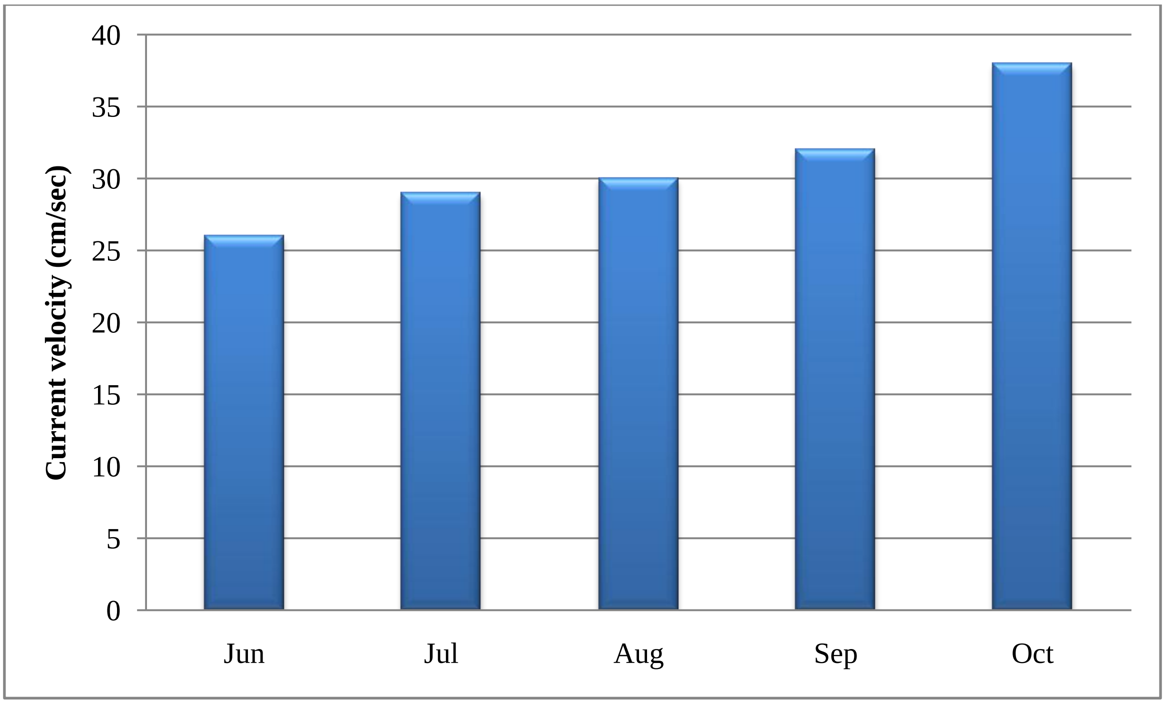

Figure 76. Monthly variations of water current velocity of Dakatia river, Roghunathpur, Chandpur during feeding regime trial-2 of cage culture

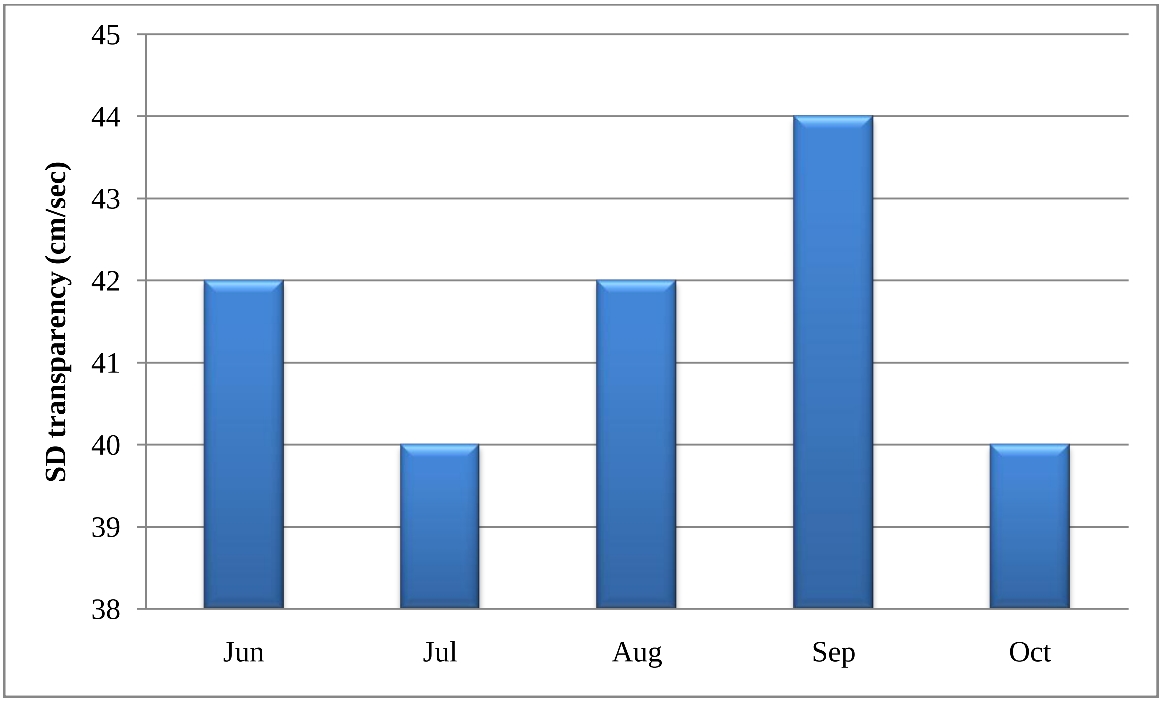

Figure 77. Monthly variations of Secchi disk transparency of water in Dakatia river, Roghunathpur, Chandpur during feeding regime trial-2 of cage culture

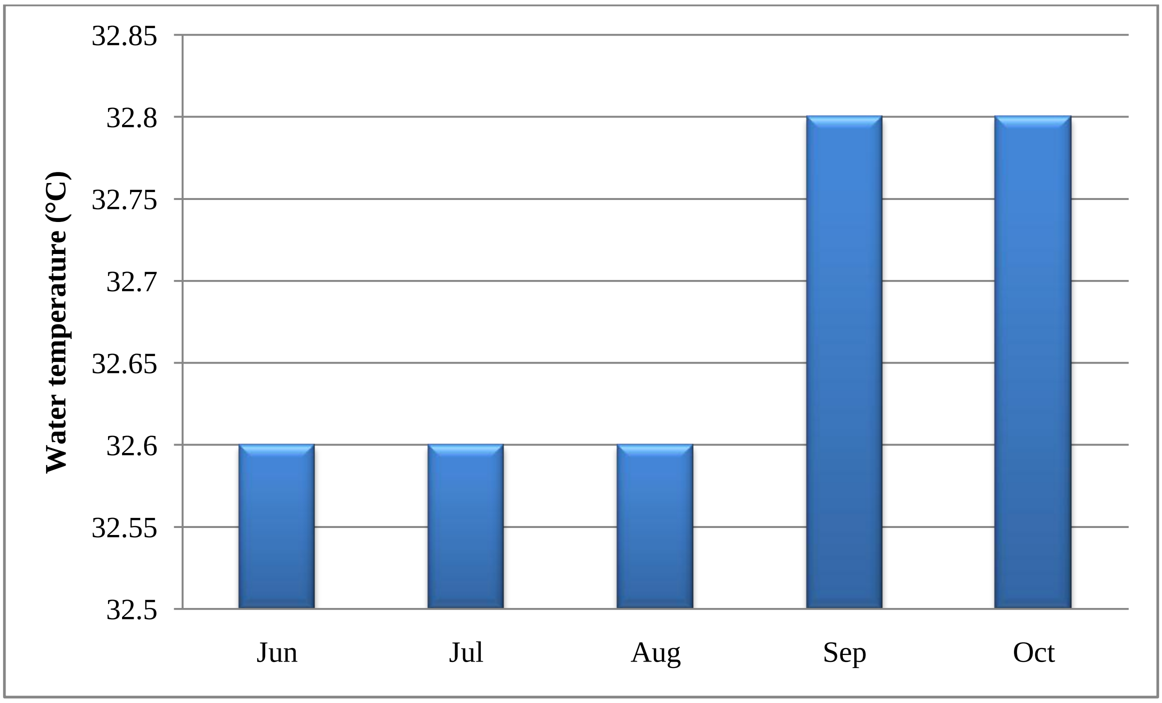

Figure 78. Monthly variations of water temperature in Dakatia river, Roghunathpur, Chandpur during feeding regime trial-2 of cage culture

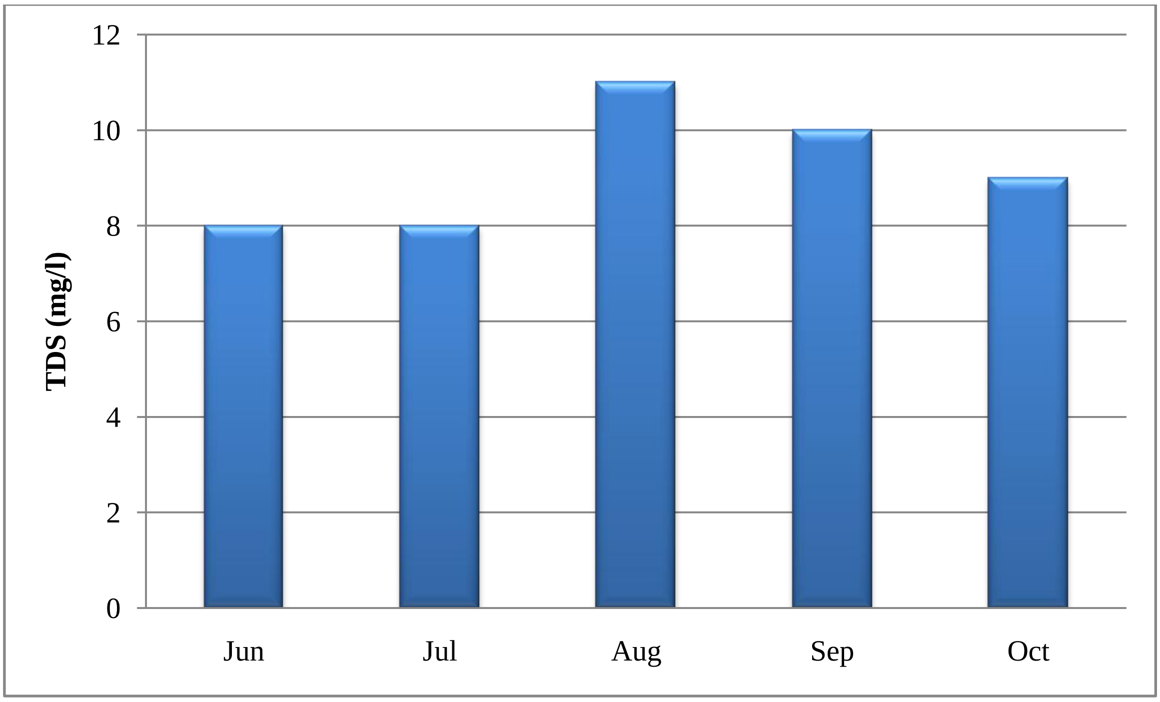

Figure 79. Monthly variations of total dissolved solids of water in Dakatia river, Roghunathpur, Chandpur during feeding regime trial-2 of cage culture

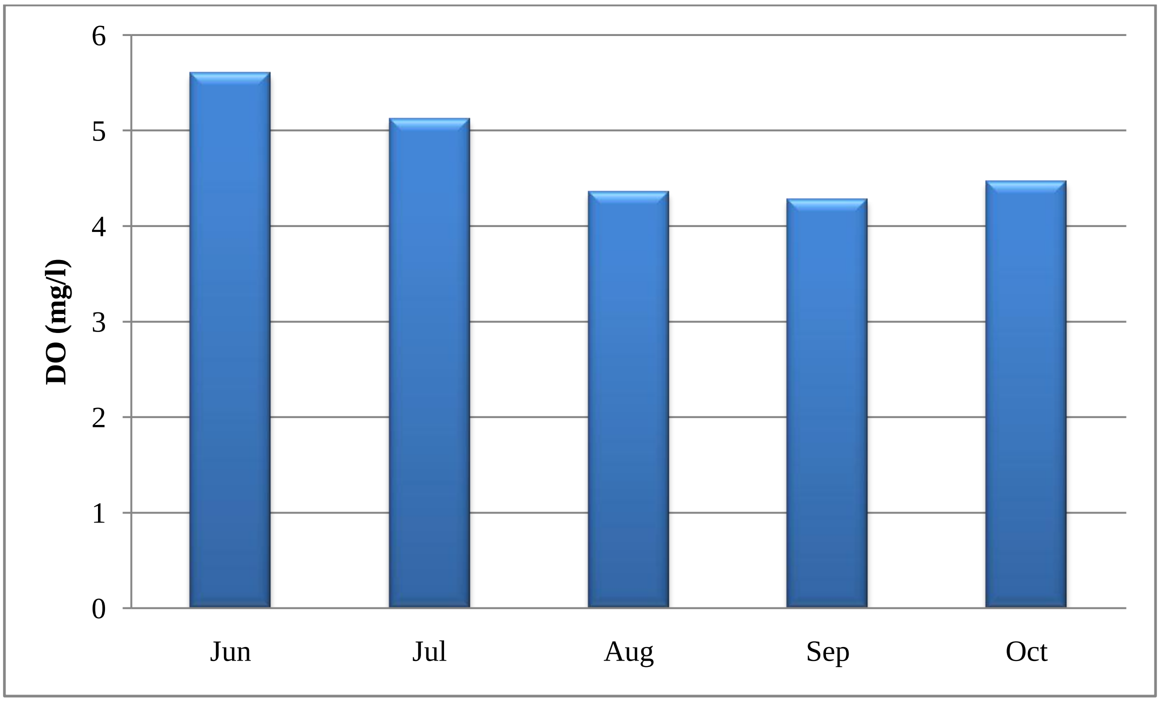

Figure 80. Monthly variations of dissolved oxygen of water in Dakatia river, Roghunathpur, Chandpur during feeding regime trial-2 of cage culture

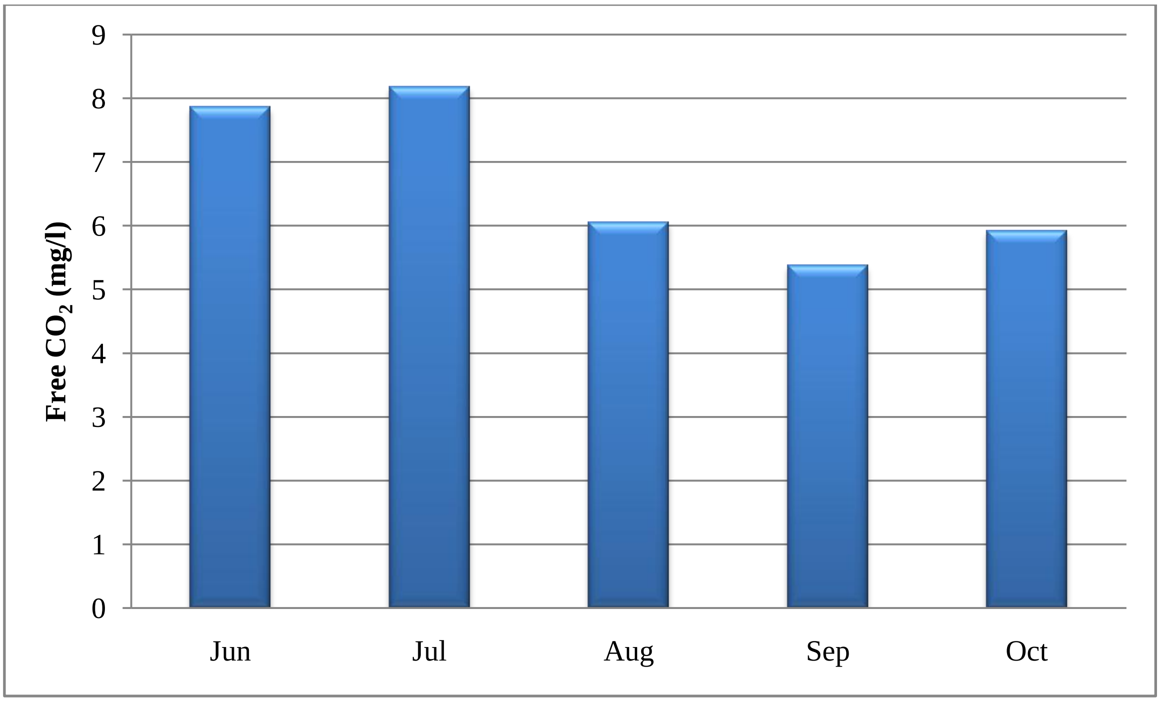

Figure 81. Monthly variations of free carbon dioxide of water in Dakatia river, Roghunathpur, Chandpur during feeding regime trial-2 of cage culture

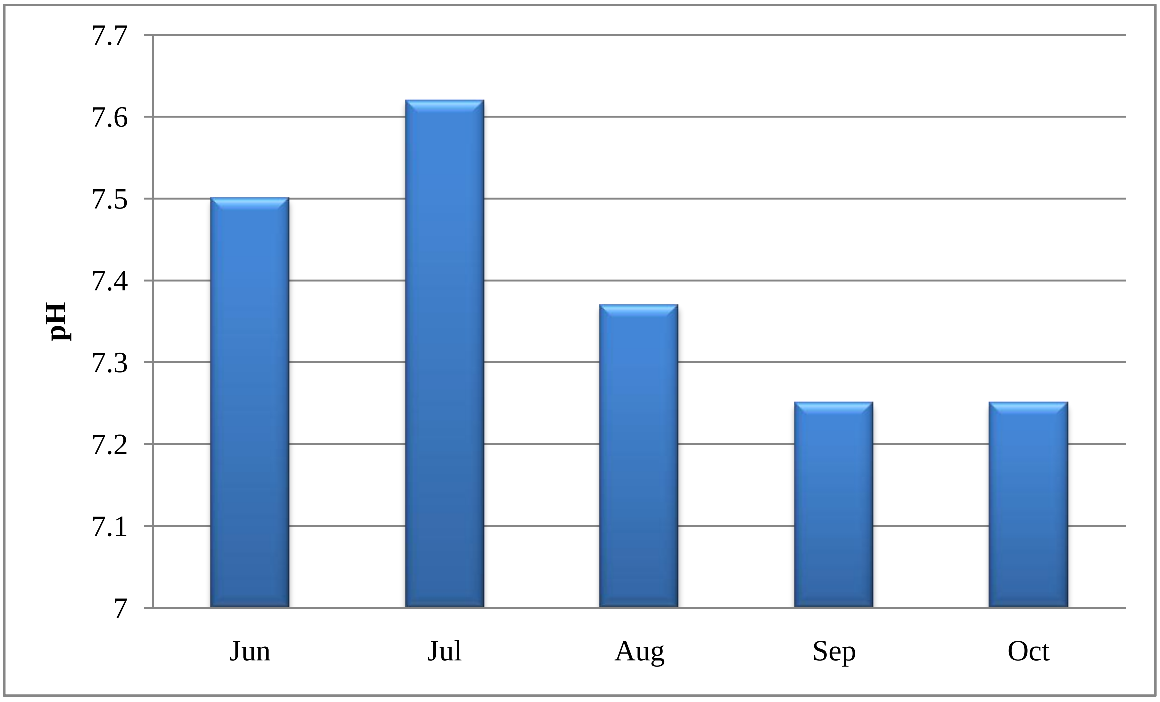

Figure 82. Monthly variations of water pH in Dakatia river, Roghunathpur, Chandpur during feeding regime trial-2 of cage culture

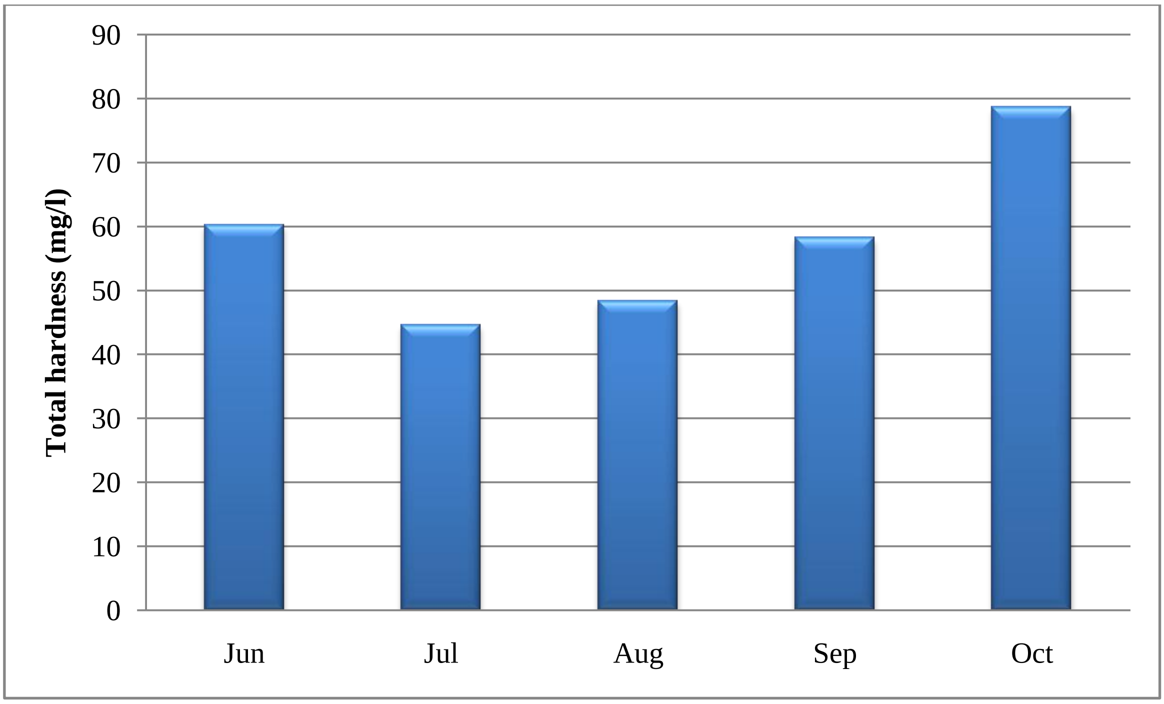

Figure 83. Monthly variations of total hardness of water in Dakatia river, Roghunathpur, Chandpur during feeding regime trial-2 of cage culture

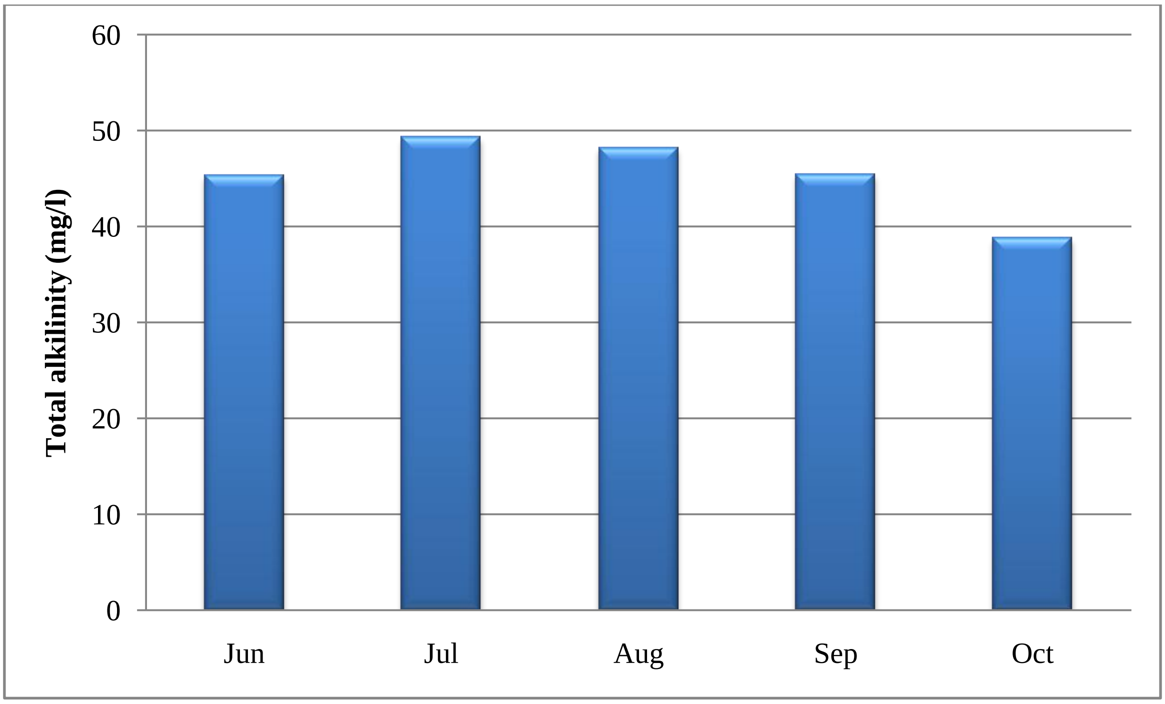

Figure 84. Monthly variations of total alkalinity of water in Dakatia river, Roghunathpur, Chandpur during feeding regime trial-2 of cage culture

Table 14. Correlation Matrix of Water Quality parameters during culture period in feeding regime trial-2

	WCV	SDT	WT	TDS	DO	CO_2	pH	TH	TA
WCV	1								
SDT	-.267	1							
WT	.816	.218	1						
TDS	.257	.504	.210	1					
DO	-.687	-.284	-.624	-.833	1				
CO_2	-.664	-.486	-.750	-.798	.914*	1			
PH	-.731	-.411	-.837	-.627	.787	.957*	1		
TH	.716	-.158	.717	-.114	-.171	-.413	-.650	1	
TA	-.773	.203	-.736	.085	.226	.438	.664	-.996**	1

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

WCV = Water Current Velocity, SDT = Secchi Disk Transparency, WT = Water Temperature, TDS =Total Dissolved Solids, DO = Dissolved Oxygen, CO_2 = Carbon Di-oxide, pH = Hydrogen Ion Concentration, TH =Total Hardness, TA =Total Alkalinity

4.4.2. Growth parameters of feeding regime trial-2

Final weight (FW)

After completion of the experimental period (120 days) of feeding regime trial-2, the mean final weight of the tilapia in cage of different treatments was attained between 284.65g to 314.46g, while the initial average weight was 20.76g for each treatment. The highest final weight was attained 314.46g in T_1 followed by T_2 (303.93g) and T_3 (284.65g) respectively (Table 15 & Figure 89). The final weight of the three treatments exhibited significant differences ($p < 0.01$) between T_1 and T_3, and T_2 and T_3 (Table 17).

