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COMPARATIVE GROWTH PERFORMANCES OF TARO PLANT IN AQUAPONICS VS OTHER SYSTEMS

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ABSTRACT: Population pressure and land scarcity hindered the development and food security in Bangladesh. To feed the enormous population, farmers increased crop production using chemical fertilizers, pesticides, herbicides which created environmental pollution and health hazards. Therefore, an experiment was carried out as organic farming to investigate the growth performances of Taro plant (*Colocasia esculenta*) in aquaponics system (T_1), hydroponics with tap water (T_2) and in soil (T_3). The healthy and equal sized Taro seedlings were used in each method and tilapia was used as experimental fish. Water quality parameters were recorded weekly, fish and vegetable growth was monitored fortnightly and soil quality was measured monthly. Two sample t-test was conducted for morphological parameters and coefficient of variation (CV) was measured for biochemical elements to find out the best performed method. The growth of Taro plant was significantly different in various systems. The highest growth was found in T_1 followed by T_3 and T_2. The mineral contents in the soil were significantly higher than the other systems. Taro plant growth was significantly higher in T_1 as waste water continuously supplied nutrients to the plants, hence, the system can be replicated anywhere in the country irrespective of geographic location and weather to overcome the environmental pollution.

KEYWORDS: Aquaponics, hydroponics, vegetables, fish and minerals.

1 INTRODUCTION

Aquaponics combines two cultivation systems mainly aquaculture and hydroponics to grow fish and vegetables together in a constructed, re-circulating ecosystem utilizing natural beneficial bacteria to convert fish wastes to plant nutrients [13]. The integration of fish and vegetables creates an ideal growing environment that is more productive than conventional methods [12]. Consequently, aquaponics is gaining more importance now a day because crop production systems are being forced towards increasing irregularities as drought, floods, storms, cyclones and diseases visit regularly. Land gets shrinking, population growth is uncontrolled, weather patterns of the country are heading towards the extreme and our agricultural sectors are suffering with the changing climate. The complex and unpredictable weather creates new challenges to the country's agriculture that highlighted the importance of developing new crop production system like aquaponics. The aquaponics has control on farming systems which can protect the crops from diseases, heavy rains, floods, drought and hailstones. Moreover, aquaponics permits farmer to be more efficient with water use, to control heat and nutrition, and to protect crops from diseases. The aquaponics is an environmental friendly and sustainable food production system. The aquaponics system has been newly introduced in the country to feed ever increasing population and for food security. Therefore, the present experiment was conducted to observe the comparative growth performances of Taro plant in aquaponics system, hydroponics and soil as traditional method.

2 MATERIALS AND METHODS

Three different methods were tested to determine the best system to grow Taro vegetable. The applied methods were T_1 = aquaponics system for soilless vegetable culture in gravel bed with fish tank waste water, T_2= hydroponics for soilless vegetable culture in gravel bed with tap water and T_3= vegetable culture in soil media with tap water as control. Tilapia was used as animal species in aquaponics system (T_1). The Completely Randomized Design (CRD) was used to conduct the experiment. The healthy and uniformed Taro seedlings were used in each method. The experiment was carried out in the Department of Aquaculture, Faculty of Fisheries, Bangladesh Agricultural University (BAU), Mymensingh, during the period from March to July, 2012.

2.1 MEASUREMENT OF SOIL AND WATER QUALITY PARAMETERS

Some essential soil and water quality parameters such as available phosphorus (P) and sulphur (S), exchangeable potassium (K) and sodium (Na) contents were measured using standard laboratory analysis procedure. Phosphorus was analyzed colorimetrically by $NaHCO_3$ extraction and ascorbic acid reduction method [10]. Exchangeable potassium was analyzed by ammonium acetate extraction method. On the other hand, the calcium chloride extraction method was used for determination of available sulphur and flame photometric method was used to determine the sodium content.

2.2 MORPHOLOGICAL DATA COLLECTION

Data on the morphological parameters were collected at 15 days intervals from planting to harvesting date. The plant height was measured from the ground level to the tip of the longest stem by a meter scale. Numbers of branches of the plants were counted properly. Diameter of the individual plant and number of stems of a plant were recorded. Leaf area was measured with an automatic digital electronic portable leaf area meter (Model LI-3100, Lincoln, NE-68504, USA). The biomass content of the Taro plant was measured at final harvest.

