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AQUAPONIC FISH PRODUCTION TRIAL IN THE WARM WATER FISHERY FARM

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Abstract: The trial was initiated to establish baseline on aquaponics fish production and to transfer the technology to farmer's field following the study trial success. A total of 340 numbers, 220 numbers of Common Carp (*Cyprinus carpio*) and 120 numbers of Grass Carp *(Ctenopharyngodon idella*) were randomly selected as experimental fish along with onion for this trial. The growth performances of fish of four tanks (Treatment (T2), Treatment (T3), and Treatment (T4) & Treatment (T5) were recorded monthly through sampling 30 fish (each species) from each treatment tank. The feeding at the rate of 2% of the body weight of the fish were followed during the trail. Data gathered were analysed for descriptive statistics using SPSS. The initial weight and length of *C. carpio* and *C. idella* were 7.43g, & 7.55 cm and 4.81g, & 6.94cm respectively. The final average weight gained and length of *C. carpio* and *C. idella* were 11.83 g, & 9.5 cm and 9.86 g & 8.6 cm respectively. The *C. carpio* has revealed the highest survival rate of 62% and *C. idella* at about 36%. Although, there was no significant difference in performances of both fish species in all tank. The highest average weight and length of leaves (onion) of 189.55g & 38cm was recorded in Tank (T2) where the stocking density of common carp was 100 fish/tank, whereas the lowest 59.7g & 26 cm were found in treatment (T1) where there is no fish in the tank. However, the yield of plant was double the times higher in new technology aquaponics. Nevertheless, aquaponics can be a promising opportunity to reconceptualise the traditional fish farming, to fetch in more money from both fish and plant simultaneously at the farm.

Keywords: Aquaponics; feeding rate; length; weight; technology

1. INTRODUCTION

Globally, aquaculture and fisheries play a crucial role in the economic development of a nation. In Bhutan, aquaculture and community fisheries programs contribute towards national food security and socio-economic development of the rural communities (National Research Centre for Riverine and Lake Fisheries [NCR&LF] 2020). Fish and fish products plays a vital role in the healthy diet of the people of Bhutan and constitutes an important component in the Bhutanese diet.

Following growing demands for fish in the mid-1970s, Bhutan initiated aquaculture development through import of a few species of carps from India. The National Research and Development Centre for Aquaculture (NRDCA) has ever since spearheaded warm water aquaculture development programs in the country. However, despite the auspicious beginning and appreciable progress made in aquaculture, production still remains far from meeting domestic demands. Continued trends of increasing fish import to make up for the demand-supply gap will inevitably result in more cash outflow thereby draining the national economy. Thus, in order to achieve self-sufficiency and economic stability, domestic fish production must increase at a rate that is concomitant to that of consumption. Existing aquaculture farms will therefore need to be strengthened and expanded to increase production. However, one constraint with expansion of aquaculture in Bhutan, is the limited available land and water resources. Which is why, it is crucial that fish production efforts must now also explore other technologies that optimise land and water usage. Aquaponics is one such technology that can be developed in areas with limited suitable land and water resources.

Aquaponics is an innovative technology that integrates traditional aquaculture and hydroponics to grow both fish and crops in a single integrated system (Salam et al. 2014). Water from the aquaculture unit is recirculated through biological filters and plant bed thereby making optimal use of water. Aquaponics relies on the feed that is introduced for fish, which then works as the system's input. As this feed is consumed, digested and excreted by the fish in the form of urea and uric acid, both rich in ammonia. The ammonia rich water along with un-eaten feed and decaying plant matter is transferred into a biofilter containing bacteria that convert ammonia into nutrients. In doing so, plants get the much-needed nutrient while purifying the water to be reused by the aquaculture unit. Some notable benefits of aquaponics are: intensive production of two agricultural products (fish and crops), water efficient, requires less soil, does not use fertilizers or chemical pesticides, higher yields, uses non-arable land, and reduced waste and affluents.

