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Growth and survival of climbing perch, *Anabas testudineus* in Nutrient Film Technique (NFT) Aquaponics System

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Abstract

The growth and survival of climbing perch, *Anabas testudineus* in a newly developed Nutrient Film Technique (NFT) aquaponics system was studied for 6 weeks. The Initial length and weight of *A. testudineus* were 5.60±0.57 cm and 3.2±0.63 g, respectively. The *Basella alba* were planted in the grow pipe of NFT aquaponics system. The Initial height and weight of *B. alba* were 10.80±1.10 cm and 9.17±1.60 g, respectively. Results revealed that there was no significant difference ($p>0.05$) in the plant growth parameters in the NFT grow pipes at the end of the 6-week experimental duration. The final average length and weight of *A. testudineus* were 9.02±0.54 cm and 14.36±2.01 g in the treatment tank and the same were 8.19±0.59 cm and 10.69±1.80 g in control tank. The survival of fish was higher (91%) in the aquaponic system compared to control (89%). RBC and haemoglobin content in blood were higher in fish reared in aquaponic system whereas fishes in control group, showed increased WBC, total plasma protein and glucose level due to the adverse environmental condition in the control. There was 34% higher growth in fishes in aquaponic tank compared to control. The Daily Weight Gain (DWG), Feed Conversion Ratio (FCR), and survival of fish grown in the aquaponic system were better than that of fishes in control tank.

Keywords: Aquaponics, Nutrient Film Technique (NFT), Climbing Perch, *Basella alba*, *Anabas testudineus,* Growth, Survival

1. Introduction

Aquaponics, the integration of Recirculatory Aquaculture System (RAS) and hydroponics (developing plants without soil) is getting overall consideration from researchers and fish culturist as a result of its high ecological and monetary advantages. In intensive aquaculture system, water gets enriched with nutrients from the fish waste and excess feed. The control of N-compounds especially ammonia is given more priority in intensive fish culture system due to its toxicity. The release of nutrient rich aquaculture wastewater into the open environment could bring about wide ecological concerns [1].

The suspended solids can be expelled by sedimentation or filtration techniques, however, expulsion of dissolved nutrients from the aquaculture effluent is a challenging task. Between 30 and 65% of feed N and up to 40% of feed P is excreted [2]. The nitrogen ammonia in the excreta could be transformed to NO_2 and finally be oxidized to NO_3 by nitrifying microbes. Nitrate is not only comparatively non-toxic to fish, but also the vital nitrogenous fertilizer for plants [3]. The light intensity, temperature, nutrient availability and growth stage influence the plant nutrient uptake. Organisms, particularly nitrifying microbes, which are required in nitrogen transformations are essential part in aquaponics. In aquaponics, the plants keep up the water quality by taking up the dissolved nutrients from the water and make water suitable for reuse. Vegetables produced as a secondary crop will increase the profit potential of the aquaponics system. The aquaponics can be considered as a piece of the natural farming since there are no pesticides and toxins used [4].

In the media bed aquaponics, anoxic condition formation and the lower oxygen level within the substrate may generate microbial metabolites which may be harmful to fish and plant growth [5]. An attempt has been made to fabricate a NFT type of aquaponics system and the system performance was studied.

The plant segment was separated from the fish raising tank so that nutrient removal ability could be assessed independently which can be used to estimate the required retention time to achieve water quality objectives. Fish and plants utilized in the present study were *Anabas testudineus* (climbing perch) and the *Basella alba* (locally known as poi sago). The *B. alba* is a creeping perennial vine and has low to medium nutrient requirements [6]. Climbing perch (*A. testudineus*) is a delicious and high-value fish species. It has accessory respiratory organs and could be farmed at high stocking density. Although investigation from engineering points of view has been carried out in the media bed and floating raft aquaponic system, few investigations have been carried out in the NFT type aquaponic system. There is no information available on the growth of *A. testudineus* in the poi sago based NFT aquaponic system. Therefore, the present study was undertaken to evaluate the growth and survival of *A. testudineus* in the NFT aquaponics system.

2. Materials and methods

The study was undertaken at ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar, India.

2.1 Aquaponic system

The aquaponics system consisted of fish culture tank, submersible water pump, trickling filter and 4 NFT grow pipes. The design of the system is given in Fig. 1. Circular Fiber Reinforced Plastic (FRP) tanks with a water holding limit of 2000 L were utilized for fish culture. The height of the FRP tank was 0.9 m. The water from the fish culture tank was pumped for 5 min in every 2 h over the tricking filter bed using a submersible water pump having the timer. The volumetric flow rate (Q_{MAX}), Head (H_{MAX}) and Wattage of the pump used were 2000 L/h, 2.5 m and 55W, respectively.