Weight gain (WG)

The monthly variations of weight gain of the tilapia of feeding regime trial-2 was in ranged between 27.51g to 109.03g in T_1, it varied from 27.34g to 103.65g in T_2 and from 19.31g to 120.93g in T_3 (Appendix 8 Figure 85). The monthly weight gain in first second and third month showed highly significant differences ($p < 0.001$) while significant differences ($p < 0.01$) was found in the fourth month between T_1 and T_3, and T_2 and T_3 (Table 16). Among the three treatments, the highest weight gain observed 293.70g in T_1 and followed by T_2 (283.16g) and T_3 (263.88g) respectively (Table 15 & Figure 90). The weight gain of the three treatments showed significant differences ($p < 0.01$) between T_1 and T_3, and T_2 and T_3 (Table 17).

Relative growth rate (RGR)

The monthly variations of relative growth rate of the different treatments in this trial ranged from 40.85% to 136.59% in T_1, from 41.07% to 132.52% in T_2, and from 73.87% to 104.99% in T_3 respectively (Appendix 8 & Figure 86). The monthly relative growth rate in first and fourth month was found highly significant differences ($p < 0.001$) while significant differences ($p < 0.01$) was found in the second month between T_1 and T_3, and T_2 and T_3 (Table 16). The highest relative growth rate was found 101.42% in T_1 followed by T_2 (99.50%) and T_3 (92.82%), respectively (Table 15 & Figure 91). The relative growth rate showed highly significant differences ($p < 0.001$) between T_1 and T_3, and T_2 and T_3 (Table 17).

Specific growth rate (SGR)

The monthly variations of specific growth rate of the different treatments in feeding regime trial-2 ranged from 1.13%/day to 2.86%/day in T_1, while in T_2 it ranged from 1.14%/day to 2.80%/day and in T_3 specific growth rate ranged from 1.83%/day to 2.39%/day (Appendix 8 & Figure 87). The monthly specific growth rate in first and fourth month was found also highly significant differences ($p < 0.001$) while significant differences ($p < 0.01$) was found in the second month between T_1 and T_3, and T_2 and T_3 (Table 16). The highest specific growth rate was found 2.25%/day in T_1 followed by T_2 (2.22%/day) and T_3 (2.17%/day), respectively (Table 15 & Figure 92). The specific growth rate of this trial also showed significant differences ($p < 0.01$) between the T_1 and T_3, and T_2 and T_3 (Table 17).

Food conversion ratio (FCR)

The monthly variations of food conversion ratio of different treatments in this trial ranged from 1.31 to 4.40 in T_1, from 1.12 to 3.65 in T_2 and from 1.14 to 1.62 in T_3, respectively (Appendix 8 & Figure 88). The monthly food conversion ratio was found significantly different ($p < 0.01$) between the T_1 and T_2, and T_2 and T_3 in first month, whereas significant differences ($p < 0.05$) found in second month between T_1 and T_2, and T_1 and T_3, but in third and fourth month it was found highly significant differences ($p < 0.001$) among the three treatments (Table 16). Food conversion ratio was found 2.24, 1.88 and 1.31 in T_1, T_2 and T_3 respectively, where T_1 shown the highest value and T_3 was the lowest (Table 15 & Figure 93). The food conversion ratio was found highly significant differences ($p < 0.001$) among the three treatments in this trial (Table 17).

Survival rate

The survival rate of the tilapia in different treatments of feeding regime trial-2 was recorded from 96.66% to 97.22%. The highest survival rate was found in T_2 (97.22%) followed by T_1 (97.00%) and T_3 (96.66%) respectively (Table 15 & Figure 94). No significant differences also were found in survival rates of different treatments in this trial (Table 17).

Gross production (GP)

The gross production of the tilapia in different treatments was recorded from 247.56kg/cage to 274.49kg/cage of the feeding regime trial-2. Gross production was recorded highest

274.49kg/cage in T_1 followed by T_2 (265.88kg/cage) and T_3 (247.56kg/cage) respectively (Table 15 & Figure 95). The gross production was found highly significant differences ($p < 0.001$) among the three treatments (Table 17).

Net production (NP)

The net production of the tilapia in different treatments was recorded from 229.50kg/cage to 256.36kg/cage of the feeding regime trial-2. Net production was also recorded highest 256.36kg/cage in T_1 followed by T_2 (247.71kg/cage) and T_3 (229.50kg/cage) respectively (Table 15 & Figure 96). Net production was found highly significant differences ($p < 0.001$) among the three treatments (Table 17).

Net profit

The detail of net profit determination of this trial is shown in table (Appendix 12). The net profit was earned from 6463Tk/cage to 14055Tk/cage in different treatments of the feeding regime trial-2. The highest net profit was earned in T_3 (14055Tk/cage) followed by T_2 (9473Tk/cage) and T_1 (6463Tk/cage) respectively (Table 15 & Figure 97). Net profit was found highly significant differences ($p < 0.001$) among the three treatments (Table 17).

Benefit cost ratio (BCR)

The detail of benefit cost ratio determination of this trial is shown in table (Appendix 12). The benefit cost ratio of the production of tilapia was determined ranged from 1.25 to 1.93 in different treatments of feeding regime trial-2. The highest benefit cost ratio was determined in T_3 (1.93) followed by T_2 (1.44) and T_1 (1.25) respectively (Table 15 & Figure 98). Benefit cost ratio expressed highly significant differences ($p < 0.001$) among the three treatments (Table 17).

Table 15. Growth performance of tilapia under different treatments of feeding regime trial- 2 in Dakatia river, Roghunathpur, Chandpur during 03 June - 01 October, 2011.

Parameters	**Treatments**				
	T_1- (6% bw feed)	T_2- (5% bw feed)	T_3- (4% bw feed)	Range	Mean ± SD
Initial weight- IW (g)	20.76	20.76	20.76	20.76 - 20.76	20.76±0
Final weight- FW (g)	314.46	303.92	284.64	284.64 - 314.46	301.01±15.12
Weight gain- WG (g)	293.70	283.16	263.88	263.88 - 293.70	280.25±15.12
Relative growth rate- RGR (%)	101.42	99.50	92.82	92.82 - 101.42	97.91±4.51
Specific growth rate- SGR (%/day)	2.25	2.22	2.17	2.17 - 2.25	2.21±0.04
Food conversion ratio- FCR	2.24	1.88	1.31	1.31 - 2.23	1.80±0.46
No. of fish harvested	873	875	870	870 - 875	872.67±2.52
Survival (%)	97.00	97.22	96.66	96.66 - 97.22	96.96±0.28
Gross production- GP (kg/cage)	274.49	265.88	247.56	247.56 - 274.49	262.64±13.75
Net production- NP (kg/cage)	256.36	247.71	229.50	229.50 - 256.36	244.52±13.71
Net profit (Tk/cage)	6463	9473	14055	6463 - 14055	9997±3823.03
Benefit cost ratio- BCR	1.25	1.44	1.93	1.25 - 1.93	1.54±0.35

Stocking density: $50/m^3$ (900/cage) in each treatment

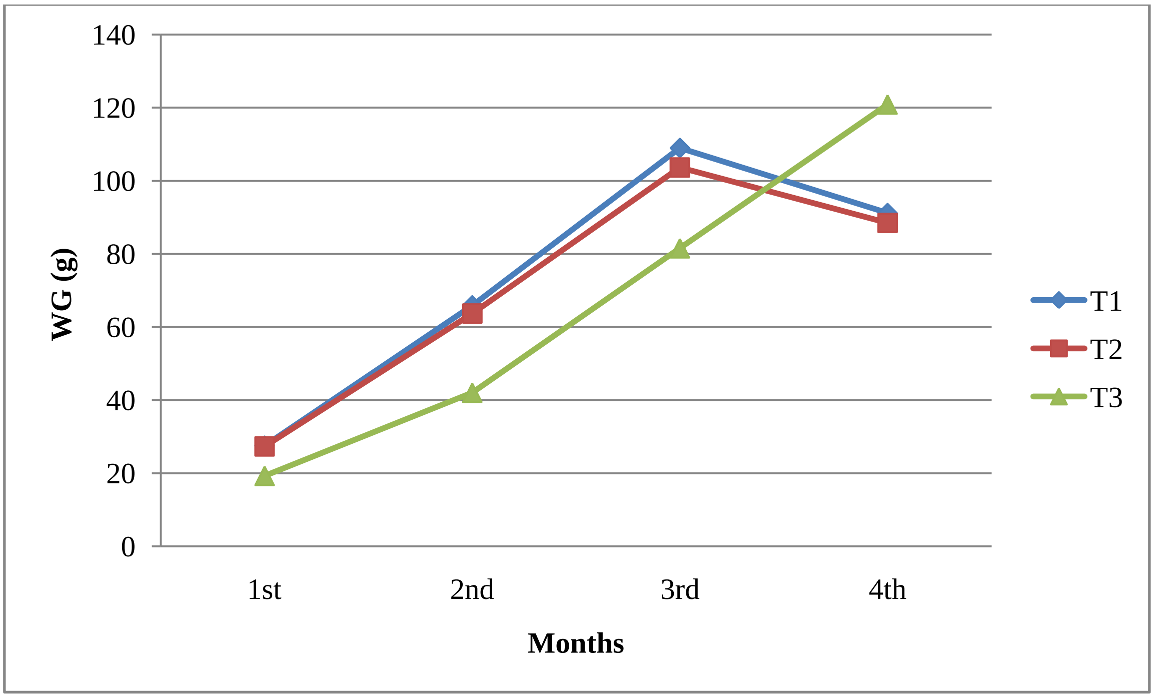

Figure 85. Monthly variations of weight gain in different treatments of feeding regime trial-2

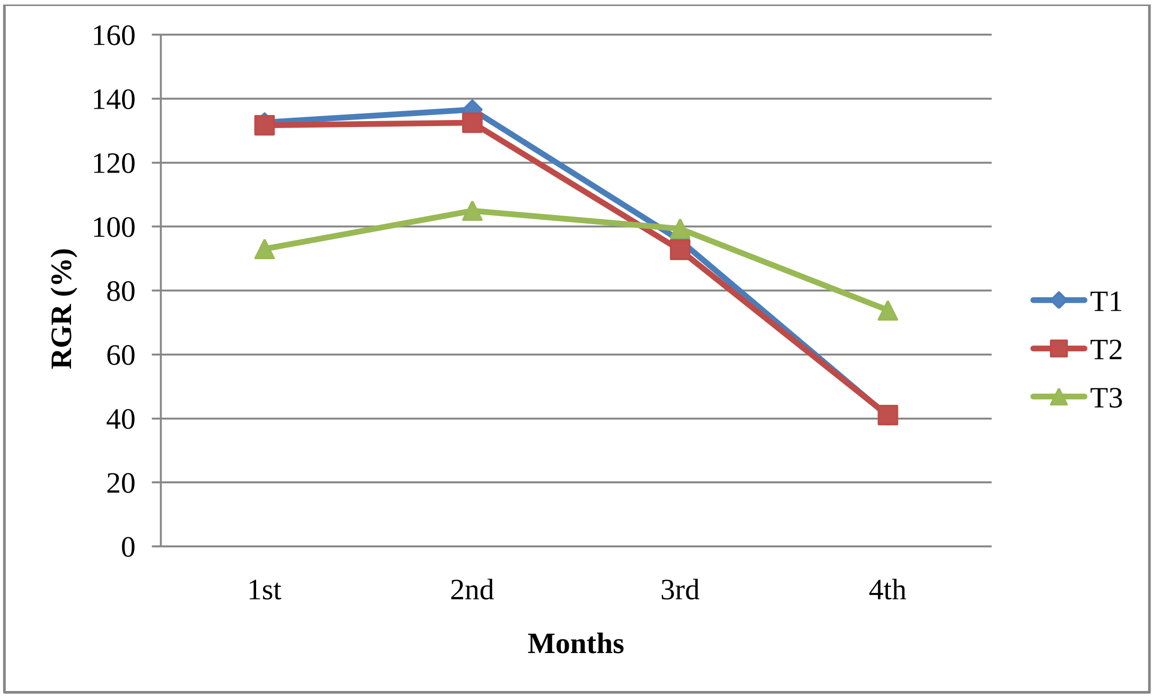

Figure 86. Monthly variations of relative growth rate in different treatments of feeding regime trial-2

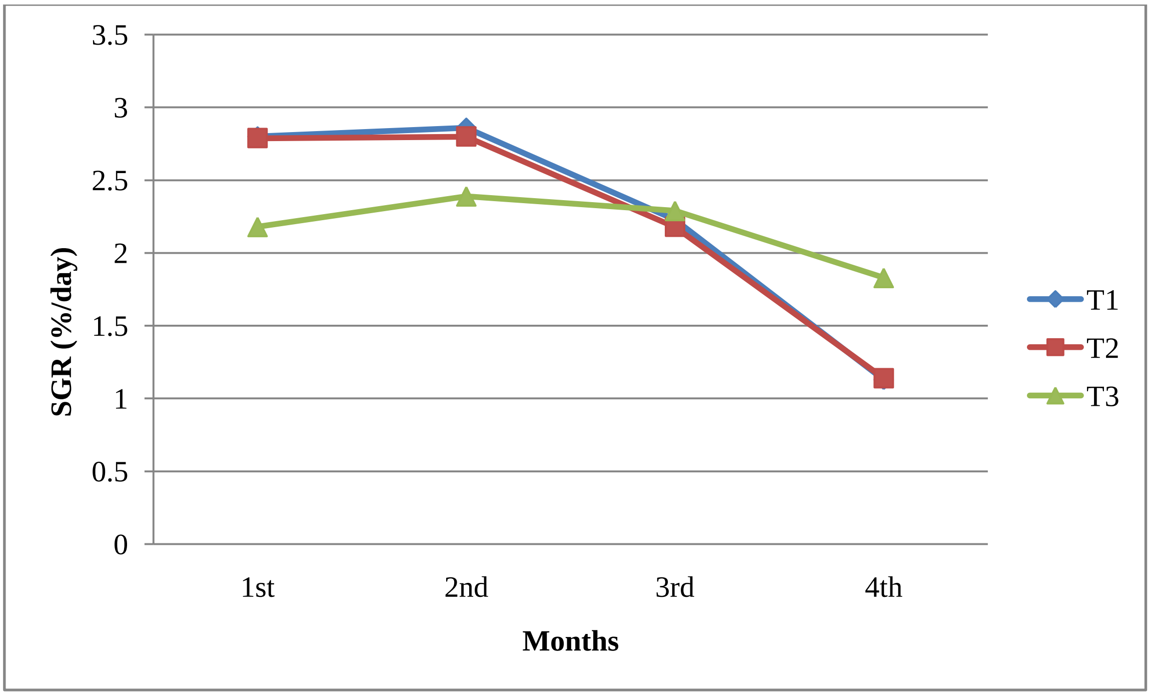

Figure 87. Monthly variations of specific growth rate in different treatments of feeding regime trial-2

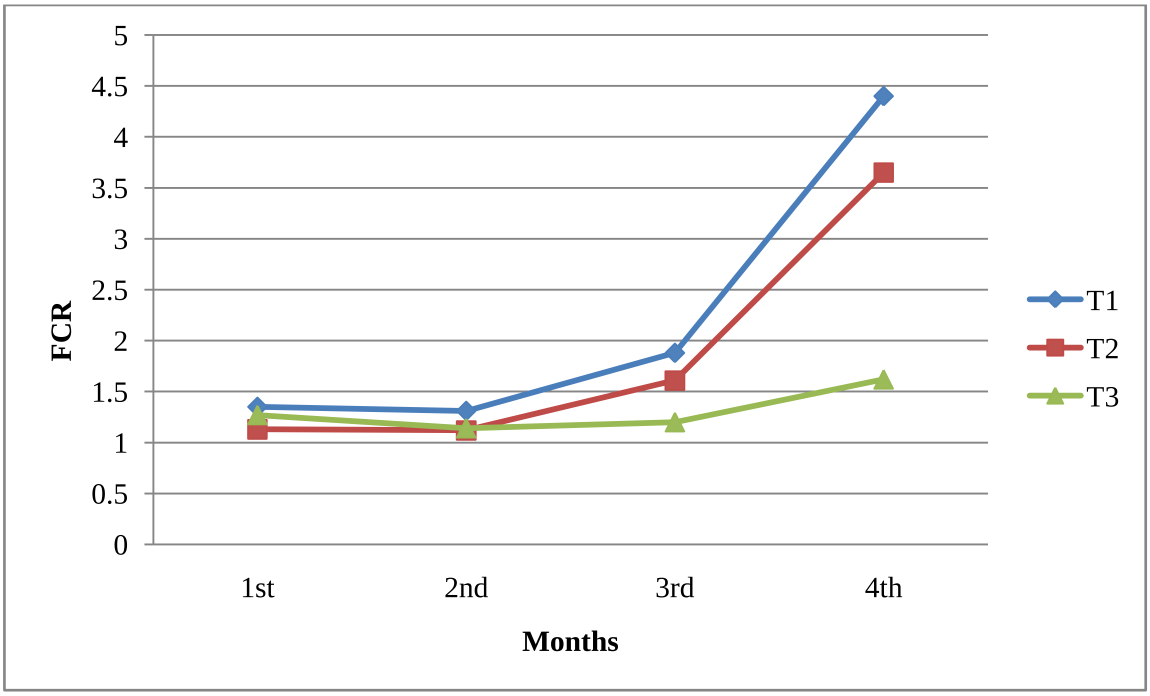

Figure 88. Monthly variations of food conversion ratio in different treatments of feeding regime trial-2

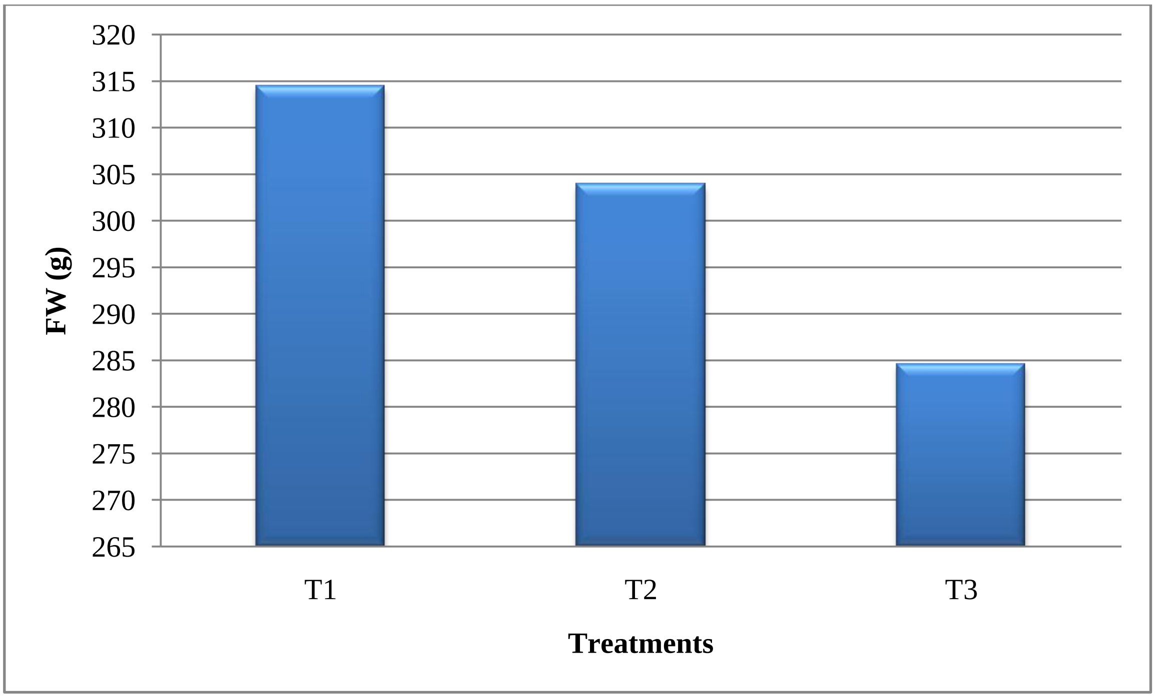

Figure 89. Final weight of tilapia in different treatments of feeding regime trial-2

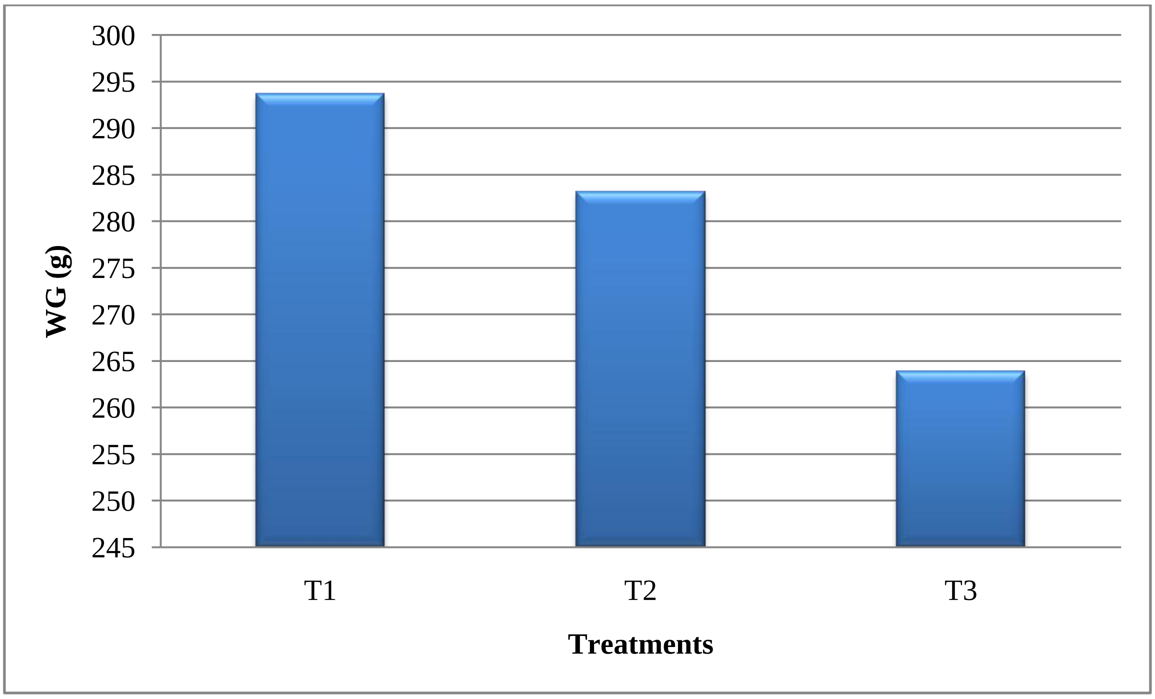

Figure 90. Weight gain of tilapia in different treatments of feeding regime trial-2

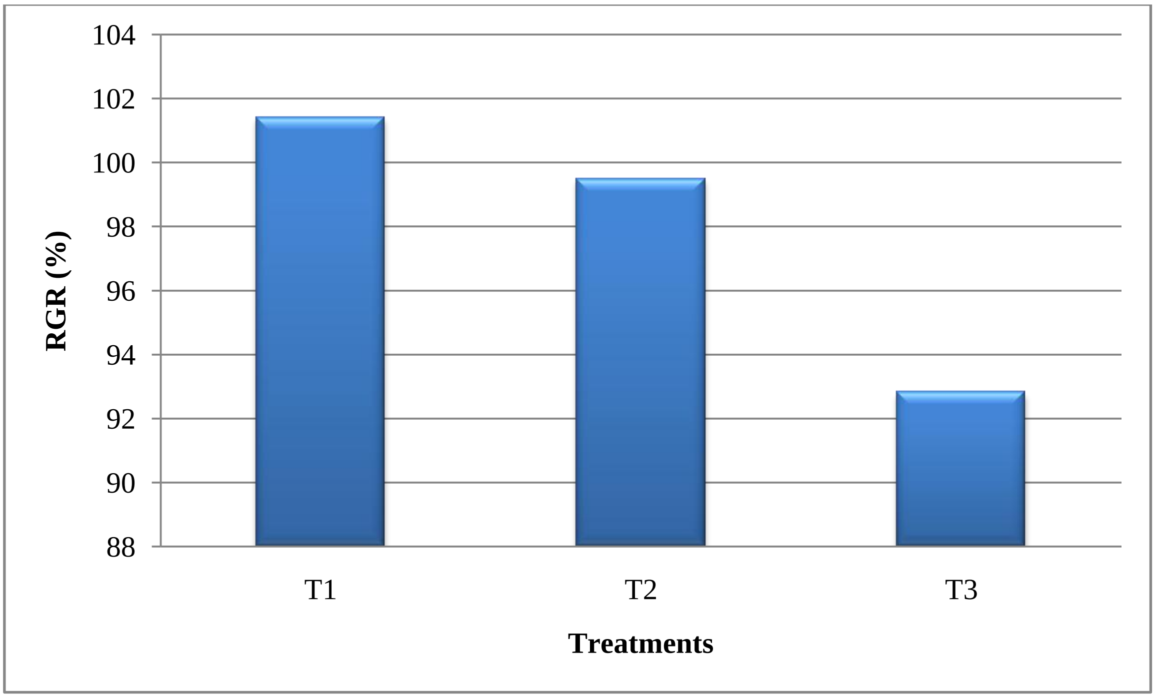

Figure 91. Relative growth rate of tilapia in different treatments of feeding regime trial-2

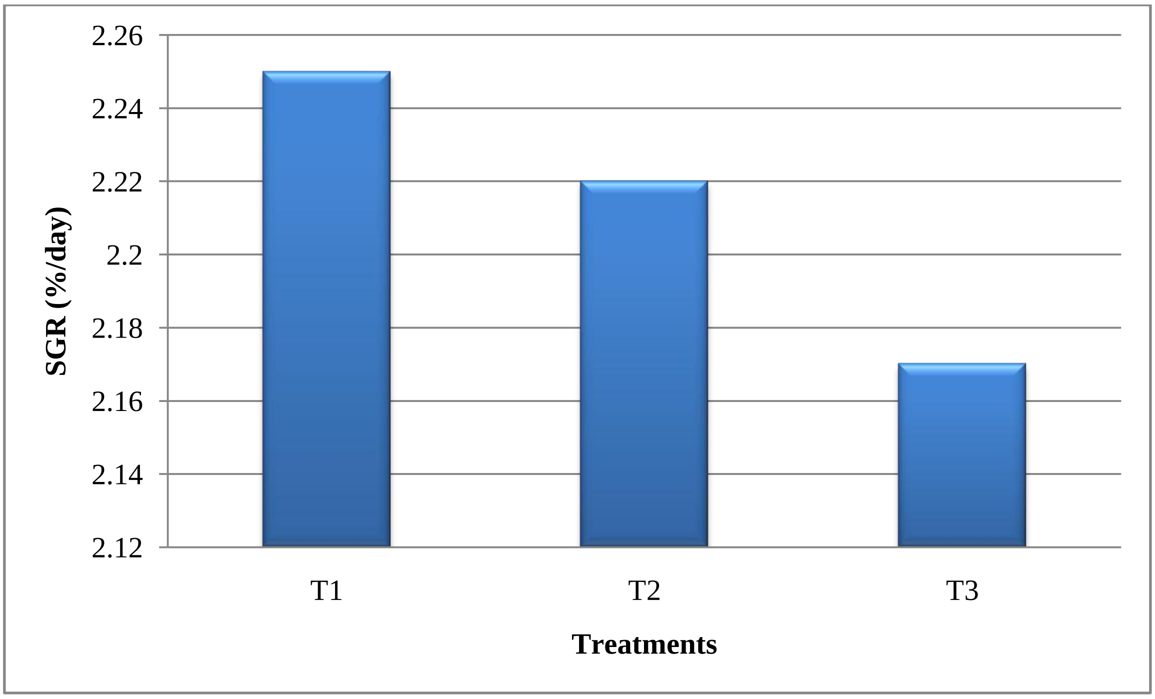

Figure 92. Specific growth rate of tilapia in different treatments of feeding regime trial-2