Given the multi-folded benefits of aquaponics and the current constraints with expansion of aquaculture in Bhutan, adoption of aquaponics technology as prove to be a viable option (Panigrahi et al. 2016). Moreover, aquaponics can provide livelihood strategies to secure food and incomes opportunities for landless and low-income groups. In order to establish a proof of concept, a pilot trial is necessary. An experimental trial was carried out at the NRDCA, Gelephu setting up an aquaponics unit infrastructure. Results from the study would lay the foundational baseline of production parameters as well as serve as a guide for standardizing aquaponics technology in Bhutan.

2. MATERIALS AND METHODS

2.1 Study area

The study was carried out at NRDCA in Gelephu, Bhutan for a period of six months from August (2018) to January (2019). The centre lies between 26°51.790' N and 90°31.961' E, and located at an altitude of 300 m (984.25 ft.) above sea level (NSB 2016). The region experiences warm and wet summer and cold and dry winter. The total average annual rainfall is 5930.3 mm (WCSD 2017).

2.2 Design of aquaponics system

A mini aquaponics system was setup for demonstrating aquaponics principles and the nitrification cycle in a re-circulating aquatic environment. Following the design by Lennard (2004), a basic component and layout was constructed (Figure 1).

The setup consisted of: five numbers of cemented fish tanks/grow bed measuring (L x B x H: 6.4 x 2.09 x 0.5 inches) and three filter tanks (L x B x H: 6.48 x 2.43 x 0.5 inches), a 2000 kg gravel (size:1/8") and a 1500 kg sand filled filter tank, two sets of water pump (each 0.5 Hp) were connected with the flow rate at 900L per 30 minutes. Bamboo rafts with 50-60 holes (each 3–8 inches deep) were placed on the top of fish tanks for plants to grow.

