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Fish culture in indoor-tank using green water technology

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Abstract

Green water indoor tank culture (GWT) of Tilapia with carp is an appropriate method for commercially producing of Tilapia in substitutional of different water bodies likes ponds, lakes, cages and reservoirs etc. that have environmental constraints such as land use conflicts, source of water, water quality and sub optimal temperatures, where a green house could be used to control temperature with minimizing the all possible constraints. This study showed that the high densities and feeding rates can be maintained through continual aeration and solid removal. Ammonia is removed by phytoplankton uptake and through nitrification on suspended organic particles within the water column. In the GWT the treatment process maintain good quality, reduce the need for water exchange and maximize water use efficiency. Phytoplankton (chlorophyta, rdodophyta, chrysophyta, cryptophyta etc.) and other organisms (Such as, zooplankton) within the water column are grazed on by fishes (tilapia, rui, catla, and common carp), thereby recycling waste nutrients and lowering feed conversion ratios. A Green Water technology (GWT) in indoor tank system for fish culture was developed in Jessore University of Science and Technology. The green water was produced and cultured in indoor tank using plant leaves, Joba (*Hibiscus-rosa-sinensis*), then Nile tilapia, rui, catla and common carp were stocked in indoor tank systems. Regular monitoring for health check, water quality check, temperature, siphoning and oxygenation with air-stone maintained adequately in indoor environment with available sunlight penetrations. The survival rate was 100%. No artificial feed was provided from stocking to harvest. Green water tank culture of tilapia with Indian major or exotic carps indicates that GWT has potential profit due to high productivity; average 150.99 ± 0.5 gm/tilapia within 120 days and no fertilization and feeding costs, which makes green water tank culture appropriate for widespread application.

Keywords: Green water, indoor-tank, tilapia, Indian and other exotic carp.

1. Introduction

Bangladesh is rich in various culture practice of aquaculture resource that are completed by lots of river, ponds, lakes, haors, baors and so on. Aquaculture, probably the faster growing food producing sector of the world and plays an important role in the socioeconomic development of many countries in view of its potential contribution to national income, nutritional security, social objectives and sustainable large export earnings^[1, 2] showed the use of fertilizer in green water tanks enhanced algal biomass and micro-organisms, which provided the essential nutrients needed for Nile Tilapia fry growth in the ground corn treatment.

Inorganic fertilizer and other agricultural chemicals are a significant source of water pollution. The University of California, Davis, reports that cropland is responsible for 96 percent of nitrates found in rural California water supplies. These chemicals can have significant detrimental effects on the local environment, affecting wildlife populations, plant health and wide range of other indicators. In recent years, all the pollutants in aquaculture systems (various organic and inorganic contaminants, nutrient and pathogen) raise too much concern because of their capacity for complex formation and interaction^[3, 4]. Eutrophication (high concentration of nutrients), which results in hypoxia, fish kill, and destroy the desirable aquatic flora and fauna^[5]. Microorganisms are of major concern because of their ability to cause diseases in fish. Since in aquaculture system raw wastewater contains a wide variety of pathogens, the reduction of pathogen contents in aquaculture waterbodies is of high priority^[3, 6]. This GWT evaluate and improve the treatment efficiency of wastewater for significant reduction of contaminants with introduction of different chemicals and feedstuffs. GWT is an economically and environmentally preferred technology compared to aquaculture technology for fish culture^[7-11].

GWT technology produce natural food for fish, which is absolutely complete and balanced act as high protein and fat sources and promote the fish growth responses. Hence, it is necessary to increase the live food in the aquatic ecosystem to improve the growth of fish. Plankton is most essential for many fish as food. Fish consume the phytoplankton, which is found abundantly in the well managed pond^[12]. Artificial feed is very expensive. Artificial feed has a strong and specific smell that is transmitted to water and flesh of the fish. Water quality is deteriorated and water exchange is required two times per day. The farmers culture fish are middle and lower class. So, they could not use feed, fertilizer and lime at the proper time and regular basis^[13].

2. Materials and Methods

2.1 Study period and site

Jessore is the pioneer and famous for seed production and practicing aquaculture technologies in all over Bangladesh, in where developed the monoculture of tilapia, koi, shing, magur and pangas and polyculture of carps with catfish and tilapia. Most of the fish farmers stock fish in the beginning of the year and rearing throughout the year for this reasons this research was carried out from January, 2017 to July, 2017. The Department of Fisheries and Marine Bioscience (FMB), Jessore University of Science and Technology (JUST), Jessore was the appropriate site for conducting the research because major beneficiaries of fisheries resource are in the same region.