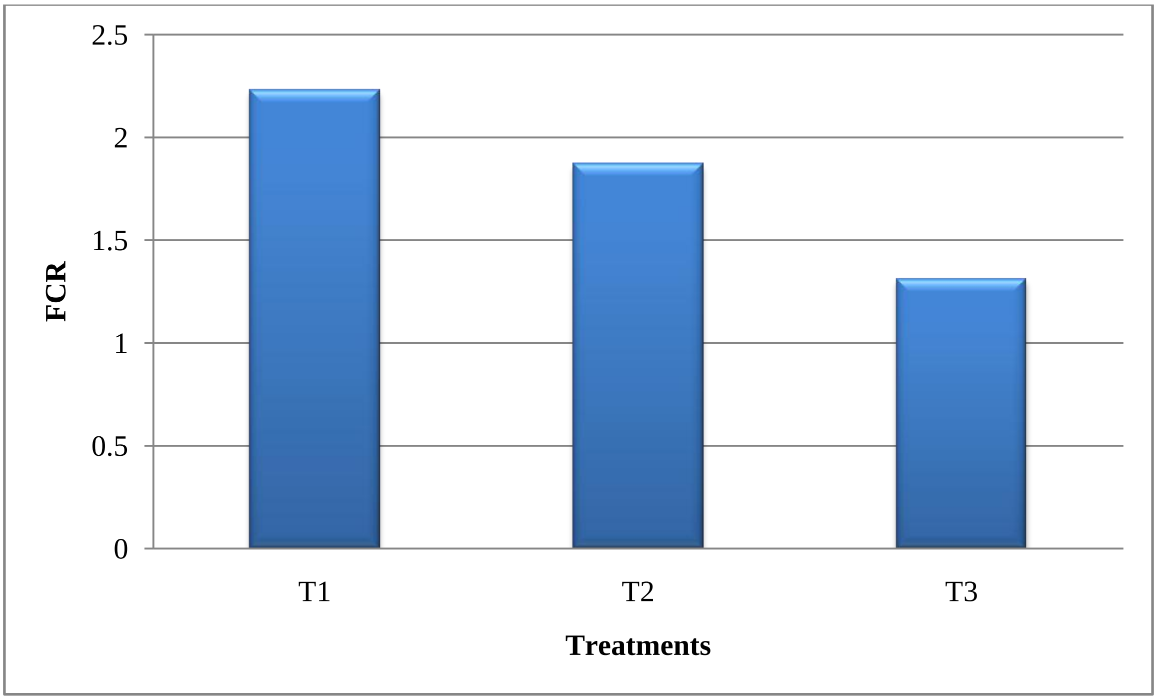

Figure 93. Food conversion ratio of tilapia in different treatments of feeding regime trial-2

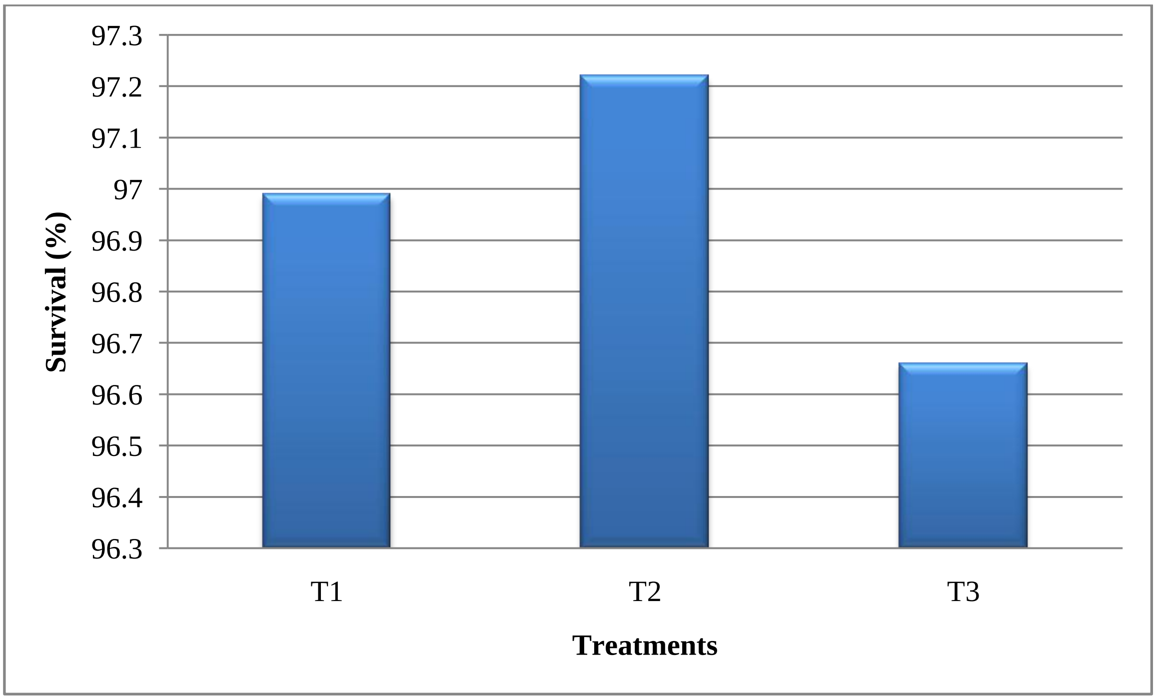

Figure 94. Survival rate of tilapia in different treatments of feeding regime trial-2

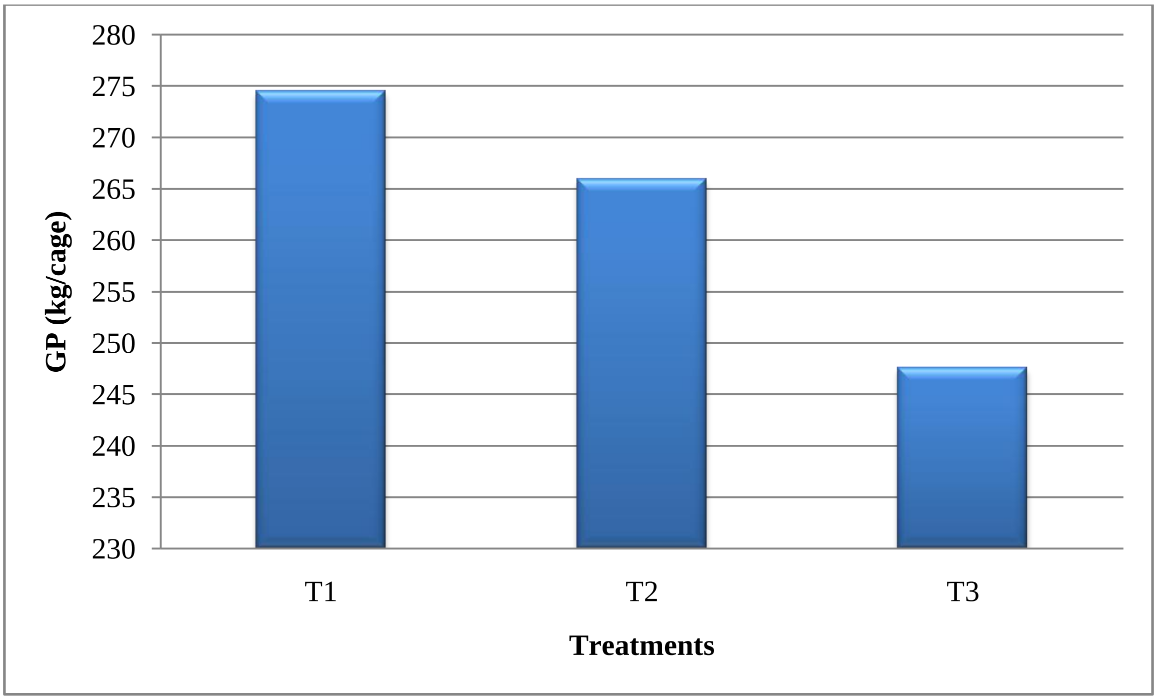

Figure 95. Gross production of tilapia in different treatments of feeding regime trial-2

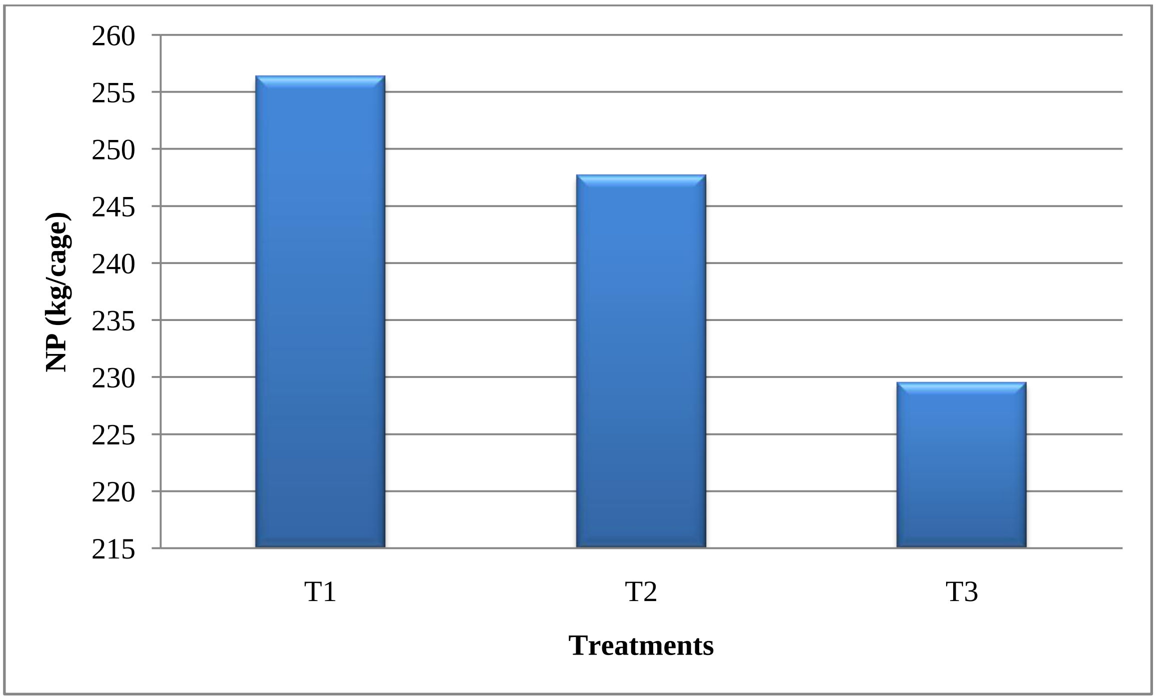

Figure 96. Net production of tilapia in different treatments of feeding regime trial-2

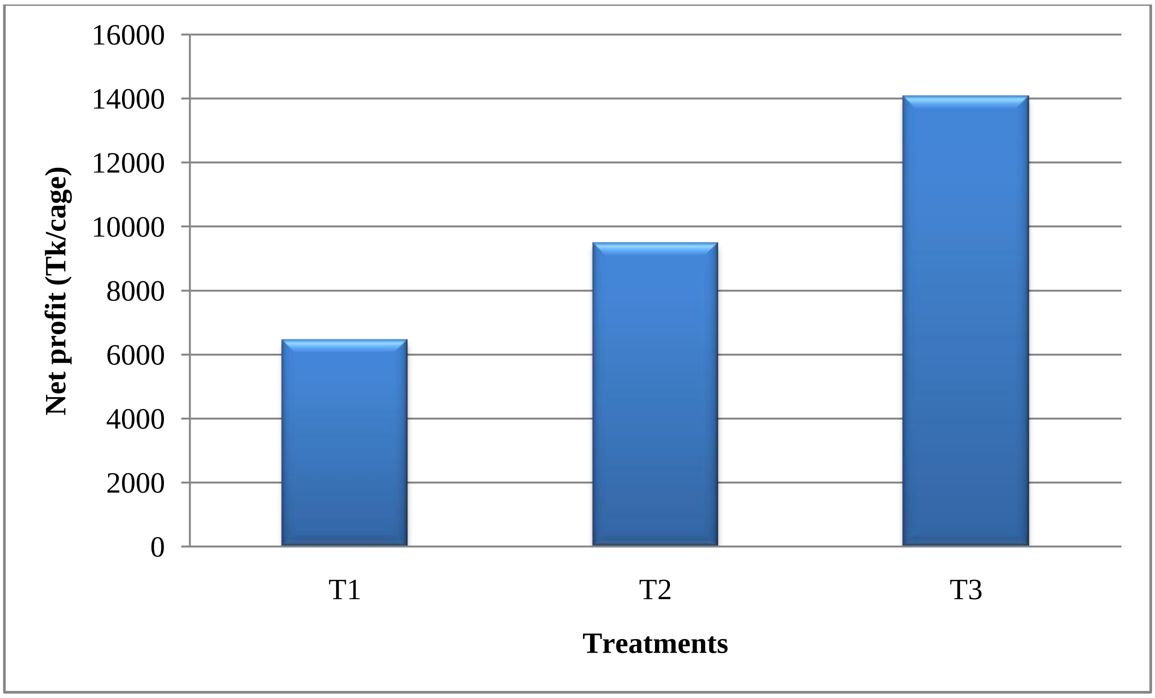

Figure 97. Net profit of tilapia in different treatments of feeding regime trial-2

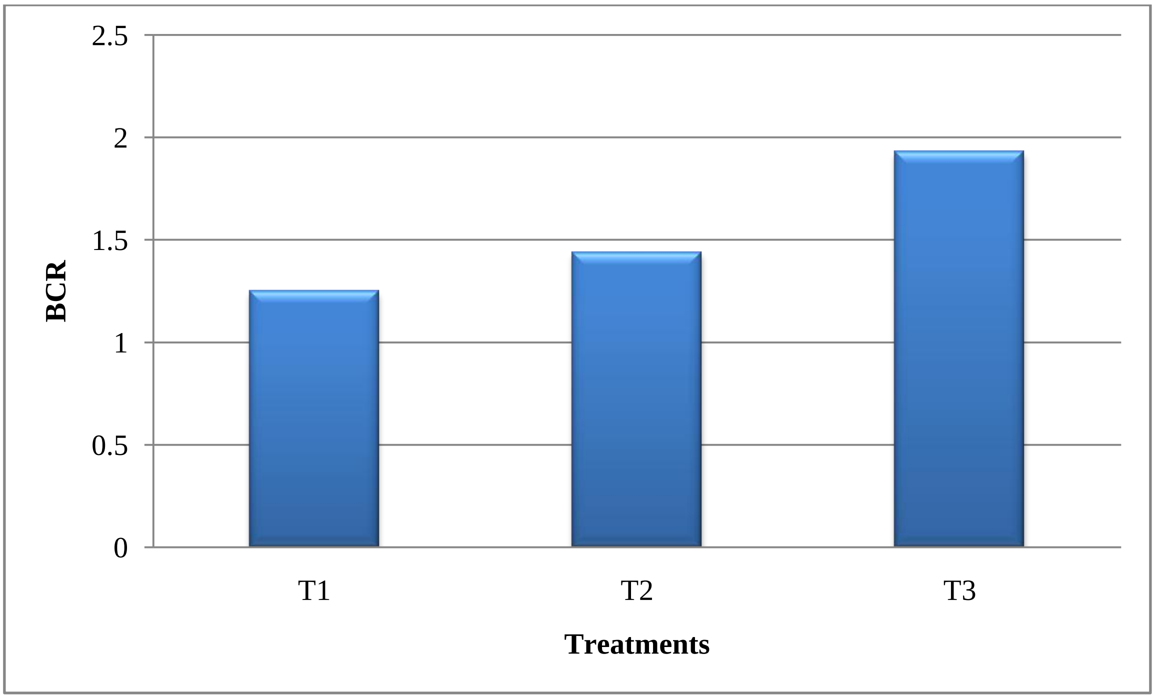

Figure 98. Benefit cost ratio of tilapia in different treatments of feeding regime trial-2

Table 16. Effect of different amount of feed supplements on monthly growth parameters of Tilapia cultured in net cage of Dakatia river, Roghunathpur, Chandpur during 03 June -01 October, 2011 at feeding regime trial-2.

Treatments	**Monthly growth parameters**															
Feed supplement (% body weight)	Mean weight gain - WG (g)				Mean relative growth rate - RGR (%)				Mean specific growth rate - SGR (%/day)				Mean food conversion ratio - FCR			
	1st month	2nd month	3rd month	4th month	1st month	2nd month	3rd month	4th month	1st month	2nd month	3rd month	4th month	1st month	2nd month	3rd month	4th month
6	27.51a	65.94a	109.03a	91.22b	132.54a	136.59a	95.74a	40.85b	2.81a	2.86a	2.23a	1.13b	1.35a	1.31a	1.88a	4.40a
5	27.35a	63.68a	103.66a	88.48b	131.72a	132.52a	92.73a	41.07b	2.80a	2.80a	2.18a	1.14b	1.13b	1.13b	1.61b	3.65b
4	19.32b	42.06b	81.59b	120.92a	93.04b	104.99b	99.38a	73.87a	2.19b	2.39b	2.29a	1.84a	1.28a	1.14b	1.20c	1.63c
LSD	2.20***	6.08***	9.30***	13.90**	10.61***	14.53**	13.56	8.36***	0.16***	0.21**	0.23	0.17***	0.11**	0.12*	0.16***	0.37***
CV (%)	4.45	5.32	4.74	6.94	4.46	5.83	7.08	8.05	3.12	3.84	5.24	6.03	4.29	5.00	4.97	5.72

Means bearing same letter(s) in a column do not differ significantly
*** indicates P < 0.001, ** indicates P < 0.01; * indicates P < 0.05

Table 17. Effect of different amount of feed supplements on different parameters of Tilapia cultured in net cage of Dakatia river, Roghunathpur, Chandpur during 03 June -01 October, 2011 at feeding regime trial-2.

Treatments	**Parameters**									
Feed supplement (% body weight)	Mean final weight (g)	Mean weight gain (g)	Mean relative growth rate (%)	Mean specific growth rate (%/day)	Mean food conversion ratio	Mean survival rate (%)	Mean gross production (kg)	Mean net production (kg)	Mean benefit cost ratio	Mean net profit (Tk)
6	314.46a	293.70a	101.43a	2.26a	2.24a	97.00a	274.49a	259.37a	1.25c	6463c
5	303.93a	283.17a	99.51a	2.23a	1.88b	97.22a	265.88b	247.71b	1.44b	9473b
4	284.65b	263.89b	92.82b	2.17b	1.31c	96.66a	247.57c	229.51c	1.93a	14055a
LSD	14.32^{**}	14.32^{**}	2.17^{***}	0.04^{**}	0.10^{***}	2.63	6.93^{***}	9.70^{***}	0.06^{***}	858.34^{***}
CV (%)	2.38	2.56	1.11	0.97	2.85	1.36	1.32	1.98	1.90	4.30

Means bearing same letter(s) in a column do not differ significantly
*** indicates $P < 0.001$, ** indicates $P < 0.01$

4.5. Proximate composition of commercial feed used for tilapia of cages

The proximate composition of commercial semi-buoyant feed used for tilapia in different cage culture trials are shown in table and graphical presentation ((Appendix 13 & Figure 99). Proximate composition of used different floating type of Mega feed such as moisture (%), ash (%), lipid (%) and crude protein (%) were determined. The moisture content determined of Tilapia nursery, Tilapia starter, Tilapia grower and Tilapia finisher were 8.93%, 8.78%, 6.69% and 10.13% respectively. The highest moisture content (10.13%) was found in Tilapia finisher and the lowest (6.69%) was in Tilapia grower. The maximum (19.62%) ash content was determined in Tilapia nursery while the minimum (14.55%) was in Tilapia finisher. Lipid content was also assessed highest (8.90%) in Tilapia nursery and lowest (4.49%) in Tilapia starter. The crude protein contents of Tilapia nursery, Tilapia starter, Tilapia grower and Tilapia finisher was determined 33.22%, 28.33%, 26.54% and 27.05% respectively, which was found some differences from labeled crude protein contents (Appendix 17 & Figure 99) when analyzed in laboratory.

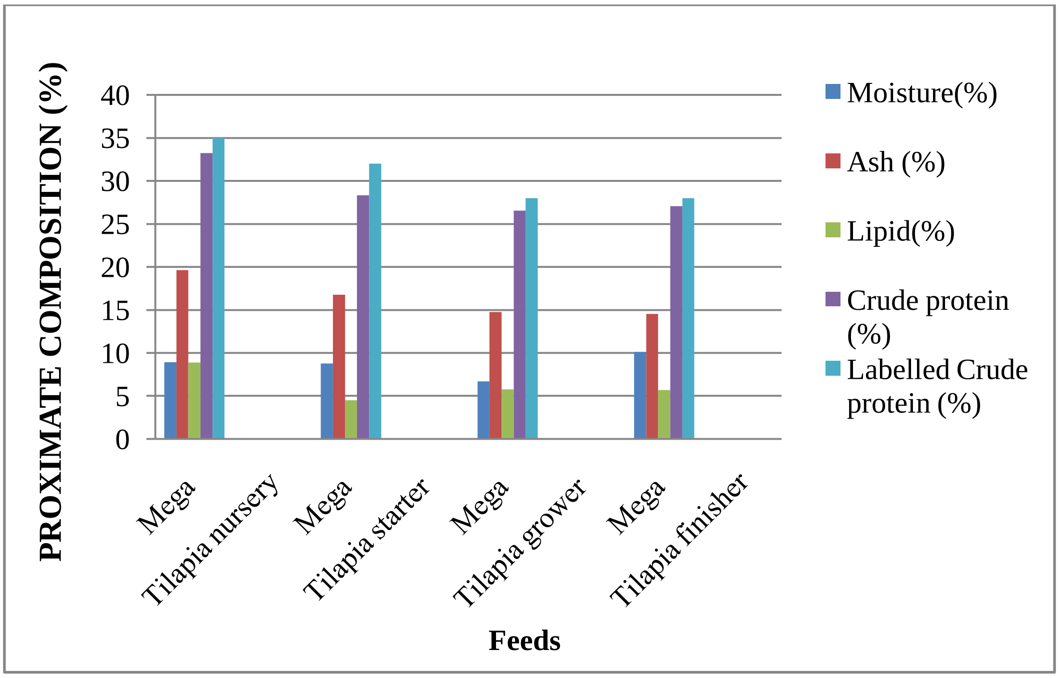

Figure 99. Proximate composition of different floating feeds used for tilapia in cage culture of Dakatia river Chandpur.

CHAPTER-5 DISCUSSION

5.1. Physicochemical parameters of cage water

The physicochemical parameters of cage water of all the trials of this study were conducted from April 2010 to October 2011. The studied parameters were water depth, current velocity, secchi-disk transparency, water temperature, total dissolved solids, dissolved oxygen, free CO_2, pH, total hardness, total alkalinity, salinity, Ammonia-NH_3 and Nitrite-NO_2 (Appendix 1, 2, 3 & 4). During the study period, all physicochemical parameters were found suitable for aquaculture (Boyd 1982). Ahmed *et al.* (2010) measured water quality parameters such as water temperature, transparency, total dissolved solids, pH, dissolved oxygen, free CO_2, total alkalinity, total hardness and NO_2-N of the Meghna, Gumti, Titas, Hoara and Dakatia rivers which are more or less similar to the present study. Water temperature, transparency, total dissolved solids, pH, dissolved oxygen, free CO_2, total alkalinity, total hardness and NO_2-N of the present study also found identical to the reported by Ahmed *et al*. (2011). Dasuki *et al*. (2013) assessed some physicochemical parameters such as water temperature, total dissolved solids, pH and dissolved oxygen of floating bamboo cages (*clarias gariepinus*) in Kubanni reservoir, Zaria, Nigeria and their findings also supported the present study. Mallasen *et al.* (2012) studied water quality parameters in upstream of tilapia net cage area, net cage rearing place and downstream of net cage area also found no significant differences among three sites which revealed that tilapia net cage culture not influenced water quality in the Nova Avanhandava reservoir, Sao Paulo State, Brazil.

The present study it was found that for stocking density trial-2 secchi disk transparency showed a positive correlation with water current velocity ($p < 0.05$; $r = 0.951$) (Table 6). But for feeding regime trial-1 secchi disk transparency showed a negative correlation with water current velocity ($p < 0.05$; $r = - 0. 953$) (Table 10). It is may be due to clay particle mixing in rainy season and trend to be removed in others season.

Water temperature showed a positive correlation with water current velocity ($p < 0.01$; $r = 0.976$) (Table 2) in stocking density trial-1 and feeding regime trial-1 ($p < 0.05$; $r = 0. 946$) (Table 10). Whereas total hardness expressed inversely correlated with current velocity ($p < 0.05$; $r = - 0.958$) (Table 2) in stocking density trial-1 and in feeding regime trial-1 ($p < 0.01$; $r = - 0. 965$) (Table 10). While total alkalinity had a positive correlation with sechi-disk transparency ($p < 0.05$; $r = 0.914$) (Table 2) in stocking density trial-1 and feeding regime trial-1 ($p < 0.05$; $r = 0.955$) (Table 10). The aforesaid correlations are may be due to the same season of the two consecutive years.