A trickling filter was developed using gravel ranging from 10 mm to 25 mm in a plastic bucket. The water from the fish tank was pumped into the filter bed. While the water pass-through the gravels in the trickling filter, the organic material present in the water was metabolised by the microorganisms attached to the medium. The outlet pipe of trickling filter was directly connected to the plant grow pipe using 1 inch PVC pipe. The Aquaponics system setup is shown in Fig. 2. Nutrient film technique (NFT) grow pipes were made using 6-inch dia PVC pipes. Four horizontally and parallel placed NFT grow pipes each having length of 3 m and 9 perforations (3-inch diameter each) for holding net pots of 3-inch size were employed for growing plants. The NFT grow pipes were connected using 6 inch 'L' joint. The water coming out of the trickling filter entered into the first NFT grow pipe and passed through all the NFT pipes and return to the fish culture tank through a 1 inch PVC pipe connected at outlet provided in the fourth NFT pipe. A Slope of 1cm was allowed in the NFT pipes for gravitational flow of water.

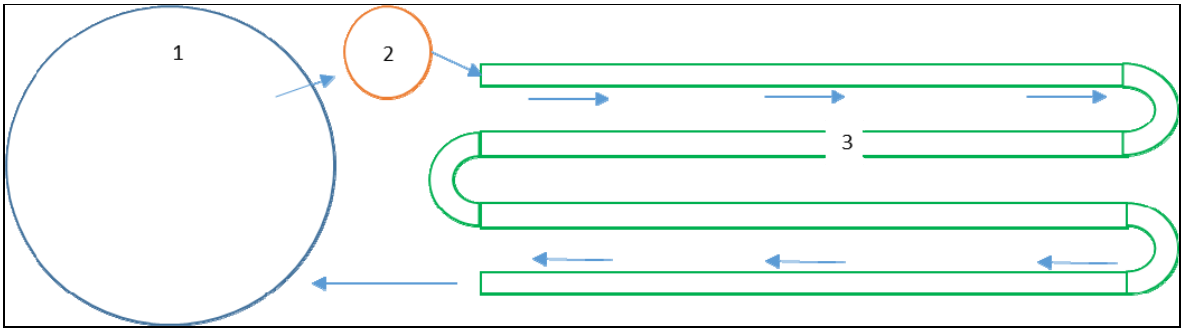

Fig 1: Schematic diagram of the experimental aquaponics system. 1. Fish tanks 2. Trickling filter 3. NFT grow pipes

Fig 2: The Aquaponics system setup. A. Fish tank and trickling filter B. NFT grow pipes

2.2. Fish and plant

The climbing perch, *A. testudineus* was stocked at the density of 75 per m^2 in the control and treatment tank each having the water volume of 2000 L. The initial length and weight of *A. testudineus* were 5.60±0.57 cm and 3.2±0.63 g, respectively. Floating fish feed with 30 % protein was fed twice a day to the fish at 6 % of the body weight. The *B.alba* (Fig. 3.) were planted in the aquaponics system. The initial height and weight of poi sago were 10.80±1.10 cm and 9.17±1.60 g, respectively. The measurements of length and wet weight of the plants were taken for studying the growth of the plant.

Fig 3: The *B. alba* planted in NFT grow pipes

2.3. Water quality monitoring and fish sampling

Samples of water for physico-chemical parameters from the tanks were collected at weekly intervals. Fish sampling was done at initial and end of the experiment for total length and weight.

2.4. Haematological analysis

Blood samples were collected from caudal peduncle of the fish from experimental tanks using 2 ml syringe with a 22-gauge needle. Ethylene diamine tetra acetic acid (2.7%) was used as an anticoagulant. The collected blood samples were immediately brought to the laboratory for haematological analysis. RBC and WBC counts were determined using improved Neubauer haemocytometer [7]. Sahli's haemoglobinometer was used to evaluate haemoglobin (Hb) percentage. Blood was centrifuged at 3000 rpm for 10 min at 4°C and plasma was separated and stored at -20°C for further biochemical analysis. Total plasma protein was estimated according to the method described by Lowry *et al* [8] and the amount of protein is expressed as g/dL. The blood glucose was determined by GOD/POD method using commercial kit (Diatek, India) and the amount of glucose is expressed as mg/dL[9].

2.5. Statistical analysis

The Duncan's Multiple Range Test was performed at to determine the significant difference in the height and wet weight of plant between the NFT grow pipes. The statistical analysis was performed using SAS v 9.2.

3. Results and Discussion

3.1. Growth of plant

In 6 weeks, the *B. alba* (Fig. 4.) was grown to 33.44±3.57cm, 34.89±3.69cm, 35.11±2.2cm and 34.33±3.81cm in the NFT grow pipe I, II, III and IV, respectively. Going through the data in Tables 1, it is clear that there was an even growth of plants in NFT Pipe I, II, III& IV.