2.2 Indoor-tank preparation for Green Water Technology (GWT)

It is indispensable to prepare the tank before starting the work. Better condition of aquarium is essential for the better as well as survivability of fishes. The experiment was conducted in 05 rectangular glass aquaria (36 inch length, 14 inch width, 15 inch depth). Among them 04 for treatment (Greenwater) and one for control (pond water). Scrub the empty aquarium with water, thoroughly washed with running water. For continuous aeration air stone aerators were used in each aquarium. The aquarium were set where sunlight penetration was available and filled with tap water.

2.3 Collection of leaves

Green water culture is an extensive culture of aquatic organisms on fertilized ponds carrying a phytoplankton bloom. An innovative technique wherein greenwater was produced in tank by using *Hibiscus-rosa-sinensis* leaves. In the experiment the leaves of Hibiscus Rosa-Sinensis were used to produce phytoplankton in the tank water. The leaves of Hibiscus Rosa-Sinensis were collected from Jessore University of Science and Technology (JUST) campus.

2.4 Preparation of extract and phytoplankton production

Collecting leaves were washed and rinsed to remove dirt. The leaves (100g) were put in the blender with water (100) and blended. The blended leaves were sieved by 2.5 mm mesh size net and put the water in a bottle. The bottle was put under a bright sunlight in three days. Aquariums that placed under sunlight penetration were filled with clear water then the green water that had been set under a bright light. Different kinds of phytoplankton were bloomed within 10 days in indoor tank culture systems. The green color of water and microscopic observations of water samples indicates the production of phytoplankton in indoor tank systems that was suitable for fish culture.

2.5 Identification of phytoplankton

Phytoplankton taxa identification is based on morphological characteristics like color, shape, motility and colony structure. Because of different pigmentation phytoplankton colour range shows wide variation among divisions; such as grass green (Chlorophyta), red (Rdodophyta) or yellow brown (Chrysophyta). Moreover movement adaptations for example; flagella number position and length is different in different taxa. While some species unicellular (Cryptophyta, Euglenophyta) some others form colonies (Cyanobacteria, Chlorophyta). Ornamentation of cell skeleton is also an important characteristic for some groups like (Bacillariophyta and Dinophyta). However sometimes Utermöhl technic is not enough to visualize these features and may require high resolution microscopes.

2.6 Collection and stocking of fish

Mono-sex Nile tilapia (*Oriochromis niloticus*), Rui (*Labeo rohita*), Katla (*Catla catla*), Common carp (*Cyprinus carpio*) were collected from commercial fish farm “Lal Motsho Khamar” located at chachra, Jessore and transported by oxygenated poly bag to the Jessore University of Science and Technology. Before stocking in the tank the fishes were weight. The average weighted was 6.56g/fingerling. Fingerlings were stocked in 05 tanks. Among these 04 tanks were filled with green water and one tank that was filled with normal pond water. 20 Nile tilapia: 2 rui: 2 catla: 2 common carp were stocked in each tank for mixed culture practicing the semi-intensive technology. Fishes were observed at every morning at 10.00 am and evening at 4.30 pm. All of the fishes were surviving in all tanks in during total treatment of the research project.

2.7 Maintenance

In aquaculture, the major factors for fish production limiting production are fish nutrients, dissolved oxygen, pH, CO₂, N₂ and waste product accumulation. Air stones maintain dissolved oxygen concentrations above 4 mg/l. Nile Tilapia is omnivore and Rui, Catla and Common carp are herbivore^[14]. So, no artificial feed was applied. Fishes were live on natural feed phytoplankton, zooplankton. Greenwater has available phytoplankton that provides natural food to live fish. Air stones maintain dissolved oxygen concentrations above 4 mg/l. Nitrogenous waste products are removed by phytoplankton uptake and microbial biosynthesis, the latter being of greater importance. In the greenwater system suspended organic matter and plankton are in constant circulation, creating a suspended growth treatment process wherein Nitrifying bacteria (*Nitrosomonas* and *Nitrobacter spp.*) oxidize toxic total ammonia nitrogen (TAN) to relatively harmless nitrate (NO₃⁻) and heterotrophic bacteria proliferate. Besides, maintaining appropriate water quality for fish culture, this process also creates microbial proteins that are grazed upon and utilization for nutrition by the fish themselves^[15-17]. In this experiment, twice weekly the sludge is drained from the tank. Solid removal increase the indoor-tank culture environment and encourages continued algae and bacterial population growth, which further improves water quality.