In cases of stocking density trial-1, total hardness expressed inversely correlated with water temperature ($p < 0.01$; $r = -0.994$) and positively related with sechi-disk transparency ($p < 0.05$; $r = 0.880$) (Table 2). On the other hand in stocking density trial-2 total dissolved solids showed a positive correlation with secchi-disk transparency ($p < 0.05$; $r = 0.925$), the pH value showed positive correlation with water current velocity ($p < 0.05$; $r = 0.916$), water temperature ($p < 0.05$; $r = 0.927$) and total dissolved solids ($p < 0.05$; $r = 0.885$); total alkalinity showed positive correlation with dissolved oxygen ($p < 0.01$; $r = 0.967$) and total hardness ($p < 0.05$; $r = 0.944$) (Table 6).

In feeding regime trial-1, water temperature had a negative correlation with secchi-disk transparency ($p < 0.01$; $r = -0.993$) (Table 10). Total alkalinity showed negative correlation with water current velocity ($p < 0.05$; $r = -0.921$) and water temperature ($p < 0.05$; $r = -0.913$), whereas positively correlated with total hardness ($p < 0.05$; $r = 0.912$) of cage water (Table 10). While feeding regime trial -2, free CO_2 had a positive correlation with dissolved oxygen ($p < 0.05$; $r = 0.914$), the pH value showed a positive correlation with free CO_2 ($p < 0.05$; $r = 0.957$); total alkalinity showed negative correlation with total hardness ($p < 0.01$; $r = -0.996$) (Table 14). From the above discussions it is found that most of the water quality parameters are related to each other.

5.2. Stocking density of tilapia in cage culture

Stocking density is one of the main factors determining fish growth (Engle and Valderrama 2001; Rahman et al. 2005) and the final biomass harvested (Boujard et al. 2002). Identifying the optimum stocking density for a species is a critical factor not only for designing an efficient culture system (Leatherland and Cho 1985), but also for optimum and sustainable culture practices. In the present study of tilapia cage culture, the mean final weight of the tilapia of different treatments of the stocking density trial-1 ranged between 202.28g and 247.27g while the initial average weight was 32.31g for each treatment. The highest final weight found in T_1 (247.27g) and followed by T_2 (231.23g) and T_3 (202.28g) respectively (Table 3 & Figure 16). Whereas in stocking density trial-2, the mean final weight of the tilapia of different treatments in cage ranged from 201.15g to 376.72g, while the initial average weight was 28.92g for each treatment. The highest final weight observed in T_1 (376.72g) followed by T_2 (276.64g) and T_3 (201.15g) respectively (Table 7 & Figure 41). The final weight exhibited highly significant differences ($p < 0.001$) among the three treatments in stocking density trial-1(Table 5) and stocking density trial-2 (Table 9). The present study revealed that the highest mean final weight followed lowest stocking density in both trials. Similar result also observed by Leboute *et al.* (1994) for Nile tilapia in cage culture. Dasuki *et al*. (2013) also reported same result that African catfish held at the highest stocking density exhibited the lowest growth in floating bamboo cages at Kubanni reservior, Zaria of Nigeria. But inversed result also reported by Dimitrov (1976) in case of carp culture in cage. It was found that the trend of weight gain followed same manner. Relative growth rate of stocking density trial-1 & 2 observed highest in lowest stocking density and followed by higher stocking densities and also significantly differences ($p < 0.001$) among the treatments (Table 5 & 9). Dasuki *et al*. (2013) reported similar findings but significant level was ($p < 0.05$). In stocking density trial-1, it was recorded that the highest specific growth rate 1.68%/day recorded in T_1 and lowest value 1.52%/day in T_3 (Table 3 & Fig 19). While in stocking density trial-2, it was found that highest specific growth rate 2.13%/day recorded in T_1 followed by T_2 (1.87%/day) and T_3 (1.61%/day), respectively (Table 7 & Figure 44). The specific growth rate expressed highly significant differences ($p < 0.001$) among the three treatments of stocking density trial-1 (Table 5) and stocking density trial-2 (Table 9). Osofero *et al.* (2009) and Alam (2010) reported that specific growth rate was found not significantly ($p > 0.05$) differences for Nile tilapia in 1 m^3 net cages. However, their results were not similar to the present study because it might be different of their cage size with the cage size of the present study. In stocking density trial-1, food conversion ratio was found 1.46, 2.01 and 2.89 in T_1, T_2 and T_3 respectively, where T_1 shown the lowest value and the T_3 was highest (Table 3 & Figure 20). Whereas in stocking density trial-2, food conversion ratio was found 1.59, 1.87 and 2.43 in T_1, T_2 and T_3 respectively, where T_3 shown the highest value and T_1 was the lowest (Table 7 & Figure 45). The present study showed highly significant differences ($p < 0.001$) of food conversion ratio of stocking density trial-1 & 2 (Table 5 & 9). Similar result also reported by Gibtan *et al.* (2008) but significant level was ($p < 0.05$). In stocking density trial-1, the survival rate of tilapia in cage was found ranged from 67.58% to 85.61%. The maximum survival rate was found in T_1 (85.61%) followed by T_2 (81.92%) and T_3 (67.58%) respectively (Table 3 & Figure 21). In stocking density trial-2 the survival rate of tilapia in cage was found varied from 84.38% to 97.92%. The highest survival rate was found in T_1 (97.92%) followed by T_2 (86.73%) and T_3 (84.38%) respectively (Table 7 &

Figure 46). Similar result observed by Yi *et al.* (1996). The survival rates of the three treatments of stocking density trial-1 was found highly significant differences ($p < 0.001$) among them (Table 5) and stocking density trial-2 also showed ($p < 0.001$) same result (Table 9). Gomes *et al.* (2006) and Rahman *et al.* (2006) reported that stocking density not significantly affected survival rate. In stocking density trial-1, gross production of the tilapia was recorded in ranged from 114.29kg/cage to 172.24kg/cage. The gross production was recorded highest 172.24kg/cage in T_3 and the lowest 114.29kg/cage in T_1 (Table 3 & Figure 22). The gross production showed highly significant differences ($p < 0.001$) between T_1 and T_2, T_3 (Table 5). In case of stocking density trial-2, gross production of the tilapia was varied from 305.54 kg/cage to 331.96 kg/cage in different treatments of the stocking density trial-2. The gross production was recorded highest 331.96 kg/cage in T_1 followed by T_2 (323.92 kg/cage) and T_3 (305.54 kg/cage) respectively (Table 7 & Figure 47). The gross production was found significantly different ($p < 0.01$) between T_1 and T_3, and T_2 and T_3 (Table 9). The net production of stocking density trial-1 & 2 also found same trend to be gross production (Table 5 & 9). Rahman *et al.* (2006) found that both gross and net yields were significantly different and were directly influenced by stocking density. In stocking density trial-1, net profit of the different treatments was found in ranged between 2263Tk/cage and 3151Tk/cage in T_1 and T_2 respectively, while no profit was earned from the T_3 due to loss (-2478Tk/cage) in this treatment (Table 3 & Figure 24). Net profit expressed highly significant differences ($p < 0.001$) among the three treatments (Table 5). Net profit of the different treatments of the stocking density trial-2 was found in ranged from 2211Tk/cage to 17215Tk/cage. The net profit was recorded highest in T_1 (17215Tk/cage) followed by T_2 (9740Tk/cage) and T_3 (2211Tk/cage) respectively (Table 7 & Figure 49). Net profit showed highly significant differences ($p < 0.001$) among the three treatments (Table 9). The study showed that net profit decreased with the increasing of stocking density in both trials. Similar result also reported by Dasuki *et al.* (2013). But Rahman *et al.* (2006) reported that net revenue increased positively with increasing stocking density. In stocking density trial-1, it was observed that the highest benefit cost ratio was achieved in T_1 (1.20) followed by T_2 (1.19) and T_3 (0.88) respectively (Table 3 & Figure 25). Whereas, the highest benefit cost ratio was achieved in T_1 (1.81) followed by T_2 (1.37) and T_3 (1.07) respectively (Table 7 & Figure 50). In both trials the benefit cost ratio exhibited the highly significant differences ($p < 0.001$) among three treatments (Table 5 & 9). It could be concluded from the above discussions stocking density of $50/m^3$ of trial-1 is the better option for tilapia cage culture.

5.3. Feeding regime of tilapia in cage culture

Fish can be produced profitably in cages (Cline and Masser 1998). Bayne *et al*. (1976) reported that tilapia in cage of controls receiving no supplementary diet the weight gain was much less. Pantastico and Baldia (1979) also reported that controls showed slower growth rates as compaired to the supplemental feed lots of tilapia in floating cages of Luguna de Bay. Silva *et al*. (2007) reported that feeding costs contributes up to 60% of the variable costs of cage culture systems. They studied on the effect of feeding rates and frequency on tambaqui (*Colossoma macropomum*) cage rearing with two feeding rates (5 and 10% body weight per day - BW/day) and two feeding frequencies (2 and 3 meals/day) over a period of 45 days and also suggests that the best feeding strategy for tambaqui during the first growth phase in cage is 10% BW/day divided in 3 meals/day. Bhujel (2013) describes the on-farm feed management practices used in the culture of the Nile tilapia (*Oreochromis niloticus*) in Thailand. Nile tilapia at 08.00 hours once-a-day resulted in low yields when compared with feeding twice or thrice daily. As there was no difference between the latter two options, twice daily is deemed to be the most economic feeding regime for cage culture. However, the present study was includes two times/day feed application under different feeding regime in both trials.

The final weight of feeding regime trial-1 was ranged between 314.48g to 328.91g, from the initial average weight of 36.20g for each treatment. The highest final weight attained in T_3 (328.91g) followed by T_2 (319.76g) and T_1 (314.48g) respectively (Table 11 & Figure 65). The final weight of the three treatments expressed significant differences ($p < 0.05$) between T_1 and T_3, and T_2 and T_3 (Table 13). The study found in case of final weight 7-5% of body weight feed application was best. In case of feeding regime trial-2 final, the mean final weight of the tilapia in cage of different treatments was attained between 284.65g to 314.46g, while the initial average weight was 20.76g for each treatment. The highest final weight was attained 314.46g in T_1 followed by T_2 (303.93g) and T_3 (284.65g) respectively (Table 15 & Figure 89). The final weight of the three treatments exhibited significant differences ($p < 0.01$) between T_1 and T_3, and T_2 and T_3 (Table 17). In feeding regime trial-2, in case of final weight the best one was 6% of body weight feed application throughout the culture period. The attained final weight differences between the feeding regime trial-1 & 2 are may be due to the differences of initial average weight of those trials. In feeding regime trial-1&2 weight gain also followed by higher application of feed to lower feed application (Table 13 & 17).

Silva *et al.* (2007) observed highest weight gain in 10% body weight/day feed application and lowest in 5% which is more or less similar to the present study.

In feeding regime trial-1, the highest relative growth rate was recorded 79.06% in T_3 followed by T_2 (76.69%) and T_1 (74.91%), respectively (Table 11 & Figure 67).While in feeding regime trial-2, the highest relative growth rate was found 101.42% in T_1 followed by T_2 (99.50%) and T_3 (92.82%), respectively (Table 15 & Figure 91). The relative growth rate showed highly significant differences ($p < 0.001$) among the three treatments of feeding regime trial-1 and between T_1 and T_3, and T_2 and T_3 in case of feeding regime trial-2 (Table 13 & 17). The highest specific growth rate was found 1.83%/day in T_3 followed by T_2 (1.80%/day) and T_1 (1.79%/day), respectively (Table 11 & Figure 68) in feeding regime trial-1, while the highest specific growth rate was found 2.25%/day in T_1 followed by T_2 (2.22%/day) and T_3 (2.17%/day), respectively (Table 15 & Figure 92). In feeding regime trial-1 & 2 specific growth rate also followed by higher application of feed to lower feed application (Table 13 & 17) but significant level was ($p < 0.05$) between the T_1 and T_3 (Table 13) for feeding regime trial-1 and ($p < 0.01$) between the T_1 and T_3, and T_2 and T_3 for feeding regime trial-2 (Table 17). Khan (1996) studied the growth performance of tilapia (GIFT) in cage under pond condition and was found specific growth rate 1.70%/day, which shows more or less similarity with the specific growth rates of different treatments of feeding regime trial-1 in the present study.

Food conversion ratio in feeding regime trial-1, was found 1.68, 2.21 and 2.69 in T_1, T_2 and T_3 respectively, where T_1 shown the lowest value and T_3 was the highest (Table 11 & Figure 69). Whereas, in feeding regime trial-2 food conversion ratio was found 2.24, 1.88 and 1.31 in T_1, T_2 and T_3 respectively, where T_1 shown the highest value and T_3 was the lowest (Table 15 & Figure 93). The food conversion ratio was found highly significant differences ($p < 0.001$) among the three treatments of trial-1 (Table 13) and trial-2 (Table 17). Hence, It was revealed that higher feed supplement causes lower feed utilization and not viable for tilapia cage culture in Bangladesh. Bhujel (2013) reported that, farmers used commercial pellets for cage culture of the Nile tilapia (*Oreochromis niloticus*) in rivers and canals of Thailand and on average, cage farmers feed three times a day, and attain FCR of 1.4–1.8 which is also supported the FCR of the present study.

The survival rate of the tilapia in different treatments in feeding regime trial-1, was varied from 96.44% to 97.33% in this trial. The highest survival rate was found in T_1 (97.33%)

followed by T_3 (96.88%) and T_2 (96.44%) respectively (Table 11 & Figure 70). Whereas in feeding regime tria-2, the survival rate of the tilapia in different treatments of feeding regime trial-2 was recorded from 96.66% to 97.22%. The highest survival rate was found in T_2 (97.22%) followed by T_1 (97.00%) and T_3 (96.66%) respectively (Table 15 & Figure 94). There are no significant ($p > 0.05$) differences for feeding regime trial-1 (Table 13) and feeding regime trial-2 (Table 17). Ahmed *et al*. (2014) reported that a commercial probiotic named "Biotics" used at the rate of 2 and 3 g/kg feed for treatments 2 and 3 respectively and no probiotic for treatment 1 with feeding regime of 4-2% (towards the end) body weight/day for all treatments achieved survival rate of 95.76%, 97.54% and 96.94% in treatment 1, 2 and 3 respectively for male mono-sex Tilapia (*Oreochromis niloticus*) in a cage culture experiment of Dakatia river, Chandpur. Their findings also similar to the present study.

Gross production in feeding regime trial-1, was recorded highest 286.78 kg/cage in T_3 followed by T_2 (277.51 kg/cage) and T_1 (275.45 kg/cage) respectively (Table 11 & Figure 71). While in trial-2, the highest gross production was 274.49kg/cage in T_1 followed by T_2 (265.88kg/cage) and T_3 (247.56kg/cage) respectively (Table 15 & Figure 95). The gross production of trial-1 was found highly significant differences ($p < 0.001$) between T_1 and T_3, and T_2 and T_3 (Table 13). While in trial-2, it was found highly significant differences ($p < 0.001$) among the three treatments (Table 17). The net production of the tilapia in different treatments was varied from 243.73 kg/cage to 255.21 kg/cage of the feeding regime trial-1 (Table 11 & Figure 72). While in trial-2, it was fluctuated from 229.50kg/cage to 256.36kg/cage (Table 15). Net production of trial-1 was highly significant differences ($p < 0.001$) between T_1 and T_3, and T_2 and T_3 (Table 13). In case of trial-2 it exhibited highly significant differences ($p < 0.001$) among the three treatments (Table 17). Hussain *et al*. (2000) reported that cage culture study involving only tilapia (GIFT strain) conducted by CARE Bangladesh, shows that a high net production (30.68 kg/m^3) can be obtained with a short period of time (124 day) which is more or less similar to the present study.

The net profit of feeding regime trial-1 was found highest in T_1 (13376Tk/cage) followed by T_2 (8605Tk/cage) and T_3 (4907Tk/cage) respectively (Table 11 & Figure 73). In case of trial-2, the highest net profit was earned in T_3 (14055Tk/cage) followed by T_2 (9473Tk/cage) and T_1 (6463Tk/cage) respectively (Table 15 & Figure 97).Net profit was found highly significant differences ($p < 0.001$) among the three treatments (Table 13 & 17) of both trials. The benefit cost ratio was achieved in T_1 (1.71) followed by T_2 (1.36) and T_3 (1.17) respectively in trial-1

(Table 11 & Figure 74). While, the highest benefit cost ratio was determined in T_3 (1.93) followed by T_2 (1.44) and T_1 (1.25) respectively (Table 15 & Figure 98) in trial-2. Benefit cost ratio expressed highly significant differences ($p < 0.001$) among the three treatments (Table 13 & 17) of both the trials. Golder *et al*. (1999) reported that a net profit of Tk 46.25 for each kg and a benefit cost ratio of 1.55 from *Pangasius sutchi* cage culture in northwest Bangladesh using commercially available grow out feed which is similar to the present study. So it is revealed that feeding regime with 4% of body weight feed supply through the culture period in trial-2 was found suitable for tilapia cage culture practice in the riverine ecosystem.

5.4. Proximate composition of feed used in cage culture

The proximate composition of commercial semi-buoyant pelletized feed used for tilapia in different cage culture trials of the present study shown (Appendix 13 & Figure 99). It was found that the highest moisture content (10.13%) was found in Tilapia finisher and the lowest (6.69%) was in Tilapia grower. While the maximum (19.62%) ash content was determined in Tilapia nursery and the minimum (14.55%) was in Tilapia finisher. Lipid content assessed highest (8.90%) in Tilapia nursery and lowest (4.49%) in Tilapia starter. The crude protein contents of Tilapia nursery, Tilapia starter, Tilapia grower and Tilapia finisher was determined 33.22%, 28.33%, 26.54% and 27.05% respectively, which was found some differences from labeled crude protein contents (Appendix 17 & Figure 99) when analyzed in laboratory. Watanabe *et al.* (1990) reported that the final mean weights were higher for tilapia of floating cage fed the diet with 28% protein than those fed at 32% protein. They also observed daily weight gain; specific growth rate and survival were higher and feed conversion ratios lower for fish fed the 28% protein diet than for those fed the 32% protein. Their used feed containing 28% protein was found more or less similar to the feed used for grow out of tilapia in cage of the present study. So it could be concluded that the used feeds for this study found suitable for cage culture practice.

CHAPTER-6 SUMMARY AND CONCLUSION

Cage culture is a promising culture system that could be easily accepted by rural people of Bangladesh. Pond aquaculture is only practiced by the farmers who have won pond and land to construct pond. Therefore, cage culture will be the alternative income source for rural people. Large scale commercial cage aquaculture from large sized net cages from river ecosystem has not been studied in Bangladesh. Cage culture package for river ecosystem has yet to be developed in Bangladesh for public demand and increase of fish production. Tilapia (*Oreochromis niloticus*) is one of the most popular fresh water fish species for cage culture in Bangladesh. Sustainable cage culture practice for tilapia in net cage mostly depends on supplemental feed and standard stocking density. So the research work was aimed to be developing suitable and environment friendly sustainable open water cage culture techniques for farmers that could be disseminated to other lotic habitat of the country.

The present study was carried out in the Dakatia river at Echoli and Roghunathpur site of Chandpur, Bangladesh from the year 2010 to 2011. The study consisted of two experiments on stocking density and feeding regime of tilapia in cage was includes two trials in each with complete randomized design (CRD). Floating net cages, having an area of 3m×3m×2m in each were installed at both sites of the Dakatia river. Before start of the each experimental trial the collected fingerlings were acclimatized to the new environment in floating cages for fifteen days. Then the fishes were stocked in experimental cages according to experimental design. The initial average weight (g) of 32.31±9.59, 28.92±8.37, 36.20±11.64 and 20.76±6.14 were stocked for each treatment of the stocking density trial-1, stocking density trial-2, feeding regime trial-1 and feeding regime trial-2 respectively. The duration of each trial was 120 days having three treatments with three replications to assess sustainable cage culture practice for tilapia in the riverine ecosystem. The stocking density of $30/m^3$, $50/m^3$ and $70/m^3$ tilapia fingerlings were used for three treatments in stocking density trial-1, and $50/m^3$, $75/m^3$ and $100/m^3$ fingerlings were used for three treatments in stocking density trial-2 respectively. The fishes were fed twice daily with pelletized semi-buoyant feed (floating type) at the rate of 5 - 3% (1st and 2nd months 5% then 3rd and 4th months 4 and 3%, respectively) of total body weight towards the end of the culture period for both of the stocking density trials. In feeding regime trial-1, the fishes were fed twice daily with pelletized semi-buoyant feed (floating type) at the rate of 5 - 3, 6 - 4 and 7 - 5% (1st month 5, 6 and 7% then 2nd month 4, 5 and 6% and next two months 3, 4 and 5% body weight in treatments-I, II and III respectively) of total body weight in the treatments-I, II and III respectively, towards the end of the culture period. In case of feeding regime trial-2, the fishes were fed twice daily with pelletized semi-buoyant feed (floating type) at the rate of 6, 5 and 4% of total body weight in the treatments-I, II and III respectively, throughout the culture period. The stocking densities of the fingerlings were 50/m^3 in all the treatments with three replications for both of the feeding regime trials. The fishes were sampled once in 30 day. At least 50 fishes were randomly sampled from each cage and their individual weight was recorded to the nearest grams. After 120 days of rearing i.e. at the time of termination of the each trial of the experiments, the final weights (g) of the individual fishes were carefully recorded. The physicochemical parameters of cage water were monitored fortnightly. The average final weight (g), weight gain (g), relative growth rate (%), specific growth rate (%/day), food conversion ratio and survival rate (%), gross production (kg/cage), net production (kg/cage), net profit (Tk/cage), benefit cost ratio of tilapia in cages were determined after completion of the each trial. Growth parameters such as weight gain (g), relative growth rate (%), specific growth rate (%/day), and food conversion ratio was also measured monthly basis. Data were statistically analyzed according to the technique of one way analysis of variance (ANOVA) for the completely randomized design to test the significance of the differences, least significant difference (LSD) and coefficient of variation (CV%) between treatments and the means of different parameters including monthly growth parameters of all the trials. Differences were considered significant at the level of 0.1% ($p < 0.001$), 1% ($p < 0.01$) and 5% ($p < 0.05$). Pearson correlation coefficients within physicochemical parameters were determined using computer with Excel and software package SPSS version-16.0. Correlations were considered significant at the level of 1% ($p < 0.01$) and 5% ($p < 0.05$).

The physicochemical parameters of cage water were found suitable for cage fish culture in all the trials. Correlations of different physicochemical parameters were related to each other and the relationship was found significant in most of the parameters.

All growth parameters of stocking density trial-1 revealed highly significant differences ($p < 0.001$) among three treatments. The maximum survival rate was found in T_1 (85.61%) followed by T_2 (81.92%) and T_3 (67.58%) respectively, having highly significant differences ($p < 0.001$). Both the gross and net productions were showed highly significant differences (p

< 0.001) between T_1 and T_2, T_3. The highest benefit cost ratio was achieved in T_1 (1.20) followed by T_2 (1.19) and T_3 (0.88) but highest profit was found in the T_2.

In stocking density trial-2, it was exhibited that all growth parameters were highly significant differences ($p < 0.001$) among three treatments. The highest survival rate was found in T_1 (97.92%) followed by T_2 (86.73%) and T_3 (84.38%) respectively which was highly significant differences ($p < 0.001$) among them. The gross production was found significantly different ($p < 0.01$) between T_1 and T_3, and T_2 and T_3 while the net production was found highly significant differences ($p < 0.001$) among the three treatments. The highest benefit cost ratio was achieved in T_1 (1.81) followed by T_2 (1.37) and T_3 (1.07) respectively. The net profit was found similar as highest in T_1 and followed by T_2 and T_3.

In case of feeding regime trial-1 the final weight, weight gain and specific growth rate showed significantly different ($p < 0.05$) among the treatments, while the relative growth rate and food conversion ratio was found highly significant differences ($p < 0.001$) among three treatments. The highest survival rate was found in T_1 (97.33%) followed by T_3 (96.88%) and T_2 (96.44%) respectively which was not significantly different. Both the gross and net productions were found highly significant differences ($p < 0.001$) between T_1 and T_3, and T_2 and T_3. The maximum benefit cost ratio was achieved in T_1 (1.71) followed by T_2 (1.36) and T_3 (1.17) respectively, which was similar as achieved net profit of the three treatments.

The final weight, weight gain and specific growth rate of feeding regime trial-2 were exhibited significant differences ($p < 0.01$) among the three treatments, whereas the relative growth rate and food conversion ratio was found highly significant differences ($p < 0.001$) among three treatments. The highest survival rate was found in T_2 (97.22%) followed by T_1 (97.00%) and T_3 (96.66%) respectively but not significantly differ with each other. The gross and the net productions were found highly significant differences ($p < 0.001$) among the three treatments. The highest benefit cost ratio was determined in T_3 (1.93) followed by T_2 (1.44) and T_1 (1.25) respectively, which was similar as determined net profit.

Proximate composition of used different floating type of Mega feed such as moisture (%), ash (%), lipid (%) and crude protein (%) were determined. The proximate composition of used floating feeds was found suitable for tilapia culture. The crude protein contents of Tilapia nursery, Tilapia starter, Tilapia grower and Tilapia finisher was determined 33.22%, 28.33%, 26.54% and 27.05% respectively, which was found some differences from labeled crude protein contents.

Hence, it could be concluded that stocking density of 50/m^3 and feeding regime with 4% of body weight feed supply through the culture period was found suitable to be sustainable for tilapia cage culture practice in the riverine ecosystem.

Recommendations

- Sustainable cage culture practice mostly depends on proper stocking density and feed supply
- Stocking density of tilapia in cage of river should not exceed 50 fish/cubic meter
- Good quality and minimum average weight of above 20g tilapia fingerlings should be used for cage culture, if available, minimum average initial weight of above 30g tilapia fingerlings should be used
- In average @ 5 - 4% of the body weight feed depending on initial size of tilapia fingerlings should be provided for first two months and then less concurrently for remaining culture period
- Excessive feed supplement may cause financial loss and environmental degradation
- Good quality pelleted floating feed should be used for cage culture practice
- The water quality of the rivers and lake was found to be suitable for cage fish culture
- Cage culture of tilapia could be practiced trough out the year in our country as all the important water quality parameters of the river found suitable for tilapia culture
- Proximate values of the commercial tilapia feed showed differences in analytical values with labeled values
- Thus, feed and seed quality are the important factors for riverine water cage fish production

Future research

- Research might be undertaken with some other fish species such as native pangas, climbing perch, grass carp and major carps to determine their species suitability in terms of growth performance and prospects in large size cage culture

- Research should be carried out on extensive cage culture practice to determine possible causative agents of different disease associated with cage fish culture and their remedies.

