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Utilization of unused Nutrients in an aquaculture Production System

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Abstract: Morning glory (*Ipomoea reptans*) and taro (*Colocasia esculenta*) were produced in a recirculating aquaculture system of mono-sex GIFT tilapia (GIFT, *Oreochromis niloticus*, L.) for a period of 15 weeks. Tilapia fry of uniform size of 0.76 g were released in three treatments (stocking densities): 106fish/m^3 (T_1), 142fish/m^3 (T_2) and 177fish/m^3 (T_3) to assess the effect of stocking density on the production of vegetables. Fish were fed with commercial feed containing 25% protein. The production of morning glory in different treatments ranged between 2642.53 to 2782.11g and the average production was 2500 g/m^2. The production of taro in the three treatments varied from 1913.52 to 1979.85g and the average production was 1800 g/m^2. Stocking density of fish had no significant influence on the production of morning glory and taro. In order to utilize the remaining nutrients, amaranth (*Amaranthus cannabinus*) was produced using a mixture of normal soil and sun-dried bottom sediment at a ratio of 5:1. A control system was maintained to compare the production performance. The germination rate and production of amaranth was significantly different in the two treatments. Production of amaranth with the mixture of normal soil and bottom sediment was 36.36 times higher than the production with normal soil. The result indicated the nutrient richness and fertility of the bottom sediment.

Keywords: Recirculating aquaculture system, mono-sex GIFT tilapia, morning glory, taro, amaranth

1. INTRODUCTION

With the rapid advancement of aquaculture production, the use of aqua feeds has increased tremendously. Of the total amount of feed applied not all of it is utilized. A substantial portion remains uneaten which is one of the principal causes of pollution in aquaculture practices. Uneaten feed and partially digested feed or faecal matter pollute the aquatic environment by loading excess amounts of phosphates, nitrogenous compounds and other additives which have been incorporated into the feed(s). The unused nutrients derived from aquaculture effluents may be used for plant production through integration. The nutrients in water may be utilized by aquatic vegetation that has economic value. The nutrient rich sediment at the bottom of production unit may be used as fertilizer. Recirculating aquaculture system may be ideal in this aspect. Recirculating aquaculture systems are designed to raise large quantities of fish in relatively small volumes of water by treating the water and then reusing it (Rakocy *et al*., 1992). In the process of reusing of water many times, non-toxic nutrients and organic matter accumulate. These materials then may be used for the production of secondary crops such as vegetables. Common, cheap, and popular vegetables such as Morning glory (*Ipomoea reptans L.*), Taro (*Colocasia esculenta*) and Amaranth (*Amaranthus cannabinus*) were used in the present experiment.

2. MATERIALS AND METHODS

Site and Duration of Experiment

The experiment was carried out in an existing recirculating aquaculture system located at the northern side of the Faculty building of Fisheries, Bangladesh Agricultural University, Mymensingh. The duration of the experiment was 15 weeks from 29th April to 9th August, 2009.

Collection and Acclimatization of Fish

Fry of mono-sex GIFT tilapia (*Oreochromis niloticus*, L.) belonging to the same age group were collected from Reliance Aquafarms, Boilor, Trishal, Mymensingh. The fry were acclimatized for seven days prior to the experiment.

Layout of the System

The system consisted of 12 equal sized cisterns and 2 smaller ones. Each cistern had inlet and outlet facilities connected to the bio-filter system which was located along the east and south sides of the system. The substrates of the bio-filter consisted of styrofoam, gravels, PVC nets and shells of mussels. The pump house was located at the south-eastern side of the system. The pumping unit consisted of two water pumps which ran alternatively for six hours to ensure continuous water flow and aeration.

Nine cisterns of uniform size were selected for conducting the experiment. The cisterns had a length, width and depth of 2.06 m, 1.8 m and 0.94 m respectively. So each cistern had an area of 3.708 m^2 and a volume of 3.486 m^3. Water level in the cisterns was adjusted at a depth of 0.76 m to maintain the water volume of 2.82 m^3. The desired level of water in the system was maintained by continuous recirculation of water at a rate of 15 l/min. In each cistern, water level

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was controlled by a PVC pipe placed at the opening of the outlet located at the middle of the cistern. The pipe was covered by a larger pipe (in terms of diameter and height) with four notches at the bottom which facilitated easy removal of waste materials from the cisterns. Water loss from the cisterns due to evaporation was adjusted every week by adding groundwater.

System Preparation

The cemented cisterns were cleaned thoroughly with washing powder and washed with freshwater. After complete drying they were filled with groundwater upto a level of 0.76 m which was maintained throughout the experiment. Polyester net was placed over each cistern to prevent fish from predatory birds.