2.8 Growth performance analysis

Nile tilapia fingerlings with similar body weight of 6.56 gm, were stocked into five tanks, with same stocking densities of each tank. During the experimental period, Average Weight Gain (AWG) and Specific Growth Rate (SGR), of stocked

fish was measured fortnightly (15 days interval) by sampling to adjust natural food quality and to observe health condition. Growth parameters such as Average Weight Gain (AWG), Specific Growth Rate (SGR), were calculated as follows Ali (2003) and Afuang (2003) [18, 19].

AWG (g/fish) = average final weight (g) – average initial weight (g)

$$SGR = \frac{(\ln \text{ final weight} - \ln \text{ initial weight})}{\text{experimental period (d)}} \times 100$$

3. Results

During the study period the phytoplankton Taxonomy and the weight of the fishes stocked in the tank were observed. Fish production in the water body is either directly or indirectly dependent on the abundance of plankton. Phytoplankton gives a green color to the water due to the presence of chlorophyll. After preparing the water within 10 days phytoplankton were blooming in the tank. When the water looks deep green color that treated phytoplankton are available in the water. It was a continuous process. The phytoplankton was produced every day and water looks deep green color.

3.1 Phytoplankton taxonomy

Phytoplankton groups can be categorized according to size and taxonomic features. Phytoplankton size range shows wide diversity. According to their size phytoplankton were grouped into four classes: picoplankton, nanoplankton, microplankton and macroplankton [20] (Table 1).

Table 1: Phytoplankton size classes (Bellinger *et al.*, 2010) [20].

Size category	Linear size (µm)
Picoplankton	0.2-2
Nanoplankton	2-20
Microplankton	20-200
Macroplankton	>200

Phytoplankton include 10 divisions according to taxonomic classification, Cyanophyta, Chlorophyta, Euglenophyta, Xanthophyta, Dinophyta, Cryptophyta, Chrysophyta, Bacillariophyta, Rhodophyta and Phaeophyta [20]. However in freshwater ecosystems only Cyanophyta, Chlorophyta, Euglenophyta, Dinophyta, Cryptophyta, Chrysophyta and Bacillariophyta, divisions were widely distributed that's why only common freshwater divisions were mentioned (Fig. 1).

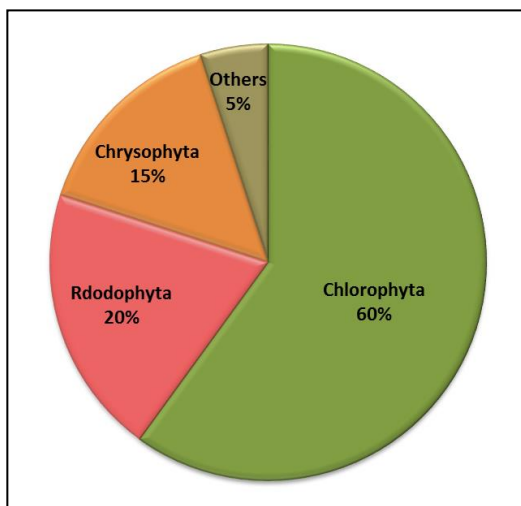


Fig 1: Percentage (%) of phytoplankton production after 10 days treatment in indoor tank.

3.2 Growth of different fish species

The average weight of the fish in all tanks was observed during the study period at fortnightly. The initial average weight of the fish were 6.56±0.5 gm. After 120 days of the study period the final average weight of the fish in the green water tank was 144.30±0.5 gm and the final average weight of the fish in the pond water tank 141.28±0.5 gm. The average final weight of fish after 120 days in the green water produced by *Hibiscus roza sinensis* leaves was better than average final weight of the fish in the pond water. Average weight gain of the fish in the green water tank after 120 days was 137.74±0.5 gm and in the pond water tank were 134.63±0.5 gm. (Table 2).

Table 2: Average weight of the fishes during study period in green water produced by *Hibiscus roza sinensis* leaves and pond water (control).

Day	Average weight (gm) of the fish in greenwater tank	Average weight (gm) of the fish in pond water tank
1 st	6.56±0.5	6.56±0.5
15 th	9.95±0.5	9.06±0.5
30 th	14.10±0.5	13.57±0.5
45 th	26.96±0.5	23.10±0.5
60 th	49.16±0.5	47.89±0.5
75 th	81.52±0.5	79.98±0.5
90 th	110.12±0.5	107.88±0.5
105 th	138.92±0.5	136.38±0.5
120 th	144.30±0.5	141.28±0.5

Among Tilapia, Rui, Catla and Common carp the growth of Tilapia is the best. The weight gain of tilapia was 150.99 gm, the weight gain of Rui was 139.585 gm, the weight gain of Catla was 139.18 gm, and the average weight gain of Common carp was 143.85 gm (Fig. 2).