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APPENDICES

Appendix 1: Monthly mean values of some selected physico-chemical parameters of cage water of stocking density trial- 1 in Dakatia river, Echoli, Chandpur during April to August, 2010

	Months						
Parameters	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Range**	**Mean ± SD**
Depth of water (m)	3.2	3.2	3.9	4.3	4.1	3.2-4.3	3.74±0.51
Current velocity (cm/sec)	17	20	24	29	32	17-32	24.40±6.18
SD transparency (cm)	54	48	43	41	46	41-54	46.40±5.02
Water temperature (°c)	30.1	31.2	31.7	32.6	32.8	30.1-32.8	31.68±1.09
TDS (mg/l)	10	6	9	8	10	6-10	8.60±1.67
Salinity (mg/l)	0	0	0	0	0	0	0
DO (mg/l)	5.15	5.63	5.52	4.14	4.12	4.12-5.63	4.91±0.73
Free CO_2 (mg/l)	6.33	7.47	8.83	6.93	5.26	5.26- 8.83	6.96±1.32
pH	7.62	7.75	7.5	7.37	7.62	7.37-7.75	7.57±0.14
T. Hardness (mg/l)	93.8	70.77	57.32	38.44	40.24	38.44-93.8	60.11±23.03
T. Alkalinity (mg/l)	107.6	56.04	33.68	44.55	46.5	33.68-107.6	57.67±29.01
Ammonia NH_3 (mg/l)	0	0	0	0	0	0	0
Nitrite NO_2, (mg/l)	0	0	0	0	0	0	0

Appendix 2: Monthly mean values of some selected physico-chemical parameters of cage water of stocking density trial-2 in Dakatia river, Roghunathpur, Chandpur during June to October 2010

	Months						
Parameters	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Range**	**Mean ± SD**
Depth of water (m)	5	5.1	5.3	5.4	5.5	5-5.5	5.26±0.21
Current velocity (cm/sec)	25	28	29	31	37	25-37	30±4.47
SD transparency (cm)	38	49	56	63	71	38-71	55.40±12.70
Water temperature (°c)	31.5	31.1	31.3	31.8	32.1	31.1-32.1	31.56±0.39
TDS (mg/l)	4	4	5	6	6	4-6	5±1
Salinity (mg/l)	0	0	0	0	0	0	0
DO (mg/l)	7.2	5.68	5.82	5.74	6.04	5.68-7.2	6.10±0.63
Free CO_2 (mg/l)	4.58	4.42	4.6	4.52	4.2	4.2-4.6	4.46±0.16
pH	7.25	7	7.5	7.75	8.4	7-8.4	7.58±0.54
T. Hardness (mg/l)	54.28	48.12	47.2	46.32	52.68	46.32-54.28	49.72±3.53
T. Alkalinity (mg/l)	68.62	53.72	54.37	52.62	60.14	52.62-68.62	57.89±6.67
Ammonia NH_3 (mg/l)	0.006	0.004	0.004	0.002	0.002	0.002-0.006	0.004±0.001
Nitrite NO_2, (mg/l)	0	0	0	0	0	0	0

Appendix.3: Monthly mean values of some selected physico-chemical parameters of cage water of feeding regime trial-1 in Dakatia river, Raghunathpur, Chandpur during April to August' 2011

	Months						
Parameters	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Range**	**Mean ± SD**
Depth of water (m)	4.2	4.5	5.1	5.3	5.6	4.2-5.6	4.94±0.58
Current velocity (cm/sec)	20	23	27	30	31	20-31	26.20±4.66
SD transparency (cm)	53	49	41	40	41	40-53	44.80±5.85
Water temperature (°c)	31.4	31.6	32.5	32.6	32.5	31.4-32.6	32.12±0.57
TDS (mg/l)	10	8	8	10	10	8-10	9.20±1.09
Salinity (mg/l)	0	0	0	0	0	0	0
DO (mg/l)	5.31	5.2	5.62	5.18	4.4	4.4-5.62	5.14±0.45
Free CO_2 (mg/l)	6.78	7.32	7.8	8.04	5.92	5.92-8.04	7.17±0.85
pH	7.75	7.5	7.75	7.5	7.5	7.5-7.75	7.60±0.14
T. Hardness (mg/l)	94.12	72.8	68.18	42.98	46.2	42.98-94.12	64.86±20.96
T. Alkalinity (mg/l)	116.3	70.42	48.24	40.56	44.68	40.56-116.3	64.04±31.41
Ammonia NH_3 (mg/l)	0	0	0	0	0	0	0
Nitrite NO_2, (mg/l)	0	0	0	0	0	0	0

Appendix 4: Monthly mean values of some selected physico-chemical parameters of cage water of feeding regime trial-2 in Dakatia river, Raghunathpur, Chandpur during June to October 2011

Parameters	Months						
	Jun	**Jul**	**Aug**	**Sep**	**Oct**	**Range**	**Mean ± SD**
Depth of water (m)	4.9	5.2	5.4	5.6	5.5	4.9-5.6	5.32±0.28
Current velocity (cm/sec)	26	29	30	32	38	26-38	31.00±4.47
SD transparency (cm)	42	40	42	44	40	40-44	41.60±1.67
Water temperature (°c)	32.6	32.6	32.6	32.8	32.8	32.6-32.8	32.68±0.10
TDS (mg/l)	8	8	11	10	9	8-11	9.20±1.30
Salinity (mg/l)	0	0	0	0	0	0	0
DO (mg/l)	5.6	5.12	4.36	4.28	4.47	4.28-5.6	4.77±0.57
Free CO_2 (mg/l)	7.86	8.18	6.06	5.38	5.92	5.38-8.18	6.68±1.25
pH	7.5	7.62	7.37	7.25	7.25	7.25-7.62	7.40±0.16
T. Hardness (mg/l)	60.24	44.62	48.39	58.21	78.6	44.62-78.6	58.01±13.24
T. Alkalinity (mg/l)	45.32	49.3	48.2	45.44	38.76	38.76-49.3	45.40±4.09
Ammonia NH_3 (mg/l)	0	0	0	0	0	0	0
Nitrite NO_2, (mg/l)	0	0	0	0	0	0	0

Appendix 5: Monthly variations of growth parameters in different treatments of stocking density trial-1

Parameter	Tret.	Months				Range	Mean ± SD
		1st	2nd	3rd	4th		
WG (g)	T_1	29.32	60.06	55.05	68.46	29.32-68.46	53.22±16.86
	T_2	23.08	59.00	48.74	68.18	23.08-68.18	49.75±19.47
	T_3	13.88	59.88	41.74	54.46	13.88-59.88	42.49±20.53
RGR (%)	T_1	90.73	100.82	44.53	38.33	38.33-100.82	68.60±31.74
	T_2	71.43	106.53	42.62	41.86	41.86-106.53	65.61±30.55
	T_3	42.97	129.61	39.40	37.01	37.01-129.61	62.24±44.97
SGR (%/day)	T_1	2.14	2.31	1.22	1.07	1.07-2.31	1.68±0.63
	T_2	1.79	2.41	1.17	1.16	1.16-2.41	1.63±0.59
	T_3	1.18	2.76	1.10	1.04	1.04-2.76	1.52±0.82
FCR	T_1	1.65	1.48	1.45	1.26	1.26-1.65	1.46±0.15
	T_2	2.10	1.40	2.53	1.93	1.40-2.53	1.99±0.46
	T_3	3.48	1.15	3.86	3.09	1.15-3.86	2.89±1.20

Appendix 6: Monthly variations of growth parameters in different treatments of stocking density trial-2

Parameter	Treat.	Months				Range	Mean ± SD
		1st	2nd	3rd	4th		
WG (g)	T_1	40.55	85.14	125.56	96.53	40.55-125.56	86.94±35.30
	T_2	24.92	75.73	76.83	70.17	24.92-76.83	61.91±24.83
	T_3	22.40	63.61	46.66	39.55	22.40-63.61	43.05±17.07
RGR (%)	T_1	140.23	122.53	81.25	34.51	34.51-140.23	94.63±47.08
	T_2	86.16	141.09	59.34	33.98	33.98-141.09	80.14±45.87
	T_3	77.46	123.97	40.60	24.47	24.47-123.97	66.62±44.19
SGR (%/day)	T_1	2.91	2.66	1.97	0.98	0.98-2.91	2.13±0.86
	T_2	2.06	2.92	1.54	0.97	0.97-2.92	1.87±0.82
	T_3	1.90	2.68	1.13	0.72	0.72-2.68	1.60±0.86
FCR	T_1	1.06	1.21	1.47	2.63	1.06-2.63	1.59±0.71
	T_2	1.76	1.06	2.01	2.65	1.06-2.65	1.87±0.65
	T_3	1.93	1.20	2.95	3.67	1.20-3.67	2.43±1.09

Appendix 7: Monthly variations of growth parameters in different treatments of feeding regime trial-1

Parameter	Tret.	Months				Range	Mean ± SD
		1st	2nd	3rd	4th		
WG (g)	T_1	45.47	69.89	75.01	87.89	45.47-87.89	69.56±17.75
	T_2	50.99	70.57	76.48	85.51	50.99-85.51	70.88±14.61
	T_3	57.14	66.72	72.89	95.96	57.14-95.96	73.17±16.51
RGR (%)	T_1	125.62	85.67	49.52	38.85	38.85-125.62	74.91±39.29
	T_2	140.86	80.93	48.48	36.51	36.51-140.86	76.69±46.71
	T_3	157.84	71.65	45.51	41.27	41.27-157.84	79.06±54.20
SGR (%/day)	T_1	2.70	2.05	1.33	1.08	1.08-2.70	1.79±0.73
	T_2	2.92	1.97	1.31	1.03	1.03-2.92	1.80±0.83
	T_3	3.15	1.79	1.24	1.15	1.15-3.15	1.83±0.92
FCR	T_1	1.18	1.40	1.82	2.32	1.18-2.32	1.68±0.50
	T_2	1.27	1.85	2.46	3.28	1.27-3.28	2.21±0.86
	T_3	1.32	2.53	3.29	3.65	1.32-3.65	2.69±1.03

Appendix 8: Monthly variations of growth parameters in different treatments of feeding regime trial-2

Parameter	Tret.	Months				Range	Mean ± SD
		1st	2nd	3rd	4th		
WG (g)	T_1	27.51	65.94	109.03	91.21	27.51-109.03	73.42±35.34
	T_2	27.34	63.68	103.65	88.48	27.34-103.65	70.78±33.32
	T_3	19.31	42.06	81.58	120.93	19.31-120.93	65.97±44.77
RGR (%)	T_1	132.54	136.59	95.74	40.85	40.85-136.59	101.43±44.37
	T_2	131.72	132.52	92.73	41.07	41.07-132.52	99.51±43.15
	T_3	93.04	104.99	99.38	73.87	73.87-104.99	92.82±13.54
SGR (%/day)	T_1	2.80	2.86	2.23	1.13	1.13-2.86	2.25±0.80
	T_2	2.79	2.80	2.18	1.14	1.14-2.80	2.22±0.78
	T_3	2.18	2.39	2.29	1.83	1.83-2.39	2.17±0.24
FCR	T_1	1.35	1.31	1.88	4.40	1.31-4.40	2.23±1.46
	T_2	1.13	1.12	1.61	3.65	1.12-3.65	1.87±1.20
	T_3	1.27	1.14	1.20	1.62	1.14-1.62	1.30±0.21

Appendix 9: Profit (Tk/cage) and benefit cost ratio (BCR) under different treatments of stocking density trial-1 in Dakatia river, Echoli, Chandpur during 15 April - 13 August, 2010

Component	**Treatment**								
Expenditure	T_1-(30/m^3) 540/cage			T_2-(50/m^3) 900/cage			T_3-70/m^3) 1260/cage		
	R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
Cage materials - (Tk/cage)	1200.00	1200.00	1200.00	1200.00	1200.00	1200.00	1200.00	1200.00	1200.00
Fingerlings- @0.80Tk/fish	432.00	432.00	432.00	720.00	720.00	720.00	1008.00	1008.00	1008.00
Nursery and others- @2.75Tk/fish	1485.00	1485.00	1485.00	2475.00	2475.00	2475.00	3465.00	3465.00	3465.00
Feed- @ 32.00Tk/kg	(243.13kg) 7780.00	(243.13kg) 7780.00	(243.13kg) 7780.00	(374.03kg) 11969.00	(374.03kg) 11969.00	(374.03kg) 11969.00	(476.41kg) 15245.00	(476.41kg) 15245.00	(476.41kg) 15245.00
Total - (Tk/cage)	10897.00	10897.00	10897.00	16364.00	16364.00	16364.00	20918.00	20918.00	20918.00
Sale proceed of tilapia									
@ 120Tk/kg and @ 90Tk/kg	11760.00 (98kg) and 1395.00 (15.5kg)	11640.00 (97kg) and 1575.00 (17.5kg)	11400.00 (95kg) and 1710.00 (19kg)	16800.00 (140kg) and 2610.00 (29kg)	16800.00 (140kg) and 2700.00 (30kg)	16800.00 (140kg) and 2835.00 (31.5kg)	12000.00 (100kg) and 6840.00 (76kg)	12000.00 (100kg) and 6300.00 (70kg)	11520.00 (96kg) and 6660.00 (74kg)
Total income- (Tk/cage)	13155.00	13215.00	13110.00	19410.00	19500.00	19635.00	18840.00	18300.00	18180.00
Net profit (Tk/cage)	2258.00	2318.00	2213.00	3046.00	3136.00	3271.00	–2078.00	–2618.00	–2738.00
BCR	1.20	1.21	1.20	1.18	1.19	1.19	0.90	0.87	0.86

Feeding: 5-3% body weight feed daily in each treatment

Appendix 10: Profit (Tk/cage) and benefit cost ratio (BCR) under different treatments of stocking density trial-2 in Dakatia river, Roghunathpur, Chandpur during 05 June - 03 October, 2010

Component Expenditure	**Treatment**								
	T_1-(50/m^3) 900/cage			T_2-(75/m^3) 1350/cage			T_3-(100/m^3) 1800/cage		
	R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
Cage materials - (Tk/cage)	1200.00	1200.00	1200.00	1200.00	1200.00	1200.00	1200.00	1200.00	1200.00
Fingerlings- @0.80Tk/fish	720.00	720.00	720.00	1080.00	1080.00	1080.00	1440.00	1440.00	1440.00
Nursery and others- @2.75Tk/fish	2475.00	2475.00	2475.00	3713.00	3713.00	3713.00	4950.00	4950.00	4950.00
Feed- @ 32.00Tk/kg	(526.25kg) 16840.00	(526.25kg) 16840.00	(526.25kg) 16840.00	(628.20kg) 20102.00	(628.20kg) 20102.00	(628.20kg) 20102.00	(726.70kg) 23254.00	(726.70kg) 23254.00	(726.70kg) 23254.00
Total - (Tk/cage)	21235.00	21235.00	21235.00	26095.00	26095.00	26095.00	30844.00	30844.00	30844.00
Sale proceed of tilapia									
@ 120Tk/kg and @ 90Tk/kg	34800.00 (290kg) and 4140.00 (46kg)	34200.00 (285kg) and 4050.00 (45kg)	34200.00 (285kg) and 3960.00 (44kg)	27000.00 (225kg) and 9135.00 (101.5kg)	25740.00 (214,5kg) and 9090.00 (101kg)	27720.00 (231kg) and 8820.00 (98kg)	22500.00 (187.5 kg) and 10710.00 (119kg)	22800.00 (190kg) and 10665.00 (118.5kg)	21600.00 (180kg) and 10890.00 (121kg)
Total income- (Tk/cage)	38940.00	38250.00	38160.00	36135.00	34830.00	36540.00	33210.00	33465.00	32490.00
Net profit (Tk/cage)	17705.00	17015.00	16925.00	10040.00	8735.00	10445.00	2366.00	2621.00	1646.00
BCR	1.83	1.80	1.79	1.38	1.33	1.40	1.07	1.08	1.05

Feeding: 5-3% body weight feed daily in each treatment

Appendix 11: Profit (Tk/cage) and benefit cost ratio (BCR) under different treatments of feeding regime trial-1 in Dakatia river, Roghunathpur, Chandpur during 15 April - 13 August, 2011

Component	**Treatment**								
Expenditure	T_1- feed 5-3% body weight daily			T_2- feed 6-4% body weight daily			T_3- feed7-5% body weight daily		
	R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
Cage materials - (Tk/cage)	1200.00	1200.00	1200.00	1200.00	1200.00	1200.00	1200.00	1200.00	1200.00
Fingerlings- @0.80Tk/fish	720.00	720.00	720.00	720.00	720.00	720.00	720.00	720.00	720.00
Nursery and others- @2.75Tk/fish	2475.00	2475.00	2475.00	2475.00	2475.00	2475.00	2475.00	2475.00	2475.00
Feed- @ 32.00Tk/kg	(443.41kg) 14189.00	(443.41kg) 14189.00	(443.41kg) 14189.00	(600.62kg) 19220.00	(600.62kg) 19220.00	(600.62kg) 19220.00	(750.25kg) 24008.00	(750.25kg) 24008.00	(750.25kg) 24008.00
Total - (Tk/cage)	18584.00	18584.00	18584.00	23615.00	23615.00	23615.00	28403.00	28403.00	28403.00
Sale proceed of tilapia									
@ 120Tk/kg and @ 90Tk/kg	28620.00 (238.5kg) and 3150.00 (35kg)	28800.00 (240kg) and 3195.00 (35.5kg)	28920.00 (241kg) and 3195.00 (35.5kg)	29160.00 (243kg) and 3195.00 (35.5kg)	28920.00 (241kg) and 3195.00 (35.5kg)	29040.00 (242kg) and 3150.00 (35kg)	30240.00 (252 kg) and 3240.00 (36kg)	30120.00 (251kg) and 3240.00 (36kg)	29760.00 (248kg) and 3330.00 (37kg)
Total income- (Tk/cage)	31770.00	31995.00	32115.00	32355.00	32115.00	32190.00	33480.00	33360.00	33090.00
Net profit (Tk/cage)	13186.00	13411.00	13531.00	8740.00	8500.00	8575.00	5077.00	4957.00	4687.00
BCR	1.70	1.72	1.72	1.37	1.35	1.36	1.17	1.17	1.16

Stocking density: $50/m^3$ (900/cage) in each treatment

Appendix 12: Profit (Tk/cage) and benefit cost ratio (BCR) under different treatments of feeding regime trial-2 in Dakatia river, Roghunathpur, Chandpur during 03 June - 01 October, 2011

Component	**Treatment**								
Expenditure	T_1- feed 6% body weight daily			T_2- feed 5% body weight daily			T_3- feed 4% body weight daily		
	R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
Cage materials - (Tk/cage)	1200.00	1200.00	1200.00	1200.00	1200.00	1200.00	1200.00	1200.00	1200.00
Fingerlings- @0.80Tk/fish	720.00	720.00	720.00	720.00	720.00	720.00	720.00	720.00	720.00
Nursery and others- @2.75Tk/fish	2475.00	2475.00	2475.00	2475.00	2475.00	2475.00	2475.00	2475.00	2475.00
Feed- @ 32.00Tk/kg	(657.55kg) 21042.00	(657.55kg) 21042.00	(657.55kg) 21042.00	(534.45kg) 17102.00	(534.45kg) 17102.00	(534.45kg) 17102.00	(331.24kg) 10600.00	(331.24kg) 10600.00	(331.24kg) 10600.00
Total - (Tk/cage)	25437.00	25437.00	25437.00	21497.00	21497.00	21497.00	14995.00	14995.00	14995.00
Sale proceed of tilapia									
@ 120Tk/kg and @ 90Tk/kg	28440.00 (237kg) and 3195.00 (35.5kg)	29220.00 (243.5kg) and 2880.00 (32kg)	29040.00 (242kg) and 2925.00 (32.5kg)	27960.00 (233kg) and 2970.00 (33kg)	28500.00 (237.5kg) and 2520.00 (28kg)	28260.00 (235.5kg) and 2700.00 (30kg)	26640.00 (222 kg) and 1890.00 (21kg)	26880.00 (224kg) and 1890.00 (21kg)	27960.00 (233kg) and 1890.00 (21kg)
Total income- (Tk/cage)	31635.00	32100.00	31965.00	30930.00	31020.00	30960.00	28530.00	28770.00	29850.00
Net profit (Tk/cage)	6198.00	6663.00	6528.00	9433.00	9523.00	9463.00	13535.00	13775.00	14855.00
BCR	1.24	1.26	1.25	1.43	1.44	1.44	1.90	1.91	1.99

Stocking density: 50/m^3 (900/cage) in each treatment

Appendix 13: Proximate composition of commercial semi-buoyant feed used for cage culture of monosex tilapia

Name and specification	**Moisture (%)**	**Ash (%)**	**Lipid (%)**	**Crude protein (%)**	**Crude protein (%) (labelled)**
Mega Feed Tilapia nursery (floating)	8.93	19.62	8.90	33.22	35
Mega Feed Tilapia starter (floating)	8.78	16.76	4.49	28.33	32
Mega Feed Tilapia grower (floating)	6.69	14.75	5.75	26.54	28
Mega Feed Tilapia finisher (floating)	10.13	14.55	5.67	27.05	28

Appendix 14: Stocking density trial-1. Effect of stocking density on tilapia cultured in net cage, Dakatia river, Echoli, Chandpur during 15 April-13 August, 2010

Initial sampling data for weight (W) Date: 15.04.2010

T_1-(Stocking density 30/m^3)			T_2-(Stocking density 50/m^3)			T_3-(Stocking density 70/m^3)		
R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)
20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8
25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4
22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5
23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2
48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5
31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6
30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9
44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7
26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9
25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5
28.7	28.7	28.7	28.7	28.7	28.7	28.7	28.7	28.7
31.2	31.2	31.2	31.2	31.2	31.2	31.2	31.2	31.2
37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3
28.3	28.3	28.3	28.3	28.3	28.3	28.3	28.3	28.3
37.8	37.8	37.8	37.8	37.8	37.8	37.8	37.8	37.8
22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5
30.4	30.4	30.4	30.4	30.4	30.4	30.4	30.4	30.4
28.3	28.3	28.3	28.3	28.3	28.3	28.3	28.3	28.3
20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9
27.3	27.3	27.3	27.3	27.3	27.3	27.3	27.3	27.3
21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2
23.3	23.3	23.3	23.3	23.3	23.3	23.3	23.3	23.3
21.8	21.8	21.8	21.8	21.8	21.8	21.8	21.8	21.8
25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3
20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4
47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5	47.5
48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2
48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5
34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5
46.7	46.7	46.7	46.7	46.7	46.7	46.7	46.7	46.7
47.8	47.8	47.8	47.8	47.8	47.8	47.8	47.8	47.8
45.6	45.6	45.6	45.6	45.6	45.6	45.6	45.6	45.6
52.6	52.6	52.6	52.6	52.6	52.6	52.6	52.6	52.6
34.4	34.4	34.4	34.4	34.4	34.4	34.4	34.4	34.4
41.8	41.8	41.8	41.8	41.8	41.8	41.8	41.8	41.8
37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2	37.2
41.6	41.6	41.6	41.6	41.6	41.6	41.6	41.6	41.6
40.7	40.7	40.7	40.7	40.7	40.7	40.7	40.7	40.7
42.9	42.9	42.9	42.9	42.9	42.9	42.9	42.9	42.9
42.6	42.6	42.6	42.6	42.6	42.6	42.6	42.6	42.6
32.2	32.2	32.2	32.2	32.2	32.2	32.2	32.2	32.2
26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7
26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4
28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4
21.9	21.9	21.9	21.9	21.9	21.9	21.9	21.9	21.9
23.8	23.8	23.8	23.8	23.8	23.8	23.8	23.8	23.8
26.1	26.1	26.1	26.1	26.1	26.1	26.1	26.1	26.1
22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1
27.3	27.3	27.3	27.3	27.3	27.3	27.3	27.3	27.3
23.4	23.4	23.4	23.4	23.4	23.4	23.4	23.4	23.4
32.312	**32.312**	**32.312**	**32.312**	**32.312**	**32.312**	**32.312**	**32.312**	**32.312**

First month sampling data for weight (W) Date: 15.05.2010

T_1-(Stocking density 30/m^3)			T_2-(Stocking density 50/m^3)			T_3-(Stocking density 70/m^3)		
R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)
57.6	102	37.4	73.1	105.4	79.3	43.6	34.1	29.4
70.3	126.3	86.7	70.2	45.5	84.4	59.7	52.3	33.8
60.4	58.4	74.6	52.7	45.3	83.6	53.2	45.1	95.2
83.1	77.2	131.3	53.7	44.2	54.1	44.9	81.6	62.6
90.3	68.9	36.2	82.6	29.4	38.6	37.4	88.2	44.6
108.6	78.4	86.8	43.9	38.1	68.1	115.1	63.3	40.2
38.2	96.8	127.3	88	107.2	53.1	61.8	29.2	30.4
52.3	103.2	45.6	86.1	33.1	57.6	63.5	22.5	34.1
126.8	72.2	39.8	44.1	61.1	48.7	45.3	46.1	32.6
44.4	59.6	28.5	32.2	33.3	32.4	36.2	57.8	78.4
46.3	54.3	61.3	42.1	55.2	47.9	80.3	21.6	64.1
137.2	68.2	72.4	70.2	65.1	38.1	54.9	36.2	44.6
63.8	58.7	55.6	54	56.2	34.4	57.4	46.8	58.9
92.4	48.9	79.3	35.3	46.4	59.1	33.8	50.2	47.3
28.3	56.3	54.6	96.8	70.7	77.6	55.9	28.8	37.2
31.6	52.1	84.6	56.8	106.3	66.2	44.4	56.1	52.5
36.8	59.1	39.8	52.2	43.7	46.2	35.7	46.1	43.8
56.4	27.3	37.1	42.7	37	53.8	32.1	36.2	67.1
48.2	47.1	49.2	71.9	55.9	64.5	43.3	23.7	52.3
46.3	56.2	35.2	38.8	37.9	68.5	65.1	27.8	33.2
78.2	38.6	82.1	61.3	42.1	84.6	41.1	51.3	62.6
90.3	56.3	36.3	34.2	67.4	39.1	59.3	68.2	57.2
72.3	67.1	62.9	41.7	41.2	41.2	44.2	61.3	80.3
56.2	97.6	86.3	38.5	57.1	39.7	45.5	29.3	32.7
58.2	60.6	62.5	61.8	51.5	63.6	35.2	82.7	38.6
72.3	85.5	52.8	37.6	53.2	132.8	33.5	64.1	29.7
46.1	71.2	61.9	41	37.8	41	85.2	56.5	86.5
96.1	53.6	66.4	56.5	73.3	44.3	35.7	43.3	32.9
36.2	43.8	34.5	48.2	61.7	61.1	49.3	54.1	31.1
26.3	51.6	29.2	43.1	57.1	47.6	57.6	36.2	27.6
36.3	28.8	54.8	68.3	50.1	62.1	55.9	36.3	26.5
57.3	42.3	46.7	39.4	41.9	38.6	44.8	50.6	37.2
52.5	38.2	33.5	47.6	37.5	36	38.6	46.2	27.1
36.2	55.1	62.8	69.7	41.6	64.3	36.9	48.1	43.2
86.3	99.6	29.4	48.4	61.9	47.2	44.7	35.3	34.1
48.2	73.8	49.1	81.6	68	46.2	43.2	29.1	46.9
31.5	52.4	36.5	29.2	51.7	72.2	39.3	23.4	56.8
33.1	44.5	76.2	62.3	41.1	54.1	36.2	25.9	29.7
52.6	135.4	36.3	112.4	56.5	38.8	35.4	31.2	30.2
46.1	44.4	53.8	44.3	49.3	40.9	36.5	48.1	52.1
40.2	70.4	91.4	40.4	45.2	59.8	30.1	68.3	48.6
43.6	54.2	109.5	42.2	36.5	44.8	36.7	38.2	33.4
77.2	48.6	63.6	41.2	102.3	38.7	32.8	21.5	61.3
89.1	50.7	30.3	38.9	52.2	38.9	34.6	82.7	35.5
67.5	53.1	39.4	82.6	93.7	40.6	29.4	36.7	24.1
59.5	51.8	73.5	92.3	63.3	39.7	48.4	63.1	86.2
58.3	39.4	62.6	68.2	67.3	36	56.4	48.2	25.6
51.6	63.3	104.3	56.1	33.2	40.1	27.5	36.1	23.4
56.8	101.8	39.6	103.6	37.7	33.2	28.9	38.7	81.3
76.1	70.4	46.8	62.6	54.2	58.9	57.7	46.2	26.7
61.03	**64.306**	**59.566**	**57.652**	**54.892**	**53.646**	**46.884**	**45.892**	**45.828**