2.3 BIOCHEMICAL STUDY

After final harvest, the plant samples were sun dried followed by oven drying at 700C for 72 hours. Exactly 0.2 gram finely ground plant sample was digested by wet oxidation method using di-acid mixture (HNO_3: $HClO_4$ = 2: 1; Jackson, 1973). Phosphorus content in the extract was determined colorimetrically by Olsen method [11]. The potassium and sulphur contents were estimated spectrophotometrically [1], [2]. The concentrations of Ca and Mg were determined by complexometric method of titration [2]. Moreover, sodium content was determined by the flame emission photometric method. Since the methods were non-similar, the arithmetic mean and standard deviation were different for the biochemical elements e.g. Ca, Mg, S, P, Na and K%. The coefficient of variation (CV) was measured to find out the consistency of the method. After calculation of CV, the bar chart of different biochemical elements were constructed to diagnosis the best method on the basis of biochemical output.

2.4 SAMPLING OF FISH

Fish was carried out fortnightly. Scoop net was used to catch the fish from the tank. Ten fishes were caught randomly and length and weight were measured carefully. Weight was taken with an electronic compact balance (KD-S/F-en) and the length with a measuring cm scale. All the data were recorded in a notebook. Immediately after recording the length and weight the fry were released in the respective tank.

2.5 T-TEST FOR MORPHOLOGICAL DATA

Two sample t-tests were conducted to find out the best performed methods on the basis of height, number of stem, diameter of the single stem, diameter of the plant and leaf area.

3 RESULTS AND DISCUSSION

The nutrient analysis of the growing media revealed that the highest amount of nutrients were found in T_3 followed by T_1 and T_2 (Table 1).

Table 1: The average nutrients content of different treatments

Treatments	P (ppm)	K (ppm)	S (ppm)	Na (ppm)
T1	0.539	6.167	2.746	19.891
T2	0.240	2.526	1.131	16.528
T3	18.767	122.604	40.338	229.197

Two sample-t test of morphological study suggested that the performance of T_1 was better than T_2 at 1% significance level (Table 2). T_1 is also significantly different at 10% level than T_3 except stem number (Table 3). The plant cultivation medium plays important role in its overall growth. A good substrate in an aquaponics system works as nutrient reservoir in the root zone and provides adequate space for gas exchange [5]. There are some advantages to growing crops in aquaponics system over growing in soil [8]

Table 2: Two sample t-test for morphological study

The hypotheses are-

H_0 :The Performance of Method T_1 and T_2 are equivalent.

H_1 :The Performance of Method T_1 is greater than performance of T_2

Character	t-value	p-value	Comment
Height	3.58	0.012**	T_1 significant
Stem No.	11.79	0.000*	T_1 significant
Diameter of Single Stem	5.27	0.003*	T_1 significant
Diameter of Plant	4.92	0.009*	T_1 significant
Leaf Area	3.77	0.003*	T_1 significant

*, **, *** means 1%, 5% and 10% level of significance

Table 3: Two sample t-test to find out the best method between T_1 and T_3

The hypotheses are-

H_0 :The Performance of Method T_1 and T_3 are equivalent.

H_1 :The Performance of Method T_1 is greater than performance of T_3.

Character	t-value	p-value	Comment
Height	1.44	0.096***	T_1 significant
Stem No.	0.00	0.50	T_1 insignificant
Diameter of Single Stem	1.88	0.051***	T_1 significant
Diameter of Plant	1.83	0.053***	T_1 significant
Leaf Area	1.67	0.066***	T_1 significant

*, **, *** means 1%, 5% and 10% level of significance

The bar chart for CV revealed that T_1 was consistently better than T_2 whereas T_1 was almost similar to T_3 for Ca, S, P, and Na contents. In case of Mg content, T_1 was more efficient (CV=0) than the other systems. But, the pattern was just reverse for K content (Figure 1).

