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DESIGN AND PERFORMANCE EVALUATION OF DIFFERENT MATERIALS AS PLANTING BED FOR AQUAPONICS SYSTEM

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Abstract

This study was conducted to design and evaluate performance of different material as planting bed for aquaponics system. It specifically aimed to evaluate performance of aquaponic system, to determine the growth and yield of lettuce (Lactuca sativa L.) using different planting materials, and to determine growth of tilapia under aquaponic system.A single factor experiment in Completely Randomized Design (CRD) with three treatments and three replications was conducted. Treatments used were the following: Treatment 1 (PVC), Treatment 2 (Styrofoam), Treatment 3 (Bamboo). The study lasted for 44 days from January 15 to February 27, 2014 at the Center for Sustainable Upland Agricultural Development, Bataan Peninsula State University, Abucay Bataan, Philippines. The result of the study revealed that using different materials as planting bed for aquaponic system has significant effect on growth and yield of lettuce. Treatment 3 (Bamboo) attained the highest average of plants, number of leaves, and weight of plants among treatment means, followed by Treatment 2 (Styrofoam) and had highly significant difference over Treatment 1 (PVC) during first batch and second batch of lettuce production. However, it was statically proved that there is no significant difference among treatments as to the growth and mortality of the fishes.

Keywords: Aquaponics system, lettuce, bamboo, Styrofoam, Bataan Philippines

INTRODUCTION

Importance of the Study

Aquaponics is a form of sustainable agriculture that combines fish and plants in a closed re-circulating system. Aquaponics is considered a form of sustainable agriculture because it uses non- renewable resources and on-farm resources efficiently while still sustaining the economic viability of the farm. Unlike traditional farming, in an aquaponic system there is a constant flow of water and more constant supply of nutrients for the plants. Waste created by the fish provides necessary nutrients for the plants while nutrient uptake by the plants improves the water quality for the fish. A separate bio filter is not needed because the plants act as a water filter when they absorb the excess nutrients that can otherwise become toxic to the fish if too many harmful compounds build up. Fish release ammonia through their waste, and high levels of this waste product can be toxic to the fish, however these levels can be reduced through the process of nitrification. Nitrifying bacteria convert ammonia to nitrite, then nitrate; a form of nitrogen that can be utilized by plants. Thus, when water returns to the fish tanks, nitrogen levels are tolerable for the fish.

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The goal in using an aquaponic system is to increase production while minimizing nutrient inputs and the consumption of water. Plants act as a filter for the water, which minimizes total consumption of water throughout growing season because it is continually recycled throughout the system and does not need to be replaced with new, clean water. Aquaponics does not require the addition of synthetic, chemical fertilizer as fish waste from the rearing tank provides adequate amounts of essential ammonia, nitrate, nitrite, phosphorus, potassium and micronutrients as well as some secondary nutrients for the healthy growth of hydroponic plants. The use o synthetic herbicides and pesticides is also unnecessary and would greatly compromise the health of the fish that are highly sensitive to water quality. Aquaponics is therefore essentially an organic form of hydroponics whose only fertility input is fish feed containing about 32 % protein.

Objectives of the Study

The general objective of this study was to design and evaluate the performance of different nutrient as planting bed for aquaponics system.

Specifically, this study was conducted to:

1. Evaluate performance of aquaponic system
2. Determine growth and yield of lettuce *(lactuca sativa L.)* using different planting material
3. Determine the growth of tilapia *(Oreochromis niloticus)* under aquaponics system.

Time and Place of the Study

The study was conducted from October 2013 to March 2014 at Center for Sustainable Upland Agricultural Development, Bataan Peninsula State University, Abucay Campus.

Scope and Delimitation of the Study

This study is only limited to the following:

1. Use of different materials for planting bed namely; bamboo, Styrofoam and PVC.
2. Use of pumice as growing media for the experimental crop.
3. Use of lettuce and Nile Tilapia in the aquaponic system.