Second month sampling data for weight (W) Date: 14.06.2010

T_1-(Stocking density 30/m^3)			T_2-(Stocking density 50/m^3)			T_3-(Stocking density 70/m^3)		
R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)
210.3	171.9	166.6	214.5	181.6	68.4	172.8	173.2	172.8
102.1	187.4	130.3	196.3	56.3	81.6	74.2	55.1	72.2
98.8	188.1	81.3	201.3	206.1	77.2	210	138.2	210
88.1	202.8	61.8	141.9	137.3	157.9	117.1	209.6	98.1
123.3	133.8	54.7	135.2	184.4	143.2	171.8	129.9	170.8
61.5	107.4	56.1	116.8	143.3	116.6	112.6	60.1	141.3
124.7	157.5	62.3	137.2	135.8	147.2	64.5	80.4	65.8
152.4	165.1	58.3	114.3	116.8	86.8	96.2	122.8	100.1
132.9	134.2	101.5	107.6	160.2	104.7	129.6	126.7	167.6
81.7	157.5	76.9	119.7	183.5	103.7	181.6	97.5	181.6
94.8	166.1	73.8	73.1	203.6	76.2	213.4	160.4	178.9
131.9	103.9	75.5	71.5	138.9	73.7	54.3	109.1	52.8
78.2	115.1	127.1	127.6	102.2	127.6	56.5	98.3	69.9
81.1	108.1	76.4	112.9	136.1	123.5	112.3	71.5	139.8
88.5	162.7	91.5	79.2	96.4	79.2	93.5	88.9	110.6
76.2	98.3	170.2	93.2	132.1	96.1	49.6	55.6	52.8
88.1	113.4	165.2	151.8	100.2	161.8	97.3	170.8	110.1
75.6	132.2	176.9	135.6	61.2	144.5	102.5	71.4	88.1
71.8	91.4	83.8	108.7	66.8	106.7	86.5	210.1	72.6
213.1	113.2	72.4	86.5	188.1	80.5	183.1	58.8	170.6
135.1	131.6	115.2	137.3	202.3	127.2	176.2	179.8	162.6
198.5	104.9	101.3	80.9	73.6	76.4	78.4	64.8	78.2
108.9	212.8	178.2	129.4	88.3	129.4	84.5	133.2	86.6
140.5	179.6	160.2	202.6	94.5	192.6	96.5	52.6	102.8
93.2	88	166.6	117.6	88.1	134.6	88.4	48.2	88.2
88.5	165.6	89	69.5	137.3	69.5	136.2	211.2	76.9
243.1	170.2	170.6	110.6	178.4	110.6	171.2	87.1	182.6
109.2	184.2	205.8	113.5	162.1	118.6	156.4	113.4	161.6
136.3	104.3	107.5	136.9	143.2	136.1	132.1	152.4	132.6
208.1	120.9	130.5	151.6	127.3	171.6	143.5	64.1	123.8
175.2	165.2	112.2	127	96.5	139	55.7	178.6	55.8
88.1	175.5	83.5	64.5	82.3	65.2	85.1	82.1	85.1
228	91.5	127.2	56.1	76.1	54.5	81.3	143.2	76.6
200.1	80.6	102.7	82.2	93	82.6	98.6	150.8	98.6
102.3	118.1	85.4	157.3	148.6	139.5	152.4	105.9	123.6
93.2	81.5	150.1	133.7	73.7	140.1	70.7	69.3	70.3
98.2	77.8	93.5	188.5	86.1	110	88.6	91.6	88.4
88.5	79.9	112.1	63.7	57.2	47.8	56.2	76.8	55.9
79.8	88.4	99.9	109.3	127.5	105.2	136.2	54.1	118.6
129	78.4	166.4	96.2	72.3	96.1	71.3	172.1	68.2
104.1	101.2	153.5	82.2	96.2	83.8	103.2	64.7	82.2
97.4	58.3	142.1	98.5	88.4	101.3	52.4	136.2	46.8
125.6	62.3	170.1	107.3	53.1	93.4	71.8	64.8	66.4
98.5	77.8	160.5	121.5	76.2	89.6	76.2	56.4	78.1
212.5	137.7	105.4	91.2	87.1	91.5	88.4	56.2	84.6
104	58.6	130.8	93.5	73.3	105.2	73.2	78.4	68.2
166	87.3	180.3	133.2	81.4	143.2	86.3	57.3	76.6
129.1	122.3	203.5	128.5	131.2	131.6	139.4	81.2	98.7
91.2	188.8	180.4	107.2	102.3	110.2	108.2	53.5	88.2
106.3	88.5	161.9	76.3	58.4	127.4	58.3	141.6	52.6
123.072	**125.838**	**122.18**	**117.854**	**115.738**	**109.618**	**107.926**	**106.2**	**104.118**

Third month sampling data for weight (W) Date: 14.07.2010

T_1-(Stocking density 30/m^3)			T_2-(Stocking density 50/m^3)			T_3-(Stocking density 70/m^3)		
R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)
218.5	204.9	193.6	203.2	180.4	212.6	179.8	90.1	88.2
101.4	212.6	179.2	183.5	86.8	136.6	208.2	142.6	218.4
230.2	139.8	162.4	209.3	190.2	148.3	184.6	156.2	188.6
147.5	228.2	227.5	173.2	168.4	168.6	87.6	168.2	89.3
200.1	178.2	163.4	171.3	152.3	148.5	101.5	150.5	106.6
232.3	162.4	83.1	188.2	170.1	185.5	95.2	163.1	153.1
177.8	141.3	173.6	191.3	204.5	111.8	126.6	96	136.2
197.6	221.1	171.2	180.6	161.2	214.5	177.1	154.1	231.2
170.8	196.3	210.6	172.1	200.4	135.1	101.2	180.1	188.6
127.6	243.5	192.8	216.1	160.6	188.8	218.7	182.6	83.5
206.6	81.6	205.1	136.3	178.6	69.2	98.1	115.6	122.7
94.6	193.2	220.1	173.2	148.6	86.9	101.8	148.8	129.3
108.2	173.4	193.5	207.5	211.3	134.1	178.2	178.3	93.9
219.6	221.4	164.5	171.7	84.2	201.2	70.1	186.6	191.6
241.3	110.5	218.5	213.5	153.2	89.5	138.9	156.1	168.1
189.8	238.6	103.2	179.8	178.3	188.6	162.3	98.4	103.3
77.7	193.4	237.5	196.5	183.5	172.2	182.4	149.5	157.2
199.6	208.2	211.8	142.8	146.3	89.1	148.9	188.1	152.8
168.2	171.4	211.4	162.8	208.4	164.1	165.6	160.3	135.8
176.6	86.4	225.4	186.6	141.3	191.8	98.6	88.1	190.2
218.1	227.9	199.3	179.9	193.5	79.6	175.8	201.3	162.2
196.6	239.1	203.8	83.5	86.2	101.3	68.1	177.3	91.1
83.1	196.2	126.2	93.6	168.6	155.6	88.6	168.2	188.1
180.6	186.8	226.5	173.3	107.9	211.9	146.2	181.1	163.8
196.2	213.6	71.5	168.2	96.3	172.8	140.1	179.6	202.6
210.6	183.2	82.3	178.9	212.3	217.6	206.1	217.3	208.6
192.8	181.2	230.2	184.5	148.6	166.2	178.6	167.8	178.6
195.1	84.1	214.5	157.2	178.8	145.2	109.8	148.1	129.2
242.1	196.6	179.3	191.3	193.1	138.9	162.4	115.8	183.2
226.9	79.8	78.2	178.7	166.5	119.3	78.6	145.6	208.4
167.4	193.4	224.2	223.2	181.2	161.2	128.5	218.4	127.7
139.3	168.2	127.8	219.3	102.9	173.3	178.2	187.1	151.8
220.1	204.6	217.6	178.5	201.3	125.2	182.2	156.6	76.6
198.6	71.6	216.9	183.2	200.8	178.4	212.5	142.2	129.3
250.6	191.8	81.3	159.6	178.6	218.7	60.4	157.1	143.1
93.9	243.1	193.5	179.4	171.3	248.3	106.2	78.6	93.2
210.2	226.4	207.2	211.3	136.5	220.9	102.3	108.7	180.2
163.5	106.3	198.5	171.1	104.3	166.8	181.2	121.8	131.5
223.4	85.8	230.6	198	216.5	170.8	158.2	116.6	180.6
106.5	217.6	94.7	97.5	163.2	232.1	94.4	175.6	158.5
245.6	131.2	188.4	102.3	131.5	104.1	72.3	182.9	182.1
188.5	191.2	178.5	168.2	83.2	142.2	201	166.2	157.3
206.2	188.6	210.2	121.5	161.3	218.6	156.3	118.6	180.1
179.8	197.8	93.7	82.3	153.5	153.2	161	175.8	133.4
89.4	233.7	235.1	78.3	181.2	198.5	188.9	126.7	182.2
208.9	171.3	183.6	96.2	212.3	103.5	92.3	168.2	185.2
217.6	141.3	221.2	102.6	173.6	218.6	212.3	148.5	77.5
134.8	226.3	87.3	118.2	180.3	244.8	177.8	158.2	88.7
224.2	94.5	157.8	207.5	169.2	121.1	93.5	158.2	72.3
198.2	193.5	136.3	173.2	88.3	140.8	218.3	137.6	81.5
181.896	**177.462**	**176.892**	**166.4**	**161.028**	**161.73**	**143.15**	**153.18**	**147.144**

Fourth (final) month sampling data for weight (W) Date: 13.08.2010

T_1-(Stocking density 30/m^3)			T_2-(Stocking density 50/m^3)			T_3-(Stocking density 70/m^3)		
R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)
268.4	218.4	226.8	362.8	273.5	327.9	242.3	184.5	313.8
368.3	232.3	248.6	228.6	226.8	224.7	218.5	209	236.8
252.4	318.9	296.3	337.2	229.6	312.9	220.5	185.2	286.9
263.2	259.9	243.6	287.8	221.4	218.9	200.5	231.6	264.5
243.9	261.2	236.5	256.3	227.6	219.3	208.3	226.3	247.7
228.6	369.4	269.4	216.8	266.5	241	232.6	192.8	171.3
362.3	231.4	282.1	312.4	226.8	277	216.8	204	296.3
245.6	228.8	223.6	221.3	273.6	216.4	232.1	216.6	184.1
357.7	193.2	262.4	332.4	221.4	220.6	206.5	228.7	287.3
299.5	352.4	267.2	227.2	229.1	240.8	188.5	230.7	205.4
250.8	298.6	249.5	249.4	331.7	220.8	328.2	186.6	237.5
276.3	249.2	351.6	211.3	227.1	314.6	198.5	191.4	199.1
216.8	223.7	241.9	263.6	303.9	225.6	280.4	181.8	235.3
268.4	218.3	313.2	220.8	218.6	330.8	202.6	203.6	182
243.6	246.4	366.6	251.9	216.3	322.8	209.5	208.5	250.4
248.6	265.1	331.4	228.8	248.4	317.5	232	188.2	176.3
297.9	291.9	261.2	233.6	309.9	237.6	262.4	196.5	210.5
220.3	212.5	267.5	209.8	302.4	272.6	243.8	248.5	197.9
238.8	248.9	226.3	259.3	241.4	219.9	218.3	205.4	177.8
215.5	233.2	326.2	297.4	252.6	325.9	230.9	234.5	177.2
328.4	208.5	251.5	242	231.2	223.4	192.3	188.8	168.4
233.4	263.6	261.3	335.4	330.6	265.4	316.5	228.5	221.2
228.9	223.4	223.4	217.9	228.3	224	221.6	208.9	203.7
223.8	253.4	220.1	235.2	312.4	239.3	318.6	272.6	201
242.6	308.6	218.3	224.8	339.3	222.5	312.8	196.4	198
256.5	246.2	263.9	211.4	341.4	237.7	305.6	273.5	178.8
320.3	224.2	256.8	229.8	218.4	256.9	213.9	180.4	213.2
241.5	209.6	228.3	266.5	269.6	238.7	252.6	247.7	210.8
259.1	218.5	260.2	215.1	221.1	269.4	196.9	264.5	185.5
334.2	252.3	253.1	227.9	266.4	228.1	229.8	286.8	186
227.6	221.2	231.3	210.2	226.1	216.2	174.5	208.2	181.5
296.5	228.5	229.5	213.8	213.2	212.6	154.3	143.8	188.2
353.6	216.3	218.6	198.6	159.6	188.1	174.3	166.8	168.4
272.4	273.4	193.5	189.8	189.5	178.6	182.5	172.4	172.7
223.6	279.2	241.2	176.7	209.4	218.6	163.6	198.4	162.6
196.3	363.8	208.2	170.2	191.2	186.6	199.6	166.6	165.6
201.4	179.4	213.7	213.5	223.1	195.6	136.2	153.1	183.5
256.5	228.6	190.7	196.6	153.2	168.6	146.6	178.2	171.2
220.3	212.5	168.6	171.4	150.1	173.2	146.3	176.2	158.2
217.1	224.3	196.2	157.8	156.2	203.2	129.8	208.6	146.8
227.5	218.5	225.3	168.2	171.2	206.2	170.2	178.2	154.2
218.9	243.4	159.6	193.5	196.5	158.9	160.5	162.6	161.6
198.5	341.2	199.1	161.4	177.6	218.6	148.4	173.1	148.8
191.3	276.5	228.3	153.2	149.2	212.8	171.5	181.6	146.2
216.3	229.9	193.5	193.4	213.2	186.8	163.5	202.3	180.2
194.5	227.4	226.2	218.8	186.5	232.6	218.6	168.5	205.4
232.4	352.6	231.5	191.4	221.2	241.4	155.6	161.3	179.5
162.3	193.6	267.2	188.6	166.4	222.3	200.3	156.5	163.6
198.1	168.9	212.8	179.3	224.2	256.6	167.5	172.5	168.6
196.5	171.2	178.2	208.4	191.2	168.9	157.8	162.6	182.6
250.744	**248.248**	**242.84**	**227.39**	**231.522**	**234.788**	**209.108**	**199.88**	**197.882**

Appendix 15: Stocking density trial-2. Effect of stocking density on tilapia cultured in net cage, Dakatia river, Roghunathpur, Chandpur during 05 June-03 October, 2010

Initial sampling data for weight (W) Date: 05.06.2010

T_1-(Stocking density 50/m^3)			T_2-(Stocking density 75/m^3)			T_3-(Stocking density 100/m^3)		
R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)
22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9	22.9
23.3	23.3	23.3	23.3	23.3	23.3	23.3	23.3	23.3
32.2	32.2	32.2	32.2	32.2	32.2	32.2	32.2	32.2
44.5	44.5	44.5	44.5	44.5	44.5	44.5	44.5	44.5
22	22	22	22	22	22	22	22	22
18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1
24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1
28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8
41.1	41.1	41.1	41.1	41.1	41.1	41.1	41.1	41.1
21	21	21	21	21	21	21	21	21
26.2	26.2	26.2	26.2	26.2	26.2	26.2	26.2	26.2
20.7	20.7	20.7	20.7	20.7	20.7	20.7	20.7	20.7
19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3
36.2	36.2	36.2	36.2	36.2	36.2	36.2	36.2	36.2
34	34	34	34	34	34	34	34	34
48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8
17.7	17.7	17.7	17.7	17.7	17.7	17.7	17.7	17.7
21.3	21.3	21.3	21.3	21.3	21.3	21.3	21.3	21.3
42.7	42.7	42.7	42.7	42.7	42.7	42.7	42.7	42.7
20.7	20.7	20.7	20.7	20.7	20.7	20.7	20.7	20.7
29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9
27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8
26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3
39	39	39	39	39	39	39	39	39
39.5	39.5	39.5	39.5	39.5	39.5	39.5	39.5	39.5
33.4	33.4	33.4	33.4	33.4	33.4	33.4	33.4	33.4
26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4
20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5
29	29	29	29	29	29	29	29	29
20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6
29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8
42.4	42.4	42.4	42.4	42.4	42.4	42.4	42.4	42.4
38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7
33.9	33.9	33.9	33.9	33.9	33.9	33.9	33.9	33.9
31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3
20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5
33.9	33.9	33.9	33.9	33.9	33.9	33.9	33.9	33.9
26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7
18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2
25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4
20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3
18.4	18.4	18.4	18.4	18.4	18.4	18.4	18.4	18.4
31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9
33.8	33.8	33.8	33.8	33.8	33.8	33.8	33.8	33.8
46.7	46.7	46.7	46.7	46.7	46.7	46.7	46.7	46.7
22.6	22.6	22.6	22.6	22.6	22.6	22.6	22.6	22.6
21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2
26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4
36.8	36.8	36.8	36.8	36.8	36.8	36.8	36.8	36.8
29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3
28.924	**28.924**	**28.924**	**28.924**	**28.924**	**28.924**	**28.924**	**28.924**	**28.924**

First month sampling data for weight (W) Date: 05.07.201

T_1-(Stocking density 50/m^3)			**T_2-(Stocking density 75/m^3)**			**T_3-(Stocking density 100/m^3)**		
R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)
58	63.4	80.4	47.4	76.2	86.2	41.7	53.1	35.2
74.9	63.7	84.2	37.7	45.7	79.7	52.4	57.8	49.3
54	35.6	72.1	55.2	78.4	70.2	33	63.1	43.3
77.2	73.4	84.7	54.8	52.8	40.3	77.4	34.8	67.4
60.4	72.3	75.4	31.9	34.6	31.4	52.7	46.4	40.9
65.7	70.8	60.3	33.1	36.2	82	50.8	52.7	74.6
65.8	72.7	58.2	50.6	56.7	72.4	34.4	67.4	37.1
35.3	54.5	94.8	77.3	58.2	64.6	67.1	36	61.5
97.5	70.8	75.7	49.3	38.7	60.8	60.3	59.7	64.4
79.5	75	83.2	76	49.4	61.8	74.8	41.7	50.5
84.1	98.4	68.5	42.2	57.8	48.7	65.7	49.8	76.4
71	80.5	98.2	57.4	74.1	67.4	77.7	44.5	74.7
85.5	85.7	56.6	39	40.2	43.9	46.8	60.5	46.5
83.9	72.6	70.8	92.5	48.2	94.7	32.5	48.5	29.7
56.4	55.3	75.2	60	64.5	70.4	45.2	47.2	30.4
74.3	80.4	70.2	64.5	62.8	42.8	48.4	32.5	42.7
89.3	70.5	74.1	40.6	94.4	74.3	62.5	46.8	44.5
72.6	65.5	37.6	32.2	45.4	53.2	44.2	67.7	25.9
107.5	70.4	53.8	71.6	58.6	38.7	56.5	65.1	49.2
95.7	72.8	90.7	54.8	46.7	56.4	58	69.3	85.7
70.9	81.7	67.3	85.3	63.2	29.8	61.2	58.8	57.2
57.5	61.9	71.4	74.3	62.9	54.3	75.5	58.2	78.5
72.9	74.2	67.2	67.1	64.8	30.1	35.8	39.9	35.8
69.4	77	72.5	36.5	68.7	33.7	36.9	38.1	36.9
71.3	70.4	70.7	24.6	80.2	55.8	45.8	34.5	55.8
50.2	70.4	83.6	78	37.4	68.7	34.5	47.8	34.5
99.2	72.3	74.8	64.2	36.8	49.5	38.1	38.9	42.1
58.3	55.7	57.6	60.2	72.4	41.3	38.9	36.2	38.9
100.1	67.8	85.4	59.8	75.6	72.5	58.2	76.7	58.2
72.9	71.7	54.7	58.5	86.2	57.8	58.8	61.2	58.8
66.2	54.4	71.3	37	46.8	51.6	70.4	43.9	74.8
55.1	80.7	75.4	77	42.7	42.3	71.7	77.8	65.1
98.2	68.1	72.6	39	33.2	68.6	47.5	32.1	71.7
81.4	50.6	62.5	51.7	24.3	58.8	29.7	41.5	50.8
53.1	66.7	41.8	45.5	57.2	48.6	30.4	44.7	32.5
65.2	80.8	56.2	51.3	49.8	50.4	42.7	32.4	45.2
68.2	90.3	58.4	26.2	54.7	56.7	41.5	29.7	48.4
73.8	54.6	70.8	29.1	42.7	49.3	23.9	41.5	62.5
70.7	73.4	55.7	31.1	80.3	86.2	49.2	72.7	44.2
75.1	70.2	71.4	45.4	43.7	79.8	78.7	70.4	56.5
75.2	71.7	60.6	30.1	52.8	70.3	35.2	64.7	41.7
84.6	62.7	75.7	64.1	31.6	47.2	49.3	58.1	57.3
77.6	75.6	66.8	45.4	27.3	39.7	39.3	38.4	33
57.7	70.4	69.7	31.9	48.5	30.3	67.1	71.6	72.4
57	37.3	56.8	50.4	31.8	57.4	46.9	41.6	52.7
38.4	55.8	78.6	24.9	53.7	50.5	71.6	67.1	48.8
51.6	58.2	60.2	47.4	37.8	61.8	37.1	42.3	34.4
71.9	74.5	56.6	26.4	54.4	49	51.5	49.3	61.7
53.8	60.8	52.8	28.4	78.6	83.4	64.1	35.7	58.2
73.2	54.7	60.6	51.2	44.7	46.7	50.5	53.6	52
71.186	**68.378**	**68.888**	**50.202**	**54.088**	**57.24**	**51.282**	**50.88**	**51.81**

Second month sampling data for weight (W) Date: 04.08.2010

T_1-(Stocking density 50/m^3)			T_2-(Stocking density 75/m^3)			T_3-(Stocking density 100/m^3)		
R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)
274.2	111.9	154.2	161.5	132.9	128.5	164.2	158.7	114.3
147.4	234.4	71.7	210	135.7	103.5	170.5	187.3	104.2
253.6	264.4	156.1	137.8	90.2	74.1	91.3	60.5	113.7
178.9	166.8	148.3	62.4	184.3	120.2	164.5	234.1	60
207.6	135.4	270.4	107.2	68.8	127.3	148.2	130.4	42.8
103.6	261.5	160.5	68.9	108.5	110.7	94.6	95.7	73.9
212.8	176.3	253.7	180.9	63.4	168.9	131.2	149.3	98.4
200.6	158.4	233.1	89	140.1	170.5	232	167.6	88.8
207.9	180.4	79.9	133.9	211.6	149.8	61.5	92.5	56.7
168.3	175.2	102.2	132.9	162.5	93.4	143.7	173.2	96.6
219.8	250.5	150.3	139.7	110.8	187.3	158.8	174.7	130.3
152.4	263.8	157.7	129.3	140.3	188.9	175.8	119.7	105.7
176.2	171.8	263.1	156.3	83.3	154.3	96.4	94.3	177.2
117.7	210.9	218.6	172.4	168.7	146.7	170.4	65.9	61.3
144.6	197.6	128.9	217	116.7	96.3	123.9	155.7	115.7
106.2	198.8	143.8	116.6	218.1	136.8	95.2	95.3	120.6
267.7	298.6	93.2	169.4	173.4	85.7	153.6	156.4	38
120.2	222.8	217.5	82.9	158.3	124.8	59.1	184.8	37.6
71.1	184.1	147.4	140.2	130	104.3	94	95.5	103.4
148.3	127.8	220.4	111.5	138.8	121.6	117.4	196.2	105.7
238.4	83.3	211.3	82.9	136.9	137.8	160.3	117.6	117.1
74.2	172.4	212.3	175.7	120.7	180.7	62.2	120.5	120.2
126.7	108.6	107.6	66.1	98.2	96.3	113.2	167.7	165.7
203.7	176.5	89.4	124.6	138.6	137.4	115.9	85.2	75.2
91.3	166.7	180.7	105.4	111.4	108.7	175.6	72.8	74.6
176.3	143.3	147.7	111.8	104.9	155.6	72.5	176.6	184.8
158.2	186.3	254.8	138.5	125.8	122.7	74.6	114.8	116.1
156.3	208.4	217.3	97.2	74.2	67.6	166.2	117.3	108.6
238.5	78.2	230.6	121.5	175.3	174.8	120	61.2	64.3
238.7	124.8	175.8	137.5	80.7	81.3	117	176.4	159.3
148.1	73.8	138.6	121	118.3	168.6	106.6	132.7	114.2
81.8	163.4	94.3	103.4	107.4	115.8	103.5	107.6	90.7
153.4	103.4	87.3	125.6	188.5	226.7	35.5	166.3	59.3
182.2	130.5	213.4	84.8	109.3	171.8	38.1	60.4	152.5
173.6	142.6	71.4	136.7	147.8	157.2	121.8	112.6	94.4
106.4	126.6	227.3	95.1	156.3	188.9	117.7	122.9	124.1
133.1	113.8	91.2	146.4	98.3	138.7	60.7	48.2	190.3
102.5	79.8	95.8	155.9	137.3	133	165	38.7	105.8
224.9	126.2	126.7	109.7	88.4	132.8	107.6	94.3	194.7
83.8	78.8	236.5	187.6	126.2	88.4	131.6	115.8	159.2
82.2	88.4	162.5	93.1	129.5	179.6	97.1	114.2	142.3
84.7	216.1	73.7	148.7	81.3	110.8	57.1	103.8	62.7
72.3	119.8	71.3	170.1	70.8	139.3	86.8	114.2	220.8
175.2	78.6	122.3	169.2	118.9	80.8	100.9	61	130.7
160.1	98.6	152.8	106.7	127.3	117.8	74.9	46.2	93.6
85.1	73.5	86.1	127.5	105.6	108.1	44.6	73.4	147.7
148	76.1	69.2	119.9	170.4	64.2	61.5	90.6	164.6
206.3	79.8	207.4	73.7	170.2	136.5	113.9	96.4	90.8
158	78.6	76.2	64.5	154.8	209.8	103	57.2	180.3
215.3	73.6	71.7	128.4	90	162.7	113.4	98.2	173.6
159.168	**151.238**	**153.484**	**126.98**	**127.994**	**133.76**	**113.302**	**117.052**	**114.462**