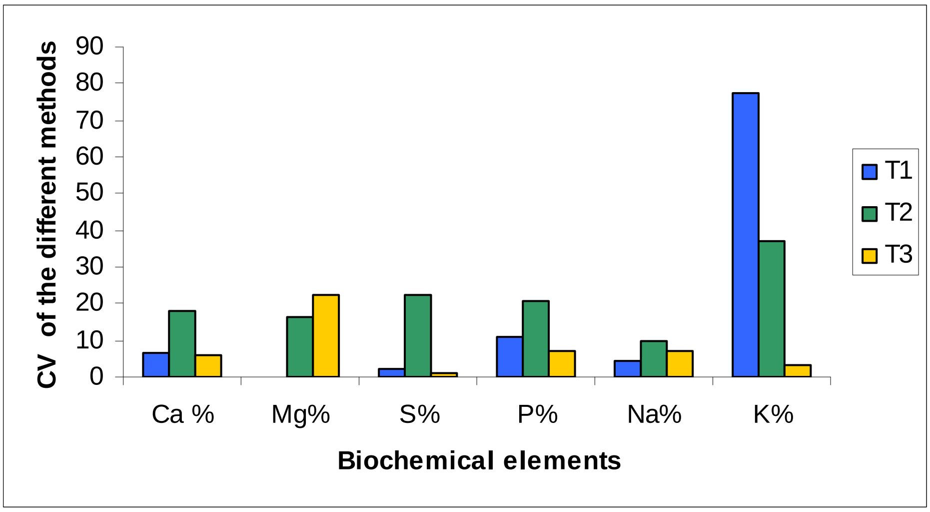

Figure 1. The bar chart for the coefficient of variance of T_1, T_2 and T_3.

The maximum biomass content was measured in T_1 followed by T_3 and T_2 (Figure 2). Reference [6] showed that the interaction between fish and vegetables creates an ideal environment that is more productive than the conventional food production method.

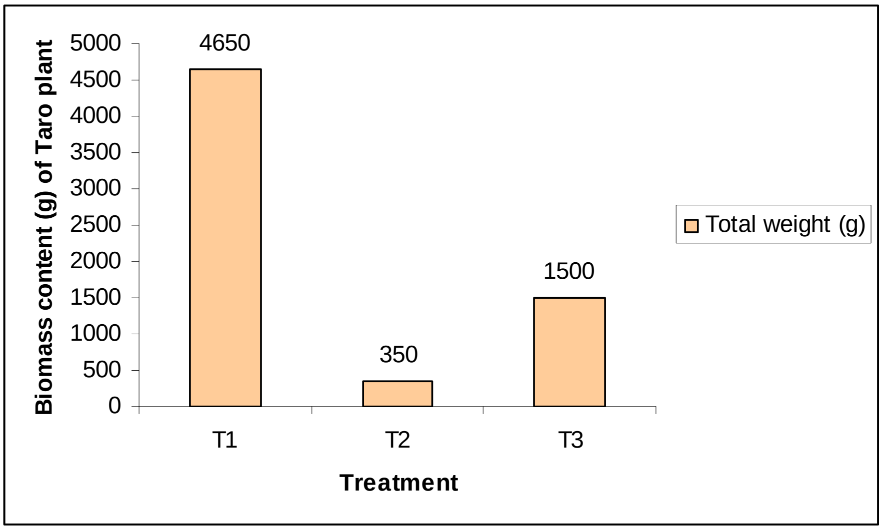

Figure 2: The biomass content of Taro plant at final harvest

The maximum average nutrients were found in T_3 followed by T_1 (Table 1). On the contrary, the highest biomass content was obtained in T_1 followed by T_3. This surprising inverse relation might be due to the consistent supply of nutrients as a result of recycling phenomenon of the fish waste water as well as the increasing nutrient uptake surface area is the adventitious for the roots of the plants for the easier penetration to the gravels in aquaponics system. This higher productivity with lower nutrient content could be the inherent outstanding potentiality of the aquaponics system. In addition, Reference [3], [6] shows the higher production in aquaponics. Reference [13], [7] mentioned that the aquaponics is an integrated system, which provides higher profit due to free nutrients, lower water requirements, elimination of separate bio-filter, less water quality monitoring, and crops and fish can be produced in the same space and time.