MATERIALS AND METHODS

Greenhouse Facilities

The study was conducted at the existing greenhouse structure, measuring 4.0 m in height, 4.0 m in width and 8.0 m in length with two layers of covering was used on the study. First layer was made up of insect proof net and other layer was composed of a roll-up and down UV – resistant plastic film.

Greenhouse Re-conditioning

The study was conducted at the existing greenhouse structure of Bataan Peninsula State University, Abucay Campus. The greenhouse used in study was properly cleaned, disinfected, reconditioned for planting and is functional based on the researcher's set-up.

Preparation of Materials and Equipment for Aquaponic System

Nine fish rearing tanks measuring (0.35 m diameter x 0.48 m height) and nine growing beds were laid inside the greenhouse. Fish rearing containers were rest on two step wood board stand or "falls set". Growing beds were made from different planting materials. Three beds utilized were bamboo (47 cm diameter by 7 cm height), three beds used were Styrofoam box and remaining three beds were made from PVC pipe (5.08 cm diameter by 40 cm 40 cm length). All growing beds were filled with growing media (pumice). Each bed contained twelve lettuce plants with a spacing of fifteen centimetre (15 cm) apart and was placed above the fish tank water.

The Aquaponic System Set- Up

Site Requirements. Minimum site requirements for this aquaponic system included access to water, electricity, heat, and level space. Potential incoming water source was from BPSU Abucay Campus water supply. Water supply was tested for the following parameters before a site was finally selected: pH and temperature.

System Requirements. Different materials needed in the conduct of study included the following: drum (polyethylene), bamboo, Styrofoam fruit box PVC pipes (1/2" elbow, PVC tee, and threaded coupling), faucet, water pump, growing media (pumice), seeds, seedling tray, tilapia fingerling, fish feed (pellet), digital weighing scale, water thermometer, pH meter and dissolved oxygen meter.

Growing Beds Preparation. Nine growing beds were made using different planting materials (3 bamboo slots, 3 beds; Styrofoam box and 3 beds: PVC pipe) filled with pumice (5 cm thickness). Initially, the bamboo was cut lengthwise and then measured 2 cm. width bamboo slots as flooring. Then the bamboo slots were set at a close distance of 0.5 cm apart. Perimeters were covered by bamboo that served as a barrier to keep the pumice from falling into the water. A 5.08 cm clearance was established from tank walls to the growing beds perimeter for an air space. The Styrofoam beds were preapared next. A 34 cm. width and 45 cm. long Styrofoam fruit box was used and fitted precisely on the fish tank. Lastly, the 2" (5 cm) nominal diameter PVC pipe was cut using hacksaw. Four pieces of PVC pipe with a length of 40.2 cm. were prepared. Each piece of PVC was drilled three 5.1 cm. diameter holes at a distance of 9.92 cm. apart. Then, two piece of ½"PVC pipe was laid perpendicular to the bottom in which the four drilled PVC pipes were tied. Inside the fish tank, a 5.08 cm clearance was maintained from the tank wall to growing beds for natural ventilation and gas exchange. All growing beds were submerged by about 2.54 cm. depth into solution for the plants to take up nutrients.

Fish Tank Preparation. A 200 liters circular polyethylene tank (0.53 m diameter x 0.91 m height) was used as fish container. Plastic tanks were divided into two (crosswise) so height became 0.455 cm. with an operating volume of 100 liters. Nine tanks were prepared for fishes and the other one was used as reservoir. Tanks were well cleaned by washing with detergents to remove seethed oils and chemicals. After that, all tanks were soaked and disinfected for twenty four (24) hours with water mixed with chlorine. Fish rearing tanks were drilled .27 cm diameter hole at the bottom wherein the drain lines were inserted.