Third month sampling data for weight (W) Date: 03.09.2010

T_1-(Stocking density 50/m^3)			**T_2-(Stocking density 75/m^3)**			**T_3-(Stocking density 100/m^3)**		
R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)
250.5	343.5	225.4	184.4	257.6	230.6	130.3	152.3	114.7
290.6	151.8	349.7	210.6	199.8	220.7	188.6	159.7	200.8
233.3	340.7	260.8	318.7	214.7	189.3	228.8	220.6	202.6
320.7	274.1	277.5	216.6	144.3	196.1	158.3	166.5	153.4
336.4	356.4	292.8	144.4	206.3	297.4	228.6	226.4	229.7
348.3	294.6	235.8	215.2	145.5	155.7	132.7	122.1	241.8
301.4	321.7	272.2	139.7	218.7	258.4	172.5	190.6	213.4
389.7	264.6	350.6	221.6	300.1	204.3	236.9	205.5	212.3
182.3	332.8	260.5	196.8	212.2	280.1	226.4	220.4	136.7
326.5	266.4	357.2	276.4	188.6	240.3	116.6	106.7	81.3
341.3	318.7	380.5	207.2	273.1	265.7	148.2	157.2	160.2
226.2	287.3	217.7	185.6	151.3	242.3	130.8	98.8	164.6
337.3	273.7	256.6	193.7	139.8	273.4	92.3	90	122.4
190.7	342.5	344.5	354.6	212.8	157.6	98.2	104.3	210.3
176.5	276.4	282.7	234.2	336.6	182.4	106.3	215.2	105.4
328.3	275.7	151.6	343.7	283.7	102.3	88.7	108.6	98.2
383.6	182.1	247.2	213.5	359.7	185.2	106.8	160.3	102.1
277.7	378.3	290.1	140.1	180.6	135.6	137.8	122.3	212.2
252.6	236.6	253.2	169.2	181.7	155.2	110.5	88.1	180.3
284.4	351.9	276.3	271.9	200.8	179.3	212.3	100.1	210.4
269.5	229.1	230.8	132.5	105.4	103.7	204.8	149.2	125.3
343.2	290.7	331.2	167.8	245.7	244.4	193.5	173.6	161.1
216.6	330.2	343.7	202.5	280.1	278.9	120.7	221.1	152.2
215.2	180.8	215.3	166.4	131.7	134.7	227.5	171.5	154.1
255.3	221.5	229.6	234.3	102.3	99.8	165.6	228	123.3
224.7	268.7	266.7	100.6	236.2	255.7	222.7	125.3	227.2
187.6	225.3	222.8	130.4	152.5	170.2	172.5	202.6	171.4
326.7	212.2	221.7	279.4	193.4	201.7	140.3	209.3	228.5
296	269.5	341.2	243.1	158.1	170.6	148.1	138.1	170.2
233.7	227.4	254.3	104.3	129.6	131.4	170.5	228.1	151.3
259.6	330.6	325.7	178.2	253.8	274.3	225.1	240	97.2
252.3	354.7	258.6	154.1	241.7	185.4	164.8	201.7	84.3
257.8	226.2	285.4	124.2	260.8	137.8	233.6	218.1	110
245.2	337.8	386.3	183.5	155.8	215.7	140.5	151.7	147.2
153	343.4	355.6	100.4	170.2	344.7	190.6	93.5	112.3
334.6	155.7	274.7	181.3	100.1	239.4	220	184.1	216.5
270.2	230.6	178.6	156.4	184.3	357.4	215.1	165.6	100.4
230.8	246.7	358.7	258.7	123.6	192.8	107.2	115.1	85.2
394.2	241.8	255.2	244.6	156.7	186.6	154.4	210.7	106.4
380.2	270.7	348.6	254.3	177.3	210.2	110	110	146.2
245.8	190.3	342.2	243.9	227.6	279.5	98.7	103.2	114.2
380.2	276.4	189.8	276	222.8	210.2	103.7	106.7	223.4
228.8	241.9	386.7	206.2	187.3	219.6	235.6	203.6	216.3
297.6	267.7	277.3	254.2	198.7	146.4	109.4	202.2	198.1
253.3	282.8	349.6	154.4	274.2	217.5	122.3	217.7	121.4
328.2	242.6	342.3	291.7	152.8	150.1	175.5	125.6	236.3
310.6	265.9	320.7	195.3	255.6	217.6	160.2	174.5	162.2
259.9	261.7	251.8	186.4	207.4	324.4	210.3	154.6	218.2
392.4	257.1	344.2	223.5	278.9	213.5	129.2	171.3	170.2
239.5	290.6	254.6	226.4	244.8	185.7	118.4	150.7	151.4
281.22	**272.808**	**286.536**	**205.862**	**204.346**	**209.036**	**160.848**	**163.262**	**160.696**

Fourth (final) month sampling data for weight (W) Date: 03.10.2010

T_1-(Stocking density 50/m^3)			**T_2-(Stocking density 75/m^3)**			**T_3-(Stocking density 100/m^3)**		
R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)
456.8	390.9	370.4	279.7	274.5	276.3	138.1	204.5	179.4
424.1	315.4	345.7	276.6	107.4	316.8	215.3	245.1	263.6
379.7	300.7	324.2	290.8	267.8	339.7	227.5	140.2	221.5
436.8	480	433.7	232.8	238.7	315.1	326.2	240.9	324.6
347.7	394.5	455.6	260.7	290.2	320.7	223.9	202.8	221.7
396.5	344.7	330.5	212.6	301.6	280.2	292.1	185.2	209.3
490	433.8	442.3	205.8	277.8	221.6	193	186.3	130.2
301.4	375.4	410.4	250.9	358.1	360.7	183.9	160.5	121.8
318.1	420.1	378.2	275.6	272.5	250.1	184.5	124.7	242.5
393.8	451.3	365.3	293.8	250.6	299.8	145.6	145.6	203.1
464.9	271.4	374.5	286.3	246.3	315.7	135.1	204.9	145.2
397.7	403.7	430.8	307.2	227.6	340.1	203	141.1	137.6
378.9	380.5	406.7	294.6	324.8	195.3	241.3	158.5	184.5
378.6	319.6	365.4	234.8	217.5	288.2	121.6	185.6	205.6
347	330.7	431.6	263	256.7	218.6	137.7	201.7	192.3
340.2	340.1	391.7	212.6	350.1	268	123.4	190.8	280.4
325.5	368.6	372.3	281	269.8	243.4	242.5	297.4	223.7
385.7	371.8	410.6	182.3	258.5	298.7	202.7	228.1	320.5
407.3	385.7	450.2	350.1	275.6	317.8	139.3	324.7	220.6
276	449.6	402.5	311.8	287.3	290.4	160.1	230.2	211.4
317.6	282.4	307.6	293.8	270.1	321.7	184.2	217.5	128.7
317.5	292.3	309.4	248	304.7	305.6	185.4	141.1	123.2
450.9	260.7	439.3	360.5	334.6	297.3	193.7	198.3	237.5
330.4	328.6	322.5	215.6	273.7	305.7	291.2	187.4	201.1
299	325.2	285.6	272.4	320.4	270.5	222.9	154.8	131.6
331.2	290	320.4	327.9	268.3	357.6	328.2	136.7	151.7
338.7	326.3	328.7	313	210.7	265.5	225.4	210	181.4
262.8	443.9	257.6	363.6	350.6	225.4	215.5	244.6	190.5
298.3	310.7	284.2	310.5	245.4	341.9	140.1	128.1	143.2
290.3	309.4	280.5	273.3	287.6	234.1	216.2	143.4	210.8
403.6	405.4	445.9	301.7	310.2	260.6	226.8	220.3	223.6
445.2	456.3	378.2	296.2	334.5	275.8	330.1	229.7	308.5
418.7	416.8	366.7	303.8	190.3	365.1	221.7	330.4	220.2
398.2	375.3	364.6	278.2	278.4	287.7	294.6	227.8	278.7
455.7	419.6	334.7	361.8	210.2	310.5	193.3	299.4	182.9
428.6	435.7	330.2	258.7	256.8	300.3	181.9	201.7	200.6
388.3	368.2	316.7	221.6	230.2	243.7	185.2	209.5	180.5
432.2	408.7	374.6	348.5	284.5	273.8	153.4	189.4	142.1
482.6	437.2	401.3	229.3	301.7	217.2	133.6	148.2	143.7
415.3	378.6	274.5	247.4	281.4	284.6	204.2	139.4	201.8
399.5	372.2	441.8	252.4	290.3	255.8	240.9	206.7	231.5
408.2	382.4	420.2	276.7	271.4	283.9	122.7	247.6	121.6
342.7	413.7	374.3	398.6	246.3	260.1	203.6	125.3	153.4
448.3	450.8	430.1	282.9	201.6	215.7	241.5	144.8	180.2
476.3	345.5	339.5	304.6	210.4	221.5	139.7	219.4	178.3
355.8	460.3	384.7	295.3	252.7	265.7	243.6	228.9	194.7
465.7	438.7	465.8	240.5	230.1	244.6	203.7	334.7	233.8
433.9	332.4	294.7	261.7	282.9	299.7	184.7	231.2	136.4
396.5	388.2	312.4	210.2	275.3	283.5	185.4	301.7	239.3
388.2	389.5	388.7	279	276.1	290.9	160.5	196.3	198.6
385.338	**375.47**	**369.36**	**278.614**	**268.696**	**282.464**	**201.814**	**203.862**	**197.792**

Appendix 16: Feeding regime trial-1. Effect of different amount of feed supplements on monosex tilapia cultured in net cage of Dakatia river,Raghunathpur, Chandpur during 15 April-13 August, 2011

Initial sampling data for weight (W) Date: 15.04.2011

T_1 (Feed @ 5-3 % of bw daily)			T_2 (Feed @ 6-4 % of bw daily)			T_3 (Feed @ 7-5 % of bw daily)		
R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)
40.1	40.1	40.1	40.1	40.1	40.1	40.1	40.1	40.1
47.6	47.6	47.6	47.6	47.6	47.6	47.6	47.6	47.6
58.4	58.4	58.4	58.4	58.4	58.4	58.4	58.4	58.4
30.2	30.2	30.2	30.2	30.2	30.2	30.2	30.2	30.2
30.2	30.2	30.2	30.2	30.2	30.2	30.2	30.2	30.2
36.9	36.9	36.9	36.9	36.9	36.9	36.9	36.9	36.9
38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7
61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4	61.4
45.4	45.4	45.4	45.4	45.4	45.4	45.4	45.4	45.4
53.5	53.5	53.5	53.5	53.5	53.5	53.5	53.5	53.5
59.3	59.3	59.3	59.3	59.3	59.3	59.3	59.3	59.3
36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7
23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5
59.4	59.4	59.4	59.4	59.4	59.4	59.4	59.4	59.4
30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1
56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2	56.2
28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5
26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6
48.3	48.3	48.3	48.3	48.3	48.3	48.3	48.3	48.3
48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5
34.6	34.6	34.6	34.6	34.6	34.6	34.6	34.6	34.6
31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3
32.7	32.7	32.7	32.7	32.7	32.7	32.7	32.7	32.7
52.5	52.5	52.5	52.5	52.5	52.5	52.5	52.5	52.5
35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7
48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5
18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2
47.9	47.9	47.9	47.9	47.9	47.9	47.9	47.9	47.9
30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9
29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8
23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7
19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8
23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2
29.7	29.7	29.7	29.7	29.7	29.7	29.7	29.7	29.7
32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1
28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8
35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6
41.3	41.3	41.3	41.3	41.3	41.3	41.3	41.3	41.3
28.9	28.9	28.9	28.9	28.9	28.9	28.9	28.9	28.9
26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3
29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3
28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6
20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9
42.5	42.5	42.5	42.5	42.5	42.5	42.5	42.5	42.5
30.6	30.6	30.6	30.6	30.6	30.6	30.6	30.6	30.6
38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4
24.4	24.4	24.4	24.4	24.4	24.4	24.4	24.4	24.4
19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5
27.3	27.3	27.3	27.3	27.3	27.3	27.3	27.3	27.3
37.7	37.7	37.7	37.7	37.7	37.7	37.7	37.7	37.7
36.204	**36.204**	**36.204**	**36.204**	**36.204**	**36.204**	**36.204**	**36.204**	**36.204**

First month sampling data for weight (W) Date: 15.05.2011

T_1 (Feed @ 5 % of bw daily)			T_2 (Feed @ 6 % of bw daily)			T_3 (Feed @ 7 % of bw daily)		
R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)
86.1	80.7	165.1	70.9	45.8	98.1	121.7	105.1	165.3
84.3	68.6	80.2	172.1	47.9	130.7	62.8	111.2	128.5
99.5	153.6	136.7	164.4	109.2	74.5	119.3	75.8	58.7
109.5	102.2	88.8	117.2	147.8	58.6	146.5	86.4	91.3
164.4	88.9	85.1	83.2	65.4	67.2	77.8	76.2	134.7
43.6	42.8	135.9	155.4	75.6	61.6	70.2	63.3	68.9
162.8	50.4	60	108.4	91.2	135.8	99.7	93.6	56.3
93.4	68.8	63.7	129.7	72.1	128.7	147.6	50.2	90.8
103.6	133.4	81.8	146.2	61.8	68.9	50.8	91.7	78.7
172.1	49.6	88.7	44.7	44.4	200.7	197.2	105.8	96.8
160.5	89.7	58.1	90.4	204.5	62.5	99.4	144.6	162.8
64.9	82.4	134.4	72.3	69.8	73.3	65.1	149.8	63.1
64.5	64.2	67.8	58.7	124.8	43.8	53	96.3	103.4
100.8	59.3	50.5	107.2	134.6	92.7	87.3	84.4	70.1
55.6	137.8	99.7	153.5	62.4	77.1	83.6	53.3	133.7
75	84.3	104.7	42.2	66.4	54.1	89.3	74.1	54.6
96.9	68.7	81.3	53.6	57.1	151.7	55.5	158.3	59.5
44.9	127.8	67.6	150.1	126.6	43.9	80.1	78.6	135.3
108.2	75.8	164.1	152.2	73.8	46.2	123.2	97.9	110.1
62.6	154	42.3	88.3	97.3	100.7	103.6	118.5	59.7
133.5	154.8	39	82.4	100.2	144.9	128.3	61.5	119.2
45.1	80.7	94.7	47.5	81.2	136.5	44.8	104.2	98.7
105.8	105.9	37.2	71.9	141.3	143.4	88.4	130.8	78.4
50.1	133.7	50.1	136.4	53.6	130.7	47.3	52.2	129.1
44	83.4	45.3	45.2	105.8	134.6	103.2	85.7	74.5
146.4	66.7	179.7	126.3	54.8	81	42.2	117.9	54
99.6	45.3	90.8	137.6	128.8	74.9	57.7	129.1	95.8
68.8	60.7	97	90.3	88.8	62.3	71.1	130.2	85.7
112.3	133.7	58.7	102.4	93.8	76.2	79.2	90.7	120.2
50.6	153.8	33.4	61.8	57.8	45.7	96.6	68.8	115.1
116.6	32.4	152.7	68.2	104.3	56.8	48.8	164.8	106.4
96.8	59.2	184.5	40.8	53.8	95.7	59.8	128.5	92.7
73.5	96.4	132.8	80.7	56.6	127.6	57.1	97.1	51.2
55.8	91.2	70.3	53.9	60.8	90.1	85.4	77.5	94.6
51	148.3	45.3	131.2	51.7	53.9	83.8	90.3	62.7
87.6	45.1	67.2	51.6	109.8	100.5	51.7	56.7	77.1
37.9	50.5	83.4	62.4	36.1	54	105.4	69.6	85.9
62.4	36.2	154.4	51.8	68.8	135.4	141.7	131.3	80.2
85.8	95.2	114.9	45.6	55.2	80.3	135.1	90.5	112.1
62.4	38.6	84	52.6	42.8	99.8	139.8	58.1	103.7
38.4	38.2	81.8	92.8	45.3	103.9	41.6	152.6	134.8
119.4	40.2	56.4	38.2	75.6	43.7	93.4	56.5	91.3
65.3	36.3	49.2	57.4	61.5	55.3	105.4	109.7	69.7
67.8	83.4	44.3	30.2	80.2	67.3	133.8	134.8	130.6
32.2	35.4	44	42.4	75.3	36.4	91.6	58.1	116.9
34.1	44.2	82.7	90.2	130.8	109.3	46.6	54.5	84.8
59.5	43.2	36.2	44.6	133.9	52.4	45.6	132.1	54.7
41.8	43.6	36.4	63.1	153.3	62.1	135.6	69.2	130.7
57.3	49.2	37.4	128.2	145.6	57.5	135.5	102.8	55.8
21.3	82.2	44.7	72.3	155.9	54.4	96.4	62.8	62.4
81.526	**79.814**	**83.7**	**87.214**	**87.638**	**86.748**	**90.532**	**95.674**	**93.826**

Second month sampling data for weight (W) Date: 14.06.2011

T_1 (Feed @ 4 % of bw daily)			T_2 (Feed @ 5 % of bw daily)			T_3 (Feed @ 6 % of bw daily)		
R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)
134.2	111.9	97.7	274.2	197.3	90.2	137.2	208.8	179.2
61.7	234.4	224.2	147.4	155.2	74.9	193.4	85.8	89.1
156.1	284.4	184.1	253.6	230.3	200.4	115.5	182.1	95.6
158.3	166.8	296.7	178.9	111.5	97.5	260.1	207.3	80.3
290.4	135.4	221.4	207.6	103.1	109.8	236.1	227.4	104.8
130.5	281.5	240.3	113.6	256.8	117.1	192.8	140.3	162.4
305.7	171.3	211.6	222.8	196.4	165.4	152.6	235.7	163.3
253.1	158.4	180.8	210.6	113.9	147.4	172.3	192.8	97.8
79.9	175.4	268.4	237.4	120.7	189.3	138.1	205.1	107.7
122.2	165.2	164.9	168.3	224.4	123.7	170.8	89.2	100.9
145.3	240.5	187	229.8	143.6	107.7	162.3	202	210.8
157.7	263.8	243.4	152.4	284.8	167.6	139.6	294.7	175.4
333.1	161.8	155.8	216.2	76.6	192.1	175.2	151.3	195.8
228.6	220.9	174.3	117.7	207.3	106.3	136.8	111.6	190.5
128.9	238.6	220.7	134.6	183.2	281.2	138.2	297.2	178.7
133.8	228.8	166.7	106.2	178.1	137.8	288.4	114.4	238.9
103.2	298.6	285.1	277.7	143.8	142.8	129.4	128.3	157.5
167.5	222.8	235.2	120.2	168.6	82.7	128.2	267.6	81.6
127.4	193.1	109.7	61.1	194.7	172.3	168.6	195.2	75.4
170.4	117.8	140.1	168.3	137.4	61.7	157.3	182.3	173.1
151.3	78.3	78.7	238.4	98.5	173.9	134.2	132.3	175.8
212.3	162.4	57.8	74.2	112.2	129.8	123.1	167.5	210.2
117.6	108.6	77.5	116.7	201.8	196.7	142.7	82.3	84.7
79.4	176.5	78.1	225.7	88.8	171.9	154.2	108.2	95.4
187.8	126.7	87.2	91.3	108.6	99.5	107.2	119.6	163.7
137.7	143.3	58.3	226.3	93.2	239.3	148.3	143.1	120.1
254.8	206.3	79.6	158.2	252.1	97.6	106.3	90.3	107.8
187.3	228.4	99.4	132.3	177.7	219.8	182.4	86.4	113.4
230.6	73.2	120.2	238.5	126.8	87.6	261.4	179.1	158.7
175.8	114.8	227.3	248.7	174.1	97.8	95.2	176.1	143.1
138.6	68.8	125.8	148.1	134.2	173.7	242.6	148.1	201.8
94.3	153.4	90.2	84.8	98.3	85.2	180.8	101.8	292.7
87.3	103.4	77.8	153.4	136.6	184.7	136.3	106.2	176.8
213.4	110.5	63.7	193.2	166.8	144.8	253.7	98.2	110.6
66.4	132.6	115.3	173.6	124.4	279.1	81.3	152.3	298.8
227.3	126.6	125.9	100.4	108.3	98.7	124.1	61.2	125.6
71.2	113.8	139.1	133.1	96.3	258.3	157.6	105.3	127.8
95.5	64.8	118.7	102.5	198.2	228.5	254.8	79.2	280.1
126.7	126.2	153.8	224.9	192.3	108.7	142.8	95.1	198.2
236.5	68.8	104.3	73.8	190.2	122.8	235.2	88.3	193.3
162.5	88.4	67.8	82.2	106.8	225.5	122.5	179.6	187.8
68.7	236.1	115	81.7	126.3	121.6	294.2	164	86.5
77.3	109.8	78.8	67.3	231.7	134.3	123.8	80.4	176.8
122.3	78.6	207.8	165.2	139.2	235.7	155.8	186.6	174.4
132.8	98.6	208.7	130.1	198.8	176.5	116.5	204.9	228.5
66.1	149.5	185.9	85.4	180.7	136.8	121.4	148.2	139.3
69.2	76.1	138.7	148	103.6	251.7	156	196.3	236.7
197.4	87.8	145.3	236.3	196.7	113.6	189.6	218.6	203.1
76.2	78.6	107.8	168	122.7	271.4	155.5	176.3	90.7
71.7	123.6	183.7	205.3	97.7	114.2	128.3	229.3	204.8
150.48	**153.718**	**150.526**	**162.124**	**156.226**	**154.952**	**164.414**	**156.478**	**159.32**

Third month sampling data for weight (W) Date: 14.07.2011

T_1 (Feed @ 3 % of bw daily)			T_2 (Feed @ 4 % of bw daily)			T_3 (Feed @ 5 % of bw daily)		
R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)
222.5	183.6	406.1	295.3	196	351.2	247.3	156.2	370.1
327.8	195.8	244.6	353.8	183.8	205.1	171.2	318.2	390.3
239.6	264.4	419.7	241.1	324.8	141.8	332.3	242.9	317.4
315.4	291.4	247.8	202.8	103.2	145.4	384.1	198.8	298.3
176.3	221.7	138.7	178.3	110.2	265.3	145.6	271.2	249.7
287.8	132.6	169.3	251.6	368.5	163.2	185.6	309.3	203.8
243.6	403.4	253.2	202.6	205.4	204.8	220.7	168.4	226.3
295.8	243.2	218.5	148.9	195.7	155.1	301.8	251.5	187.6
317.2	137.2	158.1	164.4	171.3	232.7	250.1	137.1	115.7
315.4	197.2	131.7	172.4	315.6	309.2	277.3	129.1	145.4
248.3	332.9	182.8	175.2	195.3	102.8	139.6	124.6	164.3
205.4	420.6	197.3	211.9	286.4	177.1	244.6	270.3	220.8
215.8	164.1	230.6	262.8	240.2	206.2	300.2	256.4	293.1
153.7	139.8	263.5	230.2	220.7	254.1	216.5	311.2	299.6
128.7	248.1	295.4	248.6	108.2	300.7	185.8	271.8	136.7
246.5	134.2	265.7	279.3	360.8	278.1	332.4	198.2	162.3
332.7	263.7	255.6	426.2	187.2	149.8	292.4	261.6	294.8
170.3	142.4	343.8	168.2	348.2	206.3	223.8	306.9	268.2
122.7	256.7	190.3	232.9	401.2	246.5	279.2	309.8	244.7
241.5	192.2	300.8	209.1	168.1	167.7	316.8	257.8	118.9
415.8	345.2	423.7	227.8	299.8	194.8	221.6	221.1	117.8
387.3	183.8	344.6	257.9	231.8	286.3	293.8	291.2	110.7
343.6	90.2	235.1	309.4	154.2	123.7	216.4	295.2	205.6
150.4	162.7	199.7	137.9	205.4	291.8	219.7	137.7	267.6
282.1	426.8	143.4	271.3	290.4	307.8	298.2	358.3	199.5
186.8	146.5	333.9	452.6	282.8	188.2	195.3	161.6	109.9
321.6	343.8	175.3	216.3	286.6	331.7	308.7	290.7	239.4
188.6	174.3	147.6	247.5	242.1	178.4	184.8	119.9	184.3
308.4	301.7	167.2	131.2	304.8	176.8	142.6	242.9	278.8
360.2	233.2	119.7	141.2	326.2	408.6	241.7	257.8	208.8
148.5	205.4	127.6	167.4	220.6	391.7	201.6	274.4	131.2
149.6	261.6	167.7	113.8	231.9	241.6	230.9	309.9	139.2
196.8	336.7	175.6	267.5	165.8	233.2	198.7	174.6	250.8
141.4	199.1	215.7	282.8	293.6	298.1	298.4	229.2	169.5
220.8	222.7	224.4	168.6	152.2	164.2	144.1	111.9	166.1
210.8	227.4	148.3	383.6	363.6	253.8	153.8	198.7	198.5
313.8	117.8	120.6	232.9	249.5	221.4	223.3	265.5	310.7
175.7	226.8	401.3	237.6	241.5	123.6	172.5	110.2	280.3
183.8	229.6	177.1	162.2	120.9	240.3	133.1	203.4	321.8
107.3	205.8	134.3	398.4	219.3	348.9	180.3	116.9	241.9
223.6	172.6	276.9	234.8	263.8	340.3	308.6	296.2	268.8
109.7	133.8	227.8	276.6	105.8	325.6	313.8	304.6	320.7
95.6	102.6	228.7	243.4	199.4	245.4	140.3	378.2	260.6
365.8	209.3	231.8	172.3	176.2	173.6	287.3	242.8	269.7
179.6	146.5	222.2	267.9	243.5	196.1	326.3	112.6	311.9
163.5	213.6	225.7	362.6	148.9	206.3	278.9	196.2	307.6
326.8	172.9	224.8	203.1	123.2	112.5	385.4	178.9	198.3
194.3	196.2	255.4	262.3	303.6	167.2	246.3	223.3	278.3
201.4	188.3	108.9	206.9	176.2	163.6	326.4	146.4	258.1
170.2	346.3	171.2	292.4	332.5	306.3	218.4	163.2	126.4
232.616	**221.768**	**225.394**	**239.716**	**232.938**	**230.098**	**242.77**	**227.296**	**228.816**