Tilapia culture was carried out from March to July, 2013. The initial average mean length of fish was 9.06±1.22 cm and the average mean weight of fish was 17.27±6.50 g. The mean length gain was 9.86±2.03 cm and mean weight gain was

115.86±29.56 g. There was a significant (P≤0.05) difference in mean length and weight of fish among different sampling dates. The survival rate was 91.90±1.91and fish production was 10.65±0.06 (kg/tank/cycle) (Table 4 and Figure 3). The correlation coefficient in the experiment indicated that there was high degree of correlation between the length and body weight as it was close to 1, and its positive appearance reflected the positive slope [13]. The length weight relationship was statistically significant at 95% confidence level which was representative for the population. Aquaponics vegetables are organic and healthy and no disease is encountered in aquaponics system as well as hydroponics products in indoor greenhouse system. Reference [12] proved commercial aquaponics is profitable in Australia. Tilapia performs better in low water quality as well as in re-circulatory system. According to Reference [4], tilapia is a popular fish species grown in aquaponics system.

Table 4: The growth parameters of tilapia RAS in lab condition

Parameters	Fish growth
Water flow rate (l/min)	1
Duration of culture	115
Initial stocking density(kg/m^3)	2.3±0.01
Mean initial length (cm)	9.06±1.22
Mean final length (cm)	18.92±1.37
Mean length gain (cm)	9.86±2.03
% length gain	212.91±36.33
Mean initial weight (g)	17.27±6.50
Mean final weight (g)	133.13±26.57
Mean weight gain (g)	115.86±29.56
% weight gain	926.18±481.94
Daily growth rate (g)	0.74
Survival rate (%)	91.90±1.91
Production (kg/tank/cycle)	10.65±0.06

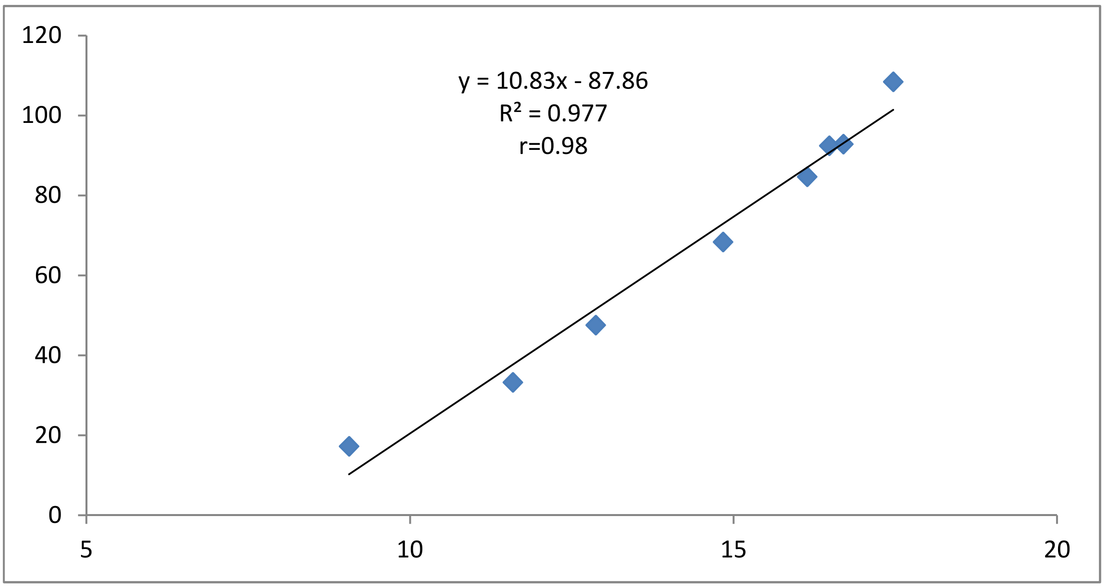

Figure 3: Regression analysis of fish length and weight showed linear relationship in RAS.

4 CONCLUSION

With the increase of population, efficient use of resources has become a prime responsibility of the policy makers around the world. Aquaponics is such a system which integrates fish culture and vegetable production allowing efficient use of water and fish feed residue as nutrient for plant. Findings suggest that aquaponic system offers better results than other media. This system can enhance the organic farming which could be environmental friendly. The present study is one of the first attempts in Bangladesh which will act as base of future studies. Further feasibility studies such as economic viability should be made. Organic nature of such agriculture will add extra-dimension towards the efforts to achieve the food security in Bangladesh.

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