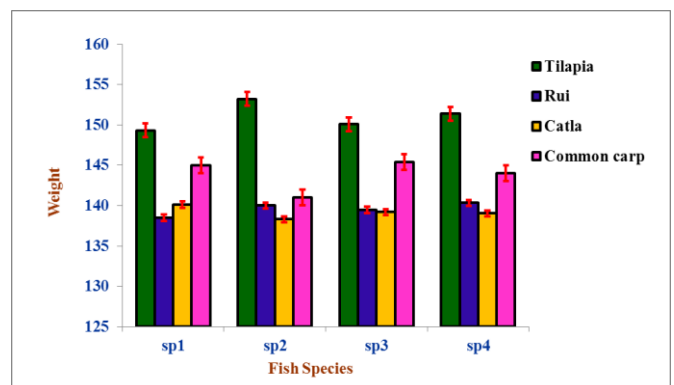


Fig 2: Weight gain of different species during the study period.

4. Discussion

A new method for phytoplankton production in the tank, identification of phytoplankton by microscope, the average growth of the fish during the study period are given in the experiment. Green water technology, GWT in this research produced different types phytoplankton using Joba leaves for certain times in the availability of sunlight penetrations without any fertilizations that enhance the growth performance of tilapia with carps over the all aquaculture techniques usually practiced in pond, lakes and reservoirs. So, in this process, the production cost of fish culture is the lowest. The production of fish is higher than traditional culture of fish.

The similar finding were also reported by [21] who showed that

use of green water improve the survival and growth rate of fish larvae, but the mechanism through which micro-algae act to generate this effect remained unclear.

Based on previous studies, Barros *et al.*, (2011) [22] showed that restricted feeding could be applied through: 1) delaying the onset of supplemental feeding to either 45-days or 75-days after stocking in fertilized ponds, which reduces the amount of feed consumed without any negative impact on the production of marketable tilapia, 2) feeding at a sub-station level of 67%, which did not reduce measurable production of marketable fish relative to fish fed at 100% satiation level and 3) feeding only on alternate days, which saved approximately half of feed cost without a significant reduction in growth, survival, or market yield of Nile tilapia in grow out ponds. But in Green Water Technology, the production cost of FaST Strain tilapia culture is low. The production of FaST Strain tilapia is higher than traditional culture of tilapia.

Soderberg RW (2006) [2] and Burford M (1997) [23] showed the use of fertilizer in green water tanks to enhance the growth of algal biomass and micro-organisms that's provided the essential nutrients for Nile tilapia fry in the ground corn treatment. Tendencia *et al.*, (2003) [15] reported that the application of feeds in pond to enhance the phytoplankton production utilizing nutrients (75%) from feeds which excreted from fish into water that's ultimately produce algal blooms and increase biological turbidity. Soderberg RW (2006) [2] told that the use of fertilizer in green water tanks enhance algal biomass and micro-organisms, which provided the essential nutrients needed for Nile tilapia fry growth in the ground corn treatment.

Turker *et al.*, (2003) [24] showed an experiment with Nile tilapia (*Oreochromis niloticus*) stocked at 26 fish/m³ and fed 32% protein feed for 24 weeks and attained a final biomass of 13.4 kg/m³, a feed conversion ratio of 1.41 and survival rate 99.3% while exchanging only 0.23% of the rearing tank volume per day. But in this experiment the phytoplankton production system remained unclear. But in this study a new method for phytoplankton production is clearly described and the survival rate of fish was 100%.

In previous study, we have seen that all used inorganic fertilizer to produce phytoplankton and used supplementary feed beside phytoplankton for better growth of fish. In this study *Hibiscus rosa sinensis* leaves were used to produce phytoplankton. The phytoplankton was clearly identified by microscope. No fertilizer and artificial or supplementary feed were used in this process. Survival rate was 100% and better growth performance showed without any artificial or supplementary feed. This process culture fish in the lowest expense. So, this is more economical than any other processes.

5. Conclusion

Green water technology (GWT) is a very easy technology for indoor-tank culture of tilapia and other herbivore fishes and this procedure is very effective to produce green water within few days. This GWT is a viable and sustainable technology and can consistently produce fish in indoor-tank without any special facilities and fertilization and feeding cost. Based on the green water production and survivability of fishes, it could be said that the farmers will be benefited because the production cost is too low and productivity is high, 150.99±0.5 gm/tilapia within 120 days. This technology would be promising and potential for future endeavor in aquaculture industry and could be done in any place where sunlight penetration is available.

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