Fourth (final) month sampling data for weight (W) Date: 13.08.2011

T_1 (Feed @ 3 % of bw daily)			**T_2 (Feed @ 4 % of bw daily)**			**T_3 (Feed @ 5 % of bw daily)**		
R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)
425.3	346.2	510	290	294.3	378.4	430.2	462.3	430.2
525	285.7	548	420.2	424.8	476.5	195.3	411.4	288.4
590	293.3	469.8	220.3	283.4	497.4	280.1	370.6	410.2
352.4	288.6	276.2	420.5	419.7	506	460.4	321.5	458.9
510	181.4	396.7	284.1	481.5	226.2	450.3	429.8	480.2
440.6	241.1	391.2	330.4	271.6	154.6	280.5	480.3	240.2
540	208.2	524	520	468.7	284.3	325.7	493.7	228.7
370.9	289.8	331.2	279.5	284.9	321.6	410.1	410.3	224.6
325.6	291.2	376.1	260.4	381.4	362.3	280.6	290.4	230.1
390.1	178.7	370.2	189.6	321.2	205.4	450.2	438.6	261.2
525	118.6	562	260.5	278.6	271.3	430.4	251.1	236.7
290.2	177.3	442.2	254.5	324.8	432.2	330.3	229.8	176.4
395.1	181.7	350.8	510	240.2	281.6	460.1	523	232.6
470.1	343.4	527	205.3	206.1	382.2	352.8	231.2	206.1
244.3	189.8	425.4	274.7	495.7	318.7	260.3	261.2	256.7
279.4	157.3	340.2	260	531	460.1	290.2	220.3	428.8
225.5	331.6	321.3	176.1	497.2	284.2	330.4	481.6	340.1
275.1	271.3	198.5	380.3	186.4	288.7	340.2	204.4	339.2
265.2	282.4	242.3	239.6	207.3	416.3	430.4	330.1	410.4
305.3	268.6	338.7	270.2	378.7	419.4	250.6	260.2	438.7
290	418.1	307.6	265.4	443.8	328.3	285.2	278.6	380.1
415.2	288.9	228.7	244.4	240.3	518	220.1	312.2	278.8
235.2	234.2	180.2	425.1	203.6	282.3	256.7	239.4	411.6
404.5	406.1	271.2	280.2	434.7	261.4	240.4	238.3	249.1
370.1	368.2	122.3	260.3	238.4	190.2	340.2	232.1	448.7
225.4	224.8	309.7	250.6	261.2	256.4	260.3	342.2	428.8
309.6	309.8	361.2	435.8	281.4	237.3	470.2	240.1	291.3
190.2	191.4	338.3	205.4	422.5	471	540	228.8	257.8
329.8	329.8	289.8	240.3	214.8	204.7	310.7	461.3	419.7
185.7	186.5	271.2	445.6	244.3	260.4	260.3	316.7	258.6
269.3	423.7	186.1	380.2	226.2	224.3	240.4	260.4	260.2
280.4	592	199.7	230.7	228.7	247.4	230.1	388.6	267.8
269.6	524	212.4	495.2	385.2	424.4	205.3	273.5	240.1
330	353.4	148.4	500	180.1	279.5	486.4	387.6	308.4
150.2	511	270.3	495.5	273.6	259.7	240.3	334.2	279.6
189.8	439.7	184.8	225.4	502	240.1	246.7	229.7	330
340.1	538	330.7	380.2	224.1	427.6	230.4	373.2	387.8
179.9	372.8	189.6	325	204.7	203.8	245.6	257.4	308.9
175.5	326.2	311.2	280	260.2	240.7	230.3	291.3	378.7
289.6	392.8	227.3	180.2	267.3	444.6	241.2	430.7	277.6
120.1	524	397.8	320.4	184.1	283.7	460.2	434.6	308.2
270.3	396.1	403.7	380.1	258.9	418.2	490.3	250.3	218.7
180.7	469.7	236.2	285.2	189.6	217.6	346.5	410.8	231.2
209.4	291.6	414.6	470.3	521	420.7	290.6	323.4	268.3
294.6	306.2	291.4	270.6	329.6	288.6	460.4	293.5	338.7
298.4	276.3	307.1	480.1	284.2	276.4	343.7	381.2	447.8
240	226.4	263.4	420	422.7	168.8	310.3	196.4	360.6
260.3	279.8	274.1	285.2	218.8	351.2	375.4	272.1	319.2
310.8	247.2	234.8	425.3	420.6	239.6	279.2	310.3	427.8
180	266.3	286	330.7	288.7	237.8	460.5	450.4	457.1
310.796	**312.824**	**319.832**	**325.192**	**316.656**	**317.442**	**332.74**	**330.822**	**323.192**

Appendix 17: Feeding regime trial-2. Effect of different amount of feed supplements on monosex tilapia cultured in net cage of Dakatia river,Raghunathpur, Chandpur during 03 June-01 October 2011.

Initial sampling data for weight (W) Date: 03.06.2011

T_1 (Feed @ 6 % of bw daily)			T_2 (Feed @ 5 % of bw daily)			T_3 (Feed @ 4 % of bw daily)		
R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)
14	14	14	14	14	14	14	14	14
17	17	17	17	17	17	17	17	17
14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2
20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4
18.9	18.9	18.9	18.9	18.9	18.9	18.9	18.9	18.9
16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2
27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.1
17.2	17.2	17.2	17.2	17.2	17.2	17.2	17.2	17.2
24.4	24.4	24.4	24.4	24.4	24.4	24.4	24.4	24.4
13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8
14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2
15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1
12.3	12.3	12.3	12.3	12.3	12.3	12.3	12.3	12.3
24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8
14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2
26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7
29.6	29.6	29.6	29.6	29.6	29.6	29.6	29.6	29.6
16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5
18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2
25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2
26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5
14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3
23	23	23	23	23	23	23	23	23
28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4
13	13	13	13	13	13	13	13	13
24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2
12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8
24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1
12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7
16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2
13	13	13	13	13	13	13	13	13
21	21	21	21	21	21	21	21	21
19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8
28.3	28.3	28.3	28.3	28.3	28.3	28.3	28.3	28.3
29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9
25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5
14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2
28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4
22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5
10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6
23.3	23.3	23.3	23.3	23.3	23.3	23.3	23.3	23.3
12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7
13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9
23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9
26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5
17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6
12.9	12.9	12.9	12.9	12.9	12.9	12.9	12.9	12.9
32.9	32.9	32.9	32.9	32.9	32.9	32.9	32.9	32.9
25	25	25	25	25	25	25	25	25
29	29	29	29	29	29	29	29	29

T_1 (Feed @ 6 % of bw daily)			T_2 (Feed @ 5 % of bw daily)			T_3 (Feed @ 4 % of bw daily)		
R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)
12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6
14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2
15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1
22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1
26.8	26.8	26.8	26.8	26.8	26.8	26.8	26.8	26.8
24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7
12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2
16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4
22	22	22	22	22	22	22	22	22
26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5
18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2
25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4
25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4
19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3
18	18	18	18	18	18	18	18	18
25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9
30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1
18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1
12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4
21.8	21.8	21.8	21.8	21.8	21.8	21.8	21.8	21.8
19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1
24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3
17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6
18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2
13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1
26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9
27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.1
16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2
10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6
22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3
17.2	17.2	17.2	17.2	17.2	17.2	17.2	17.2	17.2
18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2
19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8
26.2	26.2	26.2	26.2	26.2	26.2	26.2	26.2	26.2
18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2
35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7
32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4
34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5
27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2
21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1
16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4
18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6
26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9
29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8
15	15	15	15	15	15	15	15	15
18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2
25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9
31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3
20.763	**20.763**	**20.763**	**20.763**	**20.763**	**20.763**	**20.763**	**20.763**	**20.763**

First month sampling data for weight (W) Date: 03.07.2011

T_1 (Feed @ 6 % of bw daily)			T_2 (Feed @ 5 % of bw daily)			T_3 (Feed @ 4 % of bw daily)		
R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)
31.8	26.2	75.8	52.4	51.6	107.5	24.1	72.6	47.4
47.3	28	71.5	63.4	52.2	39.5	19.5	36.2	19.5
70.9	31.5	100.5	63.1	20.4	50.6	64.4	51.1	49
70.8	49.9	70.2	35.2	41.8	52.2	27.1	33	46.1
69.2	51.4	63.1	47.5	62.9	62.6	32.6	32.4	44.8
66.1	57.9	95.3	43.2	36.3	25.7	39.9	32.1	39.9
49	56.1	84.7	81.4	32.7	21.1	41.4	49.6	69.3
50.4	70.3	36.9	80.1	47.1	76.4	27	21.1	26.8
49.5	71.2	28.1	58.2	50.8	25.7	35.6	19.4	27.5
67.5	52	26.3	55.3	62.8	42.8	72	65.1	39.2
29	42.7	68.5	64.8	63.6	33.4	32	32.3	27.8
55.1	72.8	55.7	68.4	26.2	60.2	53.4	34	34.4
40.9	50.5	51.3	39.7	51.9	62.8	67.1	67.2	47.8
33.3	83.4	59.1	61	34.2	21.8	49.3	34.2	32.2
34.4	66.4	88.6	51.3	46.6	91.8	18.2	46.2	33.9
49.9	45.1	24.4	40	39.5	60.6	73.4	23.9	62.3
39.8	42.9	29.9	51	30.1	49.3	20.7	28	66.8
44.6	55.6	48.3	85.5	82.2	60.5	39.1	20	62.6
37.9	51.5	41.3	52.9	80.8	81.3	45.7	56	32.5
47.6	70.2	57.3	51.6	60.2	17.7	34.2	52.6	23
26.3	72.3	81.6	25.4	48.2	68.9	34.3	39.1	41.9
34.7	37.5	29.1	23.1	54.1	50.9	66.1	25.2	62.6
49.6	46.7	34.8	51.6	52.2	74.9	34.2	29.6	31.8
47.7	34.9	39.1	52.6	52.7	38.1	45.3	42.1	36.1
31.3	42.7	26.5	35	65.4	51.6	34	19.5	29.5
49.5	50.1	50.6	52.7	69.5	30.9	71.4	35.2	34.6
50.3	24.7	61.7	32.4	24.1	70.2	32.5	21.2	43.8
81.1	32.8	66.3	24.1	34.2	29.3	52.8	23.1	44.3
41.1	30.6	34.4	36.4	43.7	54.5	32.8	35.6	50.3
40.8	80.4	37.1	51	86.1	48.1	34.3	55.8	40.8
40.8	50.2	30.6	18.9	40	46.7	35.4	74.2	51.6
58.9	48.5	64.8	36.9	54.6	92.8	19.6	72.5	43.9
45	18	55.9	25.1	81.2	40	20.5	30.9	32.2
49.7	70.2	23.4	35.3	42.8	50	33.8	24	24.6
72.7	74.6	27.1	40.5	25.7	34.6	55.6	19.4	61.1
24.4	69.9	44.1	47.3	28.8	72.7	22.6	28.1	40.2
50.1	32.6	28.6	35.1	46.9	36	30.7	34	32.5
43.4	33.7	31.8	60.7	68.7	35.8	30.5	27.2	26.8
35.2	32	38.3	39.1	39.6	42.5	71.6	34.5	34.3
33.5	33	80.3	23.4	60.8	31.3	30	32.1	34.8
50.9	40.8	32.6	65.8	46.2	34.6	29.9	40	24.8
79.1	29	33.1	38.5	25.6	25.8	18.4	26.6	43.1
52.3	30.6	25	51.4	50.3	31.4	47.1	49.3	19.1
58.6	42.2	42.4	54.8	25.4	29.5	27.5	65.8	57.3
30.1	35.8	36.2	53.7	54.7	35	18.5	64.7	23.6
49.6	52.1	25.8	45.5	38.8	60	52.5	22.5	60.1
17.1	68.6	34.3	33.7	36.2	21.3	24	70.2	45.1
72.2	58.2	39.2	29.5	52	50	41.5	52.7	73.6
28	51.3	84.2	31.8	37.2	81.4	38.5	56.8	29.3
24.9	46.2	25.9	39.4	48.3	60	55.1	54.8	34.4
47.078	**48.916**	**48.832**	**46.734**	**48.158**	**49.446**	**39.154**	**40.274**	**40.818**

Second month sampling data for weight (W) Date: 02.08.2011

T_1 (Feed @ 6 % of bw daily)			T_2 (Feed @ 5 % of bw daily)			T_3 (Feed @ 4 % of bw daily)		
R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)
74.3	145.3	65.8	124.4	86.4	188.9	89.6	84.6	77
138.7	97.4	220	198.7	153.4	86.8	71.1	59.4	70.9
230.2	73.1	144.9	228.6	87.8	231.9	83.2	55.8	102.3
121.3	128.2	87.7	158.7	177.2	94.2	113.5	70.7	89.2
106.4	115.8	107.7	141.3	107.6	156.8	88.3	48.4	81.3
64.1	147.5	150.6	117.8	161.7	101.3	73.5	60.6	89.8
132.3	132.9	131.6	83.6	126.9	194.6	122.7	78.9	117.9
109.3	99.4	100.7	106.1	100.5	112.3	137.1	73.5	120
82.3	66.7	176.2	109.2	80.8	118.2	76.7	62.9	88.4
103.1	148.4	210.1	88.1	122.7	138.3	54.4	104.5	106.4
137.7	106.1	117.7	76.6	98.4	123.6	73.6	93.1	74.1
96.6	62.6	118.8	88.1	57.6	86.3	106.9	82	110.4
122.8	58.2	98.9	152.1	78.1	103.7	160.4	70.2	54.6
102.6	50.8	192.2	176.2	135.8	98.4	72.7	91.6	103.6
78.4	124.2	101.6	107.3	93.8	156.5	82.5	110	80.1
167.3	136.8	99.3	127.6	132.9	128.8	76.3	72.4	70.2
134.1	154	149.4	162.1	80.7	99.1	68.2	123.1	71.2
128.2	97.1	139.9	100.3	99.5	103.4	51.4	78	130.1
109.7	114.8	142.6	123.3	92.9	107.4	84.6	139.3	108.4
82.8	82.5	151.1	84	106.7	114.9	74.6	52.4	76.5
62.3	88.9	115.6	99.1	108.8	125.2	113.3	48.8	60.5
52.1	107.9	126.6	102.7	105.7	87.5	80.1	82.5	64.6
57.3	113.2	89.5	83.7	85.6	71.4	75.5	96.2	68.8
123.6	153.8	129.7	101.4	122	112.1	52.3	53.7	71.8
137.9	97.2	152	148.3	122.6	96.6	66.3	110.8	76.7
153.7	135.7	98.7	126.3	159.1	59.8	76.2	74.5	70.3
96.3	119.2	125.1	128.6	140.9	173.4	83.6	120.7	104.2
114.4	105.2	139.5	93.7	230	109.6	103.5	103	64.4
89.4	90.8	141.7	78.6	200.3	91.2	80.3	83.5	93.1
82.3	88.7	109.2	62.5	78.2	129.7	70.8	60.8	93.8
136.3	146.2	205.1	59.3	99	86.3	126.3	74.1	116.1
104.7	102.8	73.2	136.3	102.8	102.4	105.5	65.3	123.5
118.3	83.7	69.8	118.2	83.6	92.4	81.3	50.6	80.1
92.5	130.9	121.1	124	102.1	147.7	59.7	84.7	60.8
144.6	110.2	148.7	139.3	149.1	81.3	111.1	76.6	70.5
86.3	63.9	98.8	76.4	126.6	78.8	76.5	108.5	109.8
123.6	120.7	122.6	105.3	127.9	112.8	49.6	83.6	72.6
69.8	105.8	67	117.5	85.2	121.3	81.3	73	63.3
133.5	232.4	88.7	102.5	78.5	99.5	90.5	53.1	88.6
148.1	120.6	107.4	86.3	68.7	83.4	53.1	60	49.2
116.2	75.1	61.6	57.2	86.3	39	104.3	78.9	77.7
63.3	137.7	62.4	98.3	102.6	88.4	62.6	83.6	80.1
98.8	83.8	66.9	136.4	116.9	87.7	72.5	104.6	127.8
104.4	108	126.3	78.3	108.7	123.2	83.6	83.5	57.7
148.3	127.9	57.7	93.6	77.4	66.2	56.7	75.9	72
108.3	135.6	107.9	133.9	132.4	84	46.4	82.7	43.7
112.8	168.7	126.3	79.1	120.8	82.3	76.7	105.2	67.8
73.5	78.1	150	92.3	119	109	54.6	74.2	84.6
154.1	106.2	109	106.4	68.2	147	57.7	103.5	87.8
96.3	121.4	100.2	89.3	137	98.4	83.3	74.7	58.4
110.504	**112.042**	**120.102**	**112.178**	**112.548**	**110.66**	**81.93**	**80.844**	**83.654**

Third month sampling data for weight (W) Date: 01.09.2011

T_1 (Feed @ 6 % of bw daily)			T_2 (Feed @ 5 % of bw daily)			T_3 (Feed @ 4 % of bw daily)		
R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)
182.7	226.9	282.7	218.2	177.6	197.8	177.6	109.6	190.7
238.5	187.7	181.8	238.5	185.2	147.2	137.3	230.4	102.5
186.3	189.8	150.1	239.2	197.8	158.7	164.4	166.1	187.3
349.5	243.6	197.8	248.4	222.5	127.4	167.4	200.2	210.9
184.7	218.5	248.7	229	219.4	232.5	103.8	135.9	116.7
142.6	142.8	241	324.4	321.7	257.3	148.6	104.1	117.9
238.8	210	133.7	233.4	242.8	134	206.2	163.4	113.9
227.6	196.2	207.6	189.6	255.5	273.8	156.2	177.2	210.7
184.2	207.8	310.8	113.4	188.7	152.7	158.2	176.9	145.7
189.6	194.4	298.5	160.7	110.5	265.9	136.2	159.1	177.5
186.4	245.8	263.8	176.7	217.2	177.5	154.9	132.7	173.7
228.4	209.7	275.6	193.7	228.9	119.2	147.9	202.4	171.4
242.9	294.2	200.4	312.3	244.8	159.7	262.2	160.9	118.4
187.8	189.2	181.9	105.7	219.6	208.8	158	264.1	165.5
180.6	282.6	207.5	197.3	218.3	202.6	149.9	104.1	127.7
193.7	266.7	137.5	234.8	295.7	217.3	129	174.7	154.8
198.3	285.9	237.8	257.6	240.5	299.5	228.9	176.1	156.9
209.6	237.8	288.7	217.3	187.9	240.8	187.5	105.9	163.4
147.2	280.7	180.7	168.2	124.5	236.4	107.3	105.9	162.7
220.4	312.2	195.8	169.7	160.6	340.7	148.9	183.9	153.9
288.6	247.1	143.5	200.4	207.6	274.8	234.4	133.7	215.2
180.3	333.7	237.1	145.6	138.7	245.5	183.3	155.8	184.6
249.6	237.2	228.2	167.7	158.7	255.7	144.6	160.9	166.7
196.2	209.5	186.1	122.9	123.2	178.9	166.8	117.7	233.9
149.5	162.4	188.7	276.8	295.8	266.9	157.8	176.3	97.7
153.8	150.6	181.9	224.3	225.5	211.3	173.2	187.1	144.8
199.8	197.7	240.3	130.3	129.7	204.7	112.2	172.3	230.7
238.9	255.1	187.1	174.4	268.1	192.8	157.3	131.5	177.4
331.6	180.6	344.5	282.7	230.8	234.1	164.8	232.8	139.5
250.6	288.7	188.4	157.3	156.9	243.9	164.6	163.1	206.6
309.1	197.7	263.3	243.8	311.1	272.9	264.2	120.7	187.7
284.8	288.9	311.1	216.5	159.3	249.7	136.7	217.5	165.7
238.5	193.2	281.8	192.2	216.6	167.9	136.3	147.7	197.4
287.4	232.8	236.7	197.3	247.3	221.7	165.2	154.3	162.7
262.7	146.2	297.3	237.4	292.1	291.9	175.3	170.2	208.7
283.3	208.7	243.8	244.7	195.6	284.2	134.5	117.8	160.4
188.9	186.9	199.7	222.9	272.3	290.8	223.3	261.9	146.7
292.9	196.7	301.6	197.6	239.7	298.9	146.3	172	164.7
198.7	278.7	168.4	205.9	166.3	170.5	164.7	175.1	159.7
246.2	282.8	279.7	112.2	163.7	156.1	102.6	230.7	130.8
283.7	180.7	189.7	165.5	227.9	195.3	143.4	205.6	209.7
277.8	235.6	158.7	170.6	203.6	201.2	138.7	197.1	124.3
197.6	192.5	199.7	319.9	210.7	293.2	167.8	107.7	157.9
188.6	343.8	206.8	265.4	245	106.8	184.6	120.8	256.7
209.4	191.7	184.7	270.7	233.8	175.9	158.9	155.7	149.4
136.3	140.7	190.6	263.7	243.7	240.7	118.9	186.5	116.4
239.2	240.7	188.7	248.4	288.3	256	141.9	145.7	163.4
182.6	229.5	244.2	168.4	171.9	218.7	189.4	185.9	137.5
289.6	188.7	227.1	225.9	317.6	157.3	165.6	180.2	127.6
196.4	187.5	184.4	290.9	276.6	161.7	132.3	208.7	105.9
223.048	**224.582**	**222.124**	**211.408**	**217.556**	**217.396**	**161.6**	**166.532**	**163.052**

Fourth (final) month sampling data for weight (W) Date: 01.10.2011

T_1 (Feed @ 6 % of bw daily)			T_2 (Feed @ 5 % of bw daily)			T_3 (Feed @ 4 % of bw daily)		
R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)	W(g)
474.6	309.5	370.7	465.5	485.3	432.7	247.2	371.8	322.1
420.8	295.6	329.2	498.5	450.7	319.8	287.4	327.1	317.4
360.7	388.9	287.1	434.5	327.6	337.5	293.7	356.4	294.3
334.2	297.7	303.3	434.7	304.4	285.4	339	257.3	344.1
320.5	293.6	494.5	345	271.9	326.3	368.2	310.4	445.2
305.6	370.2	510.2	433.2	324.8	481.2	293.1	224.7	348.4
332	329.5	421.6	316.9	278.4	298.3	259.3	248.8	357.5
301.6	306.4	361.7	339.2	294.1	292.2	264.8	265.5	338.4
391.7	275.7	330.2	284.6	336.7	273.4	349.2	273.4	316.4
349.8	532.6	322.4	325	338.8	451.9	378.9	354.9	305.4
307.6	475.7	304.7	482	340.3	464.8	290.8	356.7	284.7
296.7	424.8	331.9	296.2	464.7	499.1	356.2	347.7	363.4
327.8	367.4	302.4	293.8	437.6	433.7	231.1	246.7	350.7
290.2	362.7	394.3	272.9	446.2	347.1	303.8	350.8	317
294.6	326.6	351.2	452.5	496.2	435.6	342.4	286.8	362.9
369.9	364.2	305.4	325.5	432.8	395.5	355.3	285.4	343.6
328.3	328.7	295.5	276.4	346.1	337.8	351.7	278.3	309.6
265	354.3	326.9	293.9	345.3	302.9	245.4	286.2	235.8
274.8	396.7	325.1	322.1	340.4	289.4	352.9	318.3	408.2
530	348.1	289.8	327.6	385.7	344.7	256.6	354.8	304
248.8	297.2	300.8	337.8	324.4	324.8	264.3	366.7	396.9
284	288.9	325.7	256.3	347.6	277.6	277.4	294.8	346.9
266.3	294.5	280.7	238.5	435.7	292.8	287.3	269.7	281.2
279.6	296.4	283.6	291.4	307.8	323.2	355.5	267.4	317.4
265.5	330.7	256.2	241.5	337.6	336.7	317.5	348.9	324.3
455.2	274.3	261.8	240.4	343.8	339.3	374	380.6	368.7
297.9	325.8	273.4	227.6	215.6	255.4	265.6	294.3	348.6
291.2	282.6	263.8	315.3	220.5	239.5	325.5	357.2	324.7
255.4	280.7	288.7	222.3	216.4	290.6	256.4	232.4	318.3
343.3	255.6	286.5	220.8	214.8	241.9	271.8	304.5	286.7
276.8	247.8	275.7	287.9	222.4	240.7	225	343.1	320.2
289	295.4	338.7	201.7	237.4	227.8	250.2	279.4	343.6
293.1	287.2	304	289.3	204.8	318.2	247.3	286.7	258.3
296.1	278.7	337.3	244.6	223.5	224	344.6	335.3	264.4
270.3	296.5	289.2	228.3	227.8	219.4	239.3	343.9	234.1
301.6	288.3	284.1	229	230.2	345.2	226.4	226.8	245.2
281	297.4	270.8	222.8	305.3	286.8	231.2	263.1	264.7
324.1	453.3	269.3	205.4	288.7	202.6	246.1	246.7	285.9
283.2	344.4	281.2	236.9	204.4	288.7	260.6	269.6	232.4
254.7	268.7	262.7	214.3	288.3	243.8	244.6	241.5	227.1
263.2	282.8	342.8	224.8	224.7	229.2	232.7	231.8	190.7
273	294.7	256.3	206	221.8	220.8	244.3	242.4	189.6
264.1	280.3	328	209.9	337.4	206.7	193.4	184.1	199.4
267.1	267.6	290.6	205.3	236.8	235.9	207.7	196.7	216.3
287.1	272.2	456.2	344.6	240.7	222.1	227.2	222.3	227.4
283.9	282.9	263.5	396.2	241.8	217.7	232.3	221.4	220.7
271.3	288.2	298.1	336.7	292	207.2	225.4	206.7	206.4
268	308.4	285.3	303.3	237.9	208.9	208.3	169.4	206.5
280.2	263.7	303.7	288.1	257.4	216.6	179.3	180.3	244.5
264.6	272.9	249.7	345.2	358.2	230.4	181.9	182.4	234.9
309.12	**318.94**	**315.33**	**300.644**	**309.874**	**301.276**	**276.202**	**281.842**	**295.902**