Construction of the Fish Tank Stand. Fish tanks were rested on the top of "ladder like" or "falls set" stand measuring 2.8 meters .5 meter x .5 meter. The stand was build using wood boards reinforced by lumbers nailed at the bottom to more evenly carry the weight of fish tanks. With these, the construction of the drain lines was facilitated and an aeration and comfortable working height was provided.

Plumbing and Irrigation System. Drain lines were installed at the bottom of the fish tanks, respectively. Drain lines were connected by PVC tee and elbows so that fish waste were easily carried by running water. Flow to individual tanks was regulated via faucet. Connection of pipes was sealed with silicone sealant to prevent fish tanks from leaking. Fine screen was used and cover the drain lines to prevent fish tanks from escaping. Water from the reservoir was driven by 0.1 hp submersible water pump. Aeration was generated by the gravity of the flowing water through the rest of the system and return to the storage tank which is the lowest point of the system. Every inlet lines discharged water at a rate of 0.0042 liter per second (L/sec) while outlet line discharged at a rate of 0.021 liter per second.

Fish Selection. Two (2) week old Nile tilapia fry were the fish used in the study. It was transported from Geno Mar Hatchery, Prado Santiago, Lubao, Pampanga.

Transferring and Stocking Density. Prior to transferring into tanks, fishes were hardened and conditioned for about ten minutes to prevent stress. After a few minutes, the tilapia fry were stocked at a 20 pieces of fish per 85 liters of water in fish tank.

Fish Feeding. Pellet was used as feed for the fishes. Fishes were fed twice daily with a complete, floating fish pellet with 32 percent protein. Ten minutes after feeding, the number of feed particles remaining was counted and the next day's meal will adjust so that no more than 5-10 percent of the feed provided remained after 10 minutes.

Experimental Crop. Lettuce *(Lactuca sativa L.)* is the experimental crop used on study (Panfare variety).

Seedling Preparation. Lettuce seedlings were sown in seedling trays filled with organic soil two weeks before it was transplanted into the growing beds. Watering of seedlings was done daily with knapsack sprayer to provide sufficient moisture needed by the seedlings. Seedlings trays were reared inside the protective greenhouse to prevent pest and other diseases.

Transplanting. After the seedlings reached the 14 days of development, the seedlings were carefully transplanted on different growing beds. Transplanting was done in the late afternoon to minimize damage and stress in seedlings during this period. Twelve plants were transplanted in each different growing bed or planting container at adistance of 15 cm apart. All growing beds were partially dipped at about 2.54 cm depth (float type) on the water. Inside the fish tank, a 5.08 cm clearance was managed from tank perimeter to the growing beds for air space.

Nutrient Formulation

Nutrient Mixing Preparation. Preparation of nutrients was followed by commercial nutrients preparation of Allied Botanical Corporation (ABC).

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Snap Solution Preparation. Snap solution was prepared by mixing 25 ml of solution A to 25 ml solution B per 10 liters of water. SNAP solution or Simple Nutrient Additional Program, is the latest hydroponics system developed at the University of the Philippines at Los Banos, Laguna (UPLB) Institute of Plant Breeding (IPB).

Cultural Practices

To reduce introduction of plant pests and diseases within the system, all plant materials were propagated from a certified seed and suggested standard plant protection techniques based on method or cultural practices were followed.

Regular monitoring and sanitation was done within and around the experimental area to prevent occurrence of pests and diseases. Likewise, pesticides were sprayed as the need arose.

Leaf Trimming. Trimming or removal of unwanted shoots, wilted, matured and a damaged leaf was performed. This was done regularly to restrain from diseases and to avoid insect's migration in canopy of the experimental crops and to maintain sanitation.

Harvesting. Plants were harvested twenty one (21) days after transplanting. Harvesting was done cautiously by cutting the steam of plants using scissor or a cutter.

Data Gathering

The following data were monitored, collected, and evaluated to determine production of lettuce and fish under aquaponic system.

Growth response of Plants

Growth response of lettuce was determined with the use of indicators such as height and numbers of leaves of the plants.