Table 1: Height and wet weight of plants in NFT grow Pipes

	NFT grow pipe I	NFT grow pipe II	NFT grow pipe III	NFT grow pipe IV
Height of plant	33.44±3.57^{a}	34.89±3.69^{a}	35.11±2.2^{a}	34.33±3.81^{a}
Wet weight plant	79.33±2.92^{a}	80.78±2.59^{a}	80.44±2.79^{a}	80.89±3.41^{a}

Data are expressed as mean ± standard deviation

Values with the same superscript letters in the row are not significantly different (P>0. 05)

Fig 4: Growth of B. *alba* planted in NFT grow pipes

In normal cultivation, the young shoots of poi sago are harvested with a sharp knife from 4 to 6 weeks after sowing. The harvest of the apical 15-30 cm stem of *B. alba* can be made weekly as long as vigorous growth continues [10]. The growth of the plant in the aquaponics system was at par with the terrestrial growth. In aquaponics system nutrient availability, planting time and plant spacing can influence final yield. Statistically, there was no significant difference (P>0.05) in the plant growth parameters in the NFT grow pipes which indicate water passage of 12 m in the NFT grow pipe and pumping time of 5 min in every 2 hours provide sufficient nutrient for all the plants in the NFT grow pipes.

3.2. Growth of fish

The final average length and weight of *A. testudineus* were 9.02±0.54 cm and 14.36±2.01 g in the treatment tank and in control tank it was 8.19±0.59 cm and 10.69±1.80 g. The growth and survival of *A. testudineus* in the Aquaponic System were presented in the Table 2

Table 2: Growth and survival of *A. testudineus* in the Aquaponic System

	Aquaponic Tank	Control Tank
Initial weight (g)	3.2±0.63	3.2±0.63
Final weight (g)	14.36±2.01	10.69±1.80
Weight gain (g per day)	0.27	0.18
FCR	1.4	2.2
Survival (%)	91	89

Data are expressed as mean ± standard deviation

The average daily weight gain (DWG) was 0.2g and 0.3g in control and treatment tank respectively. According to Phuong *et al* [11] the DWG of climbing perch in the trial study was 0.22 g day-1 when using pellets diet with 30% of protein. The feed conversion ratio (FCR) was 1.4 and 2.2 in the aquaponic system and control tank respectively. The survival of fish was higher (91%) in the aquaponic system compared to control (89%). Tuan *et al* [12] reported that the survival rate of fish nursed in hapas was higher than that in ponds. Long *et al* [13] found that the survival rate of climbing perch nursed in earthen ponds ranged from 3.7 to 15.6%. The growth rate, FCR, DWG and survival of fish grown in aquaponics system were better than that of *A. testudineus* grown in control. From this, it is clear that the controlled environment like in aquaponics is more suitable for rearing species like climbing perch for higher growth and survival.

3.3. Nutrient dynamics

The estimated total ammonia nitrogen (TAN) concentrations did not exceed 0.40 mg/L in aquaponics system compared to control in which the TAN reached the maximum of 2 mg/L during the experimental duration (Fig. 5.), indicating quick and efficient nitrification by the filter. The pH levels gradually declined in the aquaponics system over the period of study.