Preparation of Planting Pot and Media

Fifty four 5 l soybean oil containers were collected. The top of the containers were cut off. They were cut in the sides in rectangular shapes (2 cm × 8 cm) and holes were made at the center of their bottoms to facilitate root growth and inflow of nutrients. Three quarters of the containers were filled with decomposed water hyacinths and a thin layer of soil was placed on top of the water hyacinths to stabilize the plant seeds and stolons when planted. Six containers were then placed in each cistern. They were then half suspended into the water by hanging them from the cistern walls.

Design of Experiment

The experiment was conducted in nine cisterns with three treatments designated as T_1, T_2 and T_3. Each treatment had three replications. The cisterns were selected randomly and numbered as C_1, C_2, C_3, C_4, C_5, C_6, C_7, C_8 and C_9. C_1, C_5 and C_8 were used for T_1, C_3, C_9 and C_7 for T_2 and C_2, C_4 and C_6 for T_3.

Stocking of Fish

Mono-sex GIFT tilapia fry of uniform size (0.76 g) were stocked in three stocking densities: 106 fish/m^3, 142 fish/m^3 and 177 fish/m^3 which were designated as T_1, T_2 and T_3 respectively.

Feeding of Fish

Fish were supplied with commercial feed made by Quality Feeds Limited. They were first supplied with starter feed for ten days, then nursery feed for twenty days and finally grower feed for rest of the days. The feed contained 25% protein. At the beginning of the experiment feed was applied daily at a rate of 15% of body weight which was gradually reduced to 6% of body weight towards the end of the experiment. Feed was supplied three times a day, one-third at 9.00 AM, one-third at 1.00 PM and the rest at 5.00 PM.

Plantation

After one week of fry release, vegetables were introduced to the system. There were six containers in each cistern, three for taro and three for morning glory. Ten seeds of morning glory were sewed in each container, the seedlings were placed into the holes evenly spaced 3-4 cm apart and planted with two seeds per hole. Stolons of taro were planted, one in a container.

Sampling of Fish

Sampling of fish was done by randomly selecting ten fish from each cistern. Fish were caught by a big scoop net. The weight of fish was recorded in grams by a sensitive electronic balance. The health condition of fish was visually examined. Sampling was done at 7 days interval at the beginning of the experiment and at 15 days interval towards the end of the experiment to adjust the feeding rate.

Water Quality Monitoring

The water quality parameters observed were water temperature (°C), dissolved oxygen (mg/l), pH, alkalinity (mg/l) nitrite-nitrogen (mg/l) and nitrate-nitrogen (mg/l). Water temperature was measured every day. Dissolved oxygen and pH were recorded at 15 days interval. Nitrite-nitrogen, nitrate-nitrogen and alkalinity were recorded at the beginning, middle and end of the experiment. The number of observations was limited due to economic deficiency.

Water temperature was taken by an alcohol thermometer. Dissolved oxygen of water was measured by a dissolved oxygen meter (YSI MODEL-58, USA). Water pH was recorded with the help of a pH meter (Mettler Toledo MP 230). Total alkalinity of water samples was determined by acid titration method (APHA, 1992). Nitrite-nitrogen and nitrate-nitrogen (mg/l) were measured in the Water Quality and Pond Dynamics Laboratory, Faculty of fisheries, BAU using a portable datalogging spectrophotometer HACH DR/2010, USA. Water samples were collected in small plastic bottles from the experimental cisterns on the sampling days.

Harvesting of Plants

Morning glory was harvested at regular intervals when they reached marketable size. The weight of harvested plants from each cistern was taken in grams by an electronic balance. Kachur loti was collected regularly and weighed. The main stems and corms were harvested at the end of the experiment and the weights were recorded. The planting media were weeded regularly and the weight of the weeds was recorded.

Production of Vegetables Using Bottom Sediment of Recirculating System

Soybean oil containers (5 l capacity) were collected, their top portions were cut off and made holes at the bottom. Amaranth (*Amaranthus cannabinus*) was grown in them. Two treatments were applied, each having four replicates. Four containers were filled with normal soil and designated as TI. Four were filled with a mixture of normal soil and sun-dried bottom sediment of the system (at a ratio of 5:1) and designated as TII. The containers were placed on the walls of the cisterns, not in the water. Twenty seeds of amaranth were sewed in each container. After fifteen days, their germination rate was observed. The plants were thinned leaving only two plants in each container, the weight of the harvested plants were recorded in grams. Final harvest was done after one month and the weights were recorded

Data Analysis

The data obtained on the production of morning glory, taro and amaranth was statistically analyzed to see whether the influence of different treatments (stocking densities) on production was significant or not. One way analysis of variance (ANOVA) was done with the help of SPSS (Statistical Package for the Social Sciences).