Average weekly height of plant. Measurement was individually taken from each plant per growing beds at weekly interval. This was done by measuring the distance in centimetre (cm) from the base up to the tip of the longest leaves.

Average height of plant. Average height of plants was taken after transplanting and at harvesting time. This was done by measuring the distance in centimeters from base up to tip of the longest leaves.

Average number of leaves. This was the total number of leaves per plant during harvest. Leaves that counted were the marketable leaves.

Average weight of plant. The weights of the plants were measured at harvesting time (expressed in grams).

Growth response of fish

Growth response of fish was represented by measuring the weight and number of mortality.

Average fish weight. The weight of the fish (expressed in grams) was measured before and after harvesting time. Weighing was done with the used of digital weighing scale.

Mortality. This was taken based on the number of deaths in the population throughout the duration of the study.

Temperature and pH Monitoring

Temperature – the temperature was monitored early in the morning (8:00 AM) and late in the afternoon (5:00 PM) for more accurate result. In aquaponic system, tilapia is usually raised between 22.2 and 23.3 degree Celsius. Tilapia may become stress and die when water drops at 15 degree Celsius. This was measured using water thermometer.

pH – the pH of the water in the system was measured everyday (8:00 AM and 5:00 PM). A pH of 7 is considered as neutral value; less than 7 is being acidic and values greater than 7 being basic. Low or high pH can stress the fish causing decreased feeding activity and growth. This was measured using acidity or pH meter.

Treatments and Experimental Design

A single factor experiment in Complete Randomized Design (CRD) with three treatments and three replications was used on the study to determine the growth response of lettuce with the growth of the fish under the aquaponic system

The following are the treatments applied on the study:

Treatments

Treatment 1 - PVC

Treatment 2 - Styrofoam

Treatment 3 - Bamboo

Treatment 4 - Control (SNAP solution)

Experimental Lay - out of the Study

The different planting beds were arranged on the tank. There were lettuce plants arranged in two rows and five columns. Each column consists of twenty four (24) plant samples and twenty fish (20) each tank. Each tank was placed layer by layer to monitor the growth response of fish with respect to the growth response of lettuce under aquaponic system.

Statistical Analysis

All data were gathered was tabulated and analysed using the analysis of variance for a single factor experiment in Completely Randomized Design (CRD). Comparison among means was evaluated using Least Significance Difference Test (LSDT).

RESULT AND DISCUSSION

General Observations

Temperature of water on fish rearing tanks. With the use of water thermometer, the temperature was gathered in the morning and afternoon. highest temperature was exhibited on day 19 with 23.9 degree Celsius and lowest temperature was recorded on day 13 with 19.58 degree Celsius.

pH level of water on the fish rearing tanks. Using the pH meter, the pH level was gathered daily. Results showed that the pH level is normal and favourable for plant and fish growth.

Actual and predicted plant height with respect to bamboo beds

The actual and predicted growth response of plant with respect to bamboo beds for the entire growing period. Data were gathered from transplanting up to harvesting of lettuce. The obtained data show the fluctuations on deviation of actual and predicted plant growth.

Regression Analysis of Plant Height and Growth of Tilapia

The actual average plant height (APH) and predicted average plant height of lettuce with the respect to bamboo growing beds. It revealed that highest actual height was obtained during the twenty one days period of observation on growth of lettuce with a mean of 9.70 cm. however, highest predicted average plant height was found on the eighteenth day of observation with an average height of 9.81 cm.

Average weight of tilapia with respect to average plant height of lettuce under bamboo beds

The average weight of tilapia with respect to average plant height of lettuce under the bamboo beds for the entire growing period. Data were gathered from 1st day up to 21th day after transplanting the seeds and placing the fish on the tanks.

Average weight of tilapia with respect to average plant height of lettuce

The correlation between average weights of tilapia with respect to average height of lettuce under bamboo beds. It shows that the highest average height of lettuce was attained on the twentieth days of plant development with a mean of 9.70 cm. it is also then observed that height of plants have a corresponding weight of fish weighed an average of 3.77 grams during twentieth day.