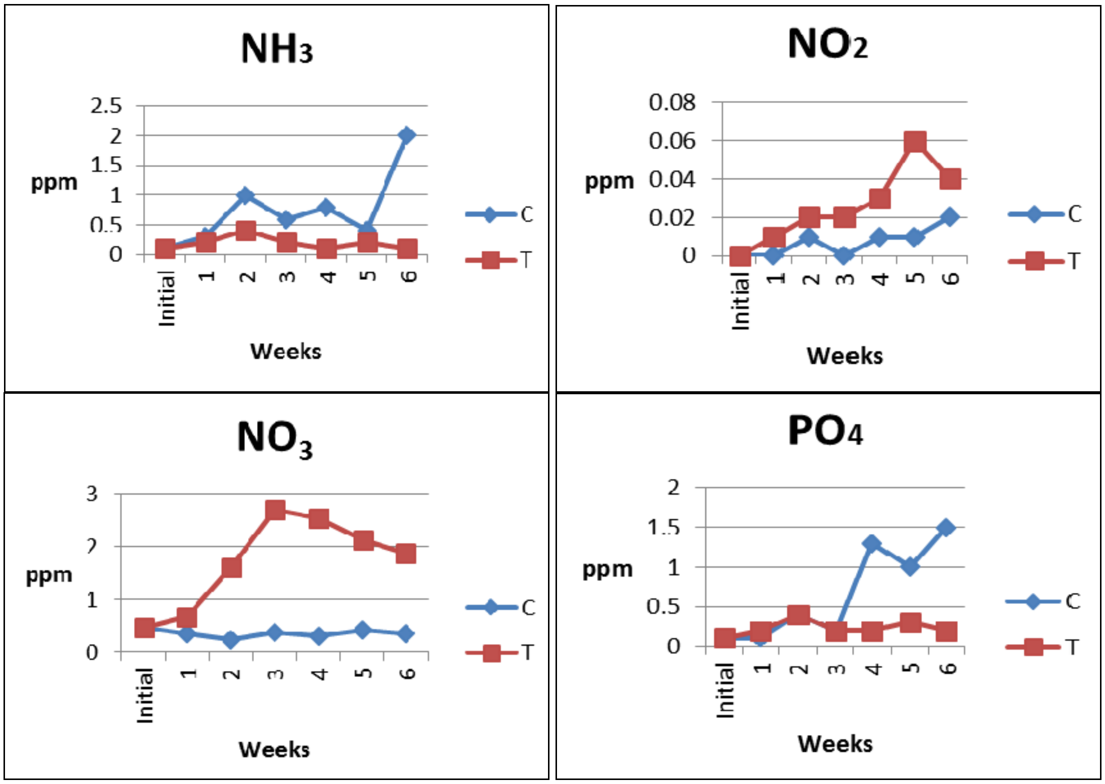

Fig 5: TAN (a), NO_2^{-}-N (b) and NO_3^{-}-N (c) and PO_4 concentration variation during the experimental duration.

The improved environmental conditions in the aquaponics system may be because of the lower levels of toxic ammonia and higher levels of NO_2 and NO_3 due to the action of ammonia-oxidizing bacteria (AOB) and nitrite oxidizing bacteria (NOB) present in the filter media of the aquaponics system. The improved environmental conditions inturn might have increased the growth rate of fish. In land based agriculture system, the major portion of irrigation water percolates into the soil. In the aquaponics system, relatively little water is used and only losses are as a result of evapotranspiration.

3.4 Haematological and biochemical changes

Haematological indexes are an important tool for the evaluation of fish physiological status. Haematological (RBC, WBC and Haemoglobin) and biochemical (total protein and glucose) values are presented in table 3.

Table 3: Haematological and biochemical parameters

	RBC (10^6cells/mm^3)	WBC (10^3cells/mm^3)	Haemoglobin (g/dL)	Total protein (g/dL)	Glucose (mg/dL)
Control	2.17	6.2	7.46	4.39	63.73
aquaponics	2.26	5.4	8.92	3.68	58.64

Changes in the haematological and biochemical parameters in the fish depend on the species, age, age at sexual maturity and health condition [14,15,16] and these parameters are closely related to surrounding environmental factors. Recently, blood biochemical parameters also got great attention as indexes of the physiological state of the internal milieu [17]. Therefore, both haematological and biochemical analysis of blood could be a useful tool for monitoring and assessing the physiological status and health condition of fish [18]. In the present study, the increased RBC (2.26×10^6cells/mm^3), haemoglobin content (8.92 g/dL) and decreased WBC (5.4×10^3cells/mm^3), total protein (3.68 g/dL) and glucose (58.64 g/dL) were found in fish reared in the aquaponic system in comparison to the control group may be attributed by the effect of better water quality parameters on the haemopoietic tissue. In control group, fishes showed increased WBC, total plasma protein and glucose level, which may be due to stress imposed by the various adverse water quality parameters especially higher level of ammonia. Thangam *et al* [19] reported that RBC count and haemoglobin found to be decreased in *Cyprinus carpio* exposed to sublethal concentration of ammonia for 35 days. Changes in WBC in response to stress have been reported in many fishes. An increase in WBC in *Oreochromis mossambicus* has been reported by Nussey *et al* [20], whereas a reduction has been reported in common carp under stress by Svobodova *et al* [21]. Shin *et al* [22] reported that the RBC count, haemoglobin and total protein were notably decreased and plasma glucose was substantially increased in rockfish, *Sebastes schlegelii*, exposed ammonia toxicity. Therefore, high concentrations of ammonia decrease survival, inhibit growth, and cause a variety of physiological dysfunctions and act as a stressor in the fish.

4. Conclusion

The newly designed NFT aquaponics system was working well for the plant and fish species studied. Statistically, there was no significant difference ($p>0.05$) in the plant growth parameters in the NFT grow pipes which indicate water passage of 12 m in the NFT grow pipe and pumping time of 5 min in every 2 hours provide sufficient nutrient for all the plants in the NFT grow pipes. The DWG, FCR, and survival of fish grown in the aquaponic system were better than that of fishes grown in control. The higher growth (34%) in fishes in aquaponics tank compared to control indicate the advantages of using aquaponics system over conventional system.

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