3. RESULTS AND DISCUSSION

Water Quality Parameters

The ranges of water quality parameters such as temperature, dissolved oxygen, pH, alkalinity, nitrite-nitrogen, and nitrate-nitrogen during the experiment are shown in **(Table 1).**

Table 1. Summary of water quality parameters during the experiment

Parameters	Value range
Water Temperature (°C)	28-33
Dissolved oxygen (mg/l)	6.2-8.5
pH	8.07-8.53
Alkalinity (mg/l)	40-78
Nitrite-Nitrogen (mg/l)	0.01-0.50
Nitrate-Nitrogen (mg/l)	0.03-1.16

The water quality parameters like temperature, dissolved oxygen, pH, alkalinity, nitrite-nitrogen and nitrate-nitrogen were within the suitable ranges for recirculating aquaculture system as described by (Drennan and Malone 1992, Masser *et al.* 1999) Rashid 2008 and Swann (2009).

Production of Morning Glory and Taro

Germination rate of morning glory was 70-80%. During the germination period the plants grew rapidly and uniformly and appeared healthy with green colour. After the germination period the plants continued to grow rapidly and showed no signs of nutrient deficiency during the growing period. At the end of the growth period, the plants reached the marketable size at an average height of 35-45 cm. The plants were cut leaving the lower part of the stem from which plants grew again. Thus three harvests of morning glory were made during the experimental period. The overall average production of morning glory from the system was 0.25 kg/m^2.

Taro grew from every stolon. The plants grew rapidly and uniformly and showed no signs of nutrient deficiency. Kachur loti was harvested at regular intervals. At the end of the experiment the plants reached the height of 80-90 cm. The overall average production of taro from the system was 0.18 kg/m^2.

The production of morning glory and taro in different treatments are shown in Table 2. The production of the vegetables did not vary significantly ($P > 0.05$) among the treatments.

(Table 2). Production of morning glory and taro in three treatments.

Treatment	Morning glory	Taro
T_1	2760.39±365.79	1979.85±76.07
T_2	2782.11±741.55	1913.52±31.69
T_3	2642.53±724.41	1947.18±98.52

The growth of morning glory and taro in the present experiment was satisfactory. The overall average vegetable production in the system was 0.43 kg/m^2. Many researchers have grown a variety of tropical vegetables in such system; however the production of taro in such system has not yet been reported. Watten and Busch (1984) got an average yield of 11.85 kg/m^3 of tomato from such integrated system. Rakocy *et al*. (1992) grew vegetables in such integrated system and got a yield of 1.35 kg/m^2 of tomato, 0.41kg/m^2 of lettuce and 1.31 kg/m^2 of cucumber. Rakocy *et al*. (2004) conducted an experiment on such integrated system where he used basil and okra in two separate systems. He got an average production of 8.0 kg/m^2 of basil and 3.04 kg/m^2 of okra. These information indicated that the integrated system of the present study was under-stocked and could be able to support about 5-10 folds of vegetables. As the system was under-stocked, there was an ample supply of nutrients in the system water. So the plants grew homogeneously without any significant difference among the treatments.

Production of Amaranth with Normal Soil and Normal Soil + Bottom Sediment

As an attempt to further utilize the nutrients remaining in the sediment, in the present study, amaranth was produced in a potting media using only normal soil and with a mixture of normal soil and sun-dried bottom sediment (at a ratio of 5:1) of the system. Seedlings appeared after 5 days of planting. The germination rates were (50±5.77)% and (77.5±19.36)% for TI and TII, respectively. After 15 days plants were thinned out leaving only two plants in each container. The plants in TI did not grow well (10-12 cm) whereas those in TII grew upto 45 days (70-80 cm) and afterwards the plants were kept for another 30 days but the plants did not grow further and flowers appeared. The mean values of biomass for TI and TII were 2.9±1.34 and 105.45±3.21 g, respectively. The production of amaranth in the two treatments varied significantly ($P< 0.05$) both in terms of germination rate (%) and biomass (g). The growth of amaranth using the second treatment was 36.36 times higher than the first treatment. This indicated that sediment had better properties (such as nutrient content, organic matter content, nutrient availability etc) than normal soil that facilitated plant growth. Rahman *et al.* (2004) used pond bottom sediment for growing morning glory in potting media. They found that pond bottom sediment performed better when mixed with compost than using bottom sediment alone. Shamsul *et al*. (2007) conducted an experiment where they produced red amaranth with different levels of pond sediment in the top soil. They found best results using 100% of pond sediment. The result of the present study was more or less similar to the findings of Rahman *et al*. (2004) and Shamsul *et al.* (2007). Further detailed study is needed for better understanding in this field.

The aquaculture system tested in the present experiment may be an ideal way of utilizing the unused nutrients derived from an aquaculture production unit. Advanced studies are regarded for better development in this field.

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