The regression analysis shows that there is a highly significance at 1% level between the growth of plants and growth of tilapia. The predicted equation H = 11.923- 0.893 AWT where H is the actual growth response of lettuce and average weight of tilapia (AWT) revealed that the computed r2 = 0.329 with a goodness of fit < 0.80.

Growth

The growth parameters include the following: average weekly height (cm) of plants, and average number of leaves during harvest.

Yield

The yield parameter included the weight of plants during harvest

Average number of leaves during harvest (Batch 1*).* Table 1 shows the average weight of plants during harvest.

As presented in Table 1, planting material that archived highest average of plant weight was observed in Treatment 3 (Bamboo) with a mean of 31.52 grams, followed by Treatment 2

(Styrofoam) with a mean of 28.36 grams. However, the lowest average plant weight gained in Treatment 1 (PVC) with a mean of 24.08 grams.

Analysis of variance shows a highly significant difference among treatments on weight of plants during harvest. Combination of SNAP solution with fish waste (ammonia) has a great effect on weight of the plants.

Comparison among means revealed that Treatment 3 (Bamboo) gained the highest weight with mean of 31.52 grams during harvest. However Treatment 2 (Styrofoam) with mean of 28.36 grams is significantly different from Treatment 1 (PVC) with mean of 24.08 grams. The result proves that the presence of fish waste and SNAP solution has a great effect on the weight of plants subjected to Treatment 2 and Treatment 3.

Table 1. Average weight (grams) of plants during harvest.

TREATMENTS	REPLICATIONS			TOTAL	MEAN
	I	II	III		
T1-PVC pipe	25.28	24.79	22.17	72.24	24.08
T2-Styrofoam	31.88	26.21	27.00	85.09	28.36
T3-Bamboo	31.59	33.30	29.68	94.57	31.52
Grand Total (G)				**251.90**	
Grand Mean					**27.99**

Means with the same letter are not significantly different at 5% level by LSD.
LSD.05 = 4.54243 LSD.01 = 6.8814

Yield

The yield parameter included the weight of plants during harvest

Average weight of plants during harvest (Batch 2). Table 2 shows the average weight of plants during harvest.

As presented in Table 2, the planting material that achieved highest average of plant weight was observed in Treatment 2 (Styrofoam) with a mean of 27.29 grams, followed by Treatment 3 (Bamboo) with a mean of 26.38 grams. However, lowest average plant weight gained in Treatment 1 (PVC) with a mean of 19.76 grams.

Analysis of variance shows a highly significant difference among treatments on weight of plants during harvest. It provides that using materials affects the development and growth of plants.

Comparison among means revealed that Treatment 3 and Treatment 2 are comparable to each other, although T2 obtained the highest average weight; however they are significantly different

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from Treatment 1. This also proved that using bamboo or Styrofoam can help the plants execute well to a gain the higher weight.

Fish Growth

Average initial weight of fish. Average initial weight of fishes weighed in grams is presented in Table 3.

It can be noted that the highest average initial weight of fishes was weighed in Treatment 2 (Styrofoam) with a mean of 1.50 grams, followed by treatment 1 (PVC) and Treatment 3 (Bamboo) with means of 1.51 grams, and 1.50 grams, respectively.

Analysis of variance revealed that no significant difference was found out among treatment means. Results showed the uniformity of fish in terms of weight.