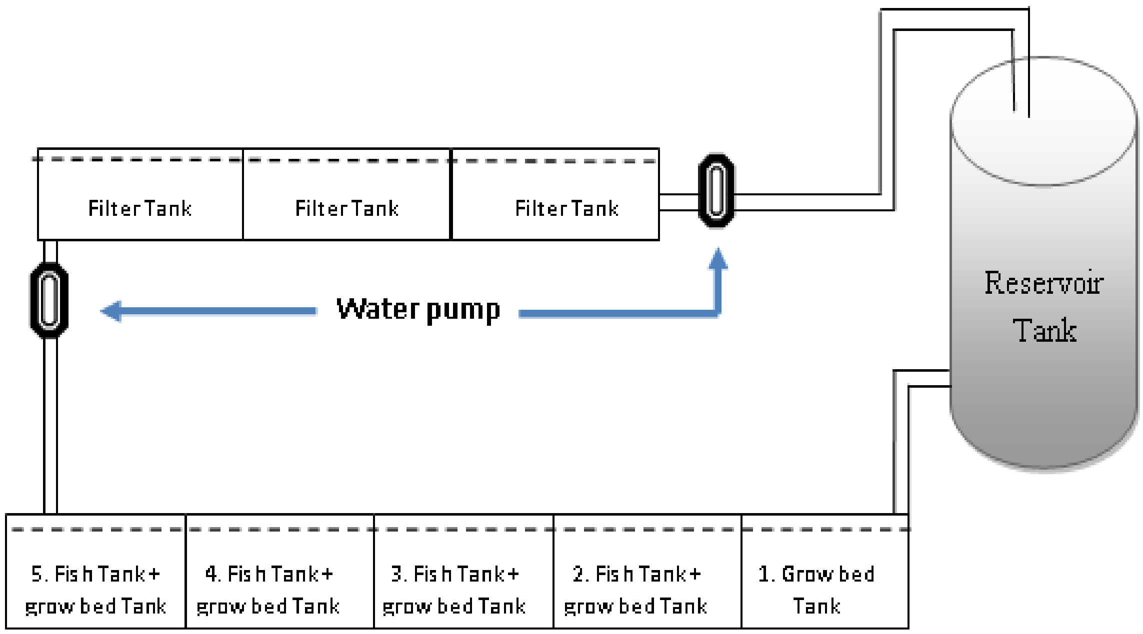

Figure 1: Layout and Design of Mini Aquaponics System

2.3 Selection of fish species and plant

A total of 340 stunted fingerlings (*Ctenopharyngodon Idella:* 220 and *Cyprinus carpio*: 120) were stocked in a different stocking density for the experiment. The initial weight and length of *Cyprinus carpio* and *Ctenopharyngodon idella* were 7.43g, 7.55cm and 4.81g, 6.94cm respectively. Treatment 2 received 100 numbers of *C. carpio* whereas equal numbers of both fish species of 45, 40 and 35 were stocked into Treatment 3, Treatment 4 and Treatment 5 respectively with varying stocking density. Treatment 1 comprised only onion bulbs in plant grow out tanks and no fish in the fish culture tanks. Following a series of literature review and climatic conditions, onion bulbs were selected as the candidate plant for the study. 50 numbers of onion bulbs were planted in T1 and 60 numbers of onion bulbs in other four tanks (T2, T3, T4 & T5). The animals were selected using simple random sampling.

2.4 Feeding schedule

Fish were fed with two types of feeds (60% Mustard oil Cake and 40% of Rice bran). Feeding was done at the rate of 2% of the body weight.

2.5 Data collection, recording and analysis

Data was collected every month for period of six months (August, 2018 to January, 2019). Specifically, weight and total length of fish were measured using an electronic weighing scale and length measuring board. 30 fish were sampled each time. Data was analysed using the Statistical Package for Social Sciences (SPSS) version 23.0. Descriptive statistics was used to determine mean and standard deviation of body weight and length. Microsoft Excel program was used to generate graphs and tables.

2. RESULTS AND DISCUSSION

3.1 Water quality parameters

Water quality parameters such as temperature, dissolved oxygen (DO), and pH were examined and recorded three times a day (i.e., 9 am, 12.30 pm & 4.30 pm). DO, temperature and pH were measured using a digital handheld DO and pH-meter that was calibrated during each and every reading. Water transparency and water colour were also observed and recorded during the entire culture period. These data were collected on Mondays, Wednesdays, and Fridays, and processed in a Microsoft Excel to generate visualization using relevant analysis

Water parameters including temperature, pH and DO were measured in each and every treatment. There were no significant differences ($p>.05$) among the water quality parameters in all the treatments. Mean water parameters for each month of the culture period (180 days). The average daily DO, pH and water temperatures were 6.02±1.65 ppm, 8.01±0.34 and 23.7±3.81ºC recorded respectively. In accordance to DeLong et al. (2009) the optimum DO level recommended to maintain is 5-8 ppm in aquaponics systems. DO range recorded during this study was within the above recommended range which is acceptable threshold.

Boyd (1998) reported that fish need a pH range of 7- 9 to exhibit the best growth performance, whereas, Sallenave (2016) recommended maintaining pH at 6.8 to 7.0 for the optimum growth of three components of an aquaponics system (fish, plants and nitrifying bacteria). The recommended temperature range is 18–30 °C which should be managed out based on the target fish, and plant species cultivated; bacteria can also

Table 1: Feeding schedule for Aquaponics research tanks

Treatment	Stunted fingerlings (No)		Total Biomass (g)		Feeding Rate (2%)		Feed Provided (g)		Total Qty (g)
	C. carpio	*C. idella*	*C. carpio*	*C. idella*	*C. carpio*	*C. idella*	MoC 60%	RB 40%	
T 2	100		743.4		14.87		8.92	5.95	14.87
T 3	45	45	334.5	216.36	6.69	4.33	6.61	4.41	11.02
T 4	40	40	297.36	192.32	5.95	3.85	5.88	3.93	9.81
T 5	35	35	260.19	168.28	5.2	3.37	5.14	3.43	8.57

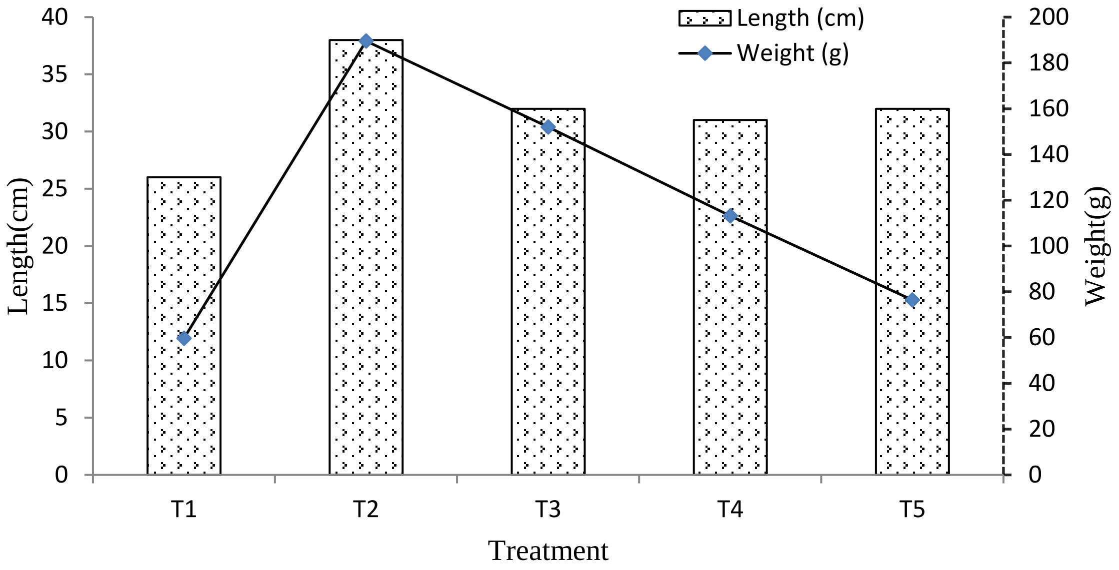

Figure 2: Average weight and length of onion leaves

thrive throughout this range (Somerville et al. 2014).

3.2 Performance of plants

Variable such as fresh weight (g), total length (cm) and total number of leaves per plant were measured and recorded. The leaves were harvested fortnightly by cutting and the plant weight and length were weighed and measured. The germination of roots was observed within 24 hours and leaves germinated after 3 to 5 days of planting in all the treatments. On 180 days culture period, leaves were harvested three times per batch and replanted every month.

The highest average weight of 189.55g and length of 38cm was recorded in T2 where the stocking density of *C. carpio* was 100 fish/tank, whereas the lowest weight of 59.7g and length of 26 cm were found in T1 where there is no fish in the tank. The T1 has the lowest weight and length of onions (59.7g & 26cm) may be due to availability of less nutrient in water following series of water supply system from T1 to T5, which is aquaponics model oriented for this study. (Figure 2).

3.3 Growth performance of fish

The total weight (g) and total length (cm) of *C. carpio* and *C. idella* were measured and recorded monthly. The initial weight and length of *C. carpio* was 7.43g, and 7.55 cm whereas, 4.81g initial weight and 6.94cm length *C. idella* were stocked. The final highest weight and length of *C. carpio* was 11.83 g and 9.5 cm. Similarly, *C. idella* exhibited highest weight of 9.86g, and longest length of 8.6 cm. The survival rate recorded was 62% for *C. carpio* and 36% *C. Idella* revealing the robustness and compatibility traits of *C. carpio* in this aquaponics model.

4. CONCLUSIONS & RECOMMENDATION

The trial was carried out to compare the growth of two species namely *Cyprinus carpio* and *Ctenopharyngodon idella* (weight and length) in different fish tanks. Additionally, the trial also aimed to develop a basic aquaponics setup trial infrastructure at NRDCA. There was no significant difference ($p > .05$) in weight gain in both fish species. Although, no conclusive results were generated, the study still offers a proof of concept that aquaponics technology can be developed and standardized in Bhutan. Our study did not find any significant growth in fish, which could be due to imbalance in the aquaponics ecosystem (balancing biomass in fish, plants and bacteria). Future studies should focus on selection of appropriate candidate species of plants and fish and at the same time maintaining a proper balance in the aquaponic ecosystem. With adequate calibration and standardization, aquaponics technology still represents a viable alternative for increasing fish production in the country. The trial duration was short to carry out the detailed study which was not adequate to capture efficiency and effectiveness of promising aquaculture technology. Therefore, further in-depth and comprehensive research for a longer duration with more fish populations may be recommended with proper data recording to defer rearing mortality during trial period.

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