Table 2. Average weight (grams) of plants during harvest

TREATMENTS	REPLICATIONS			TOTAL	MEAN
	I	II	III		
T1-PVC pipe	21.19	17.53	20.57	59.29	19.76
T2-Styrofoam	26.11	28.78	26.97	81.86	27.29b
T3-Bamboo	26.73	26.97	25.43	79.13	26.38b
Grand Total (G)				**220.28**	
Grand Mean					**24.48**

Means with the same letter are not significantly different at 5% level by LSD.
LSD.05 = 2.91386 LSD.01 = 4.41425

Table 3. Average initial weight (grams) of fish

TREATMENTS	REPLICATIONS			TOTAL	MEAN
	I	II	III		
T1-PVC pipe	1.53	1.5	1.5	4.53	1.51a
T2-Styrofoam	1.53	1.5	1.47	4.50	1.50a

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T3-Bamboo	1.5	1.43	1.5	4.43	1.48a
Grand Total (G)				**13.46**	
Grand Mean					**1.50**

Means with the same letter are not significantly different at 5% level by LSD.
LSD.05 = 6.14012 LSD.01 = 9.30176

Average weight of fishes after the fish batch of lettuce (3 weeks). The average weight of fishes after 20 days is presented in Table 4.

Treatment 1 (PVC) revealed the highest average weight of fishes with a mean of 2.07 grams followed by Treatment 3 (Bamboo) and Treatment 2 (Styrofoam) with means of 2.03 grams and 1.99 grams respectively.

Analysis of variance of average weight of fishes during three (3) weeks revealed no significant effect. Different treatments did not affect the weight of fishes. Although fishes from T1 (PVC) has the highest average weight with a mean of 2.07 grams, however T3 (Bamboo) is comparable to T2 (Styrofoam).

Table 4. Average weight (grams) of fish sample three (3) weeks after transferring

TREATMENTS	REPLICATIONS			TOTAL	MEAN
	I	II	III		
T1-PVC pipe	2.0	2.1	2.1	6.20	2.07a
T2-Styrofoam	2.0	1.93	2.03	5.96	1.99a
T3-Bamboo	2.1	2.0	2.0	6.10	2.03a
Grand Total (G)				**18.26**	
Grand Mean					**2.03**

Means with the same letter are not significantly different at 5% level by LSD.
LSD.05 = 0.11124 LSD.01 = 0.16852

Average weight of fish after the 2nd batch of lettuce (3 weeks). The average weight of fishes weighed in grams is presented in table 5.

It can be noted that Treatment 1 (PVC) gained highest average weight fishes with mean of 4.04 grams followed by Treatment 3 (Bamboo) and Treatment 2 (Styrofoam) with means of 3.92 grams and 3.82 grams respectively.
Analysis of variance shown that there is no significant difference among treatment means. It only proves that all treatments are comparable and did not affect the weight of fishes during the second batch of lettuce production.

Table 5. Average weight (grams) of fish during the second batch of lettuce

TREATMENTS	REPLICATIONS			TOTAL	MEAN
	I	II	III		
T1-PVC pipe	3.65	3.76	4.04	11.45	3.82a
T2-Styrofoam	4.51	3.60	4.02	12.13	4.04a
T3-Bamboo	3.85	4.11	3.80	11.76	3.92a
Grand Total (G)				**35.34**	
Grand Mean					**3.93**

Means with the same letter are not significantly different at 5% level by LSD

Fish mortality. The number of morality in the fish population.Treatment 3 (Bamboo) and Treatment 2 (Styrofoam) recorded highest number of mortality during the duration of the study with a mean of 3.33; however Treatment 1 (PVC) recorded the lowest number of mortality with a mean of 2.67.
Analysis of variance signified that there is no significant difference in treatment means. It was observed that the mortality of fishes was not affected by different treatment. This is however verified that fish mortality is due to fry stage.

Cost and return analysis. Table 6 shown initial cost of production of aquaponic system revealed on investment was 3.93%.

Table 6. Cost and Return Analysis of the Aquaponic system

ITEMS	AMOUNT (Php)/YEAR
FIXED COST	P 800.00

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Depreciation	300.00
Repair and maintenance	500.00
VARIABLE COST	P 13,125.00
Labor	2,100.00
Electricity	600.00
Materials	
1. 55 gallon drum	2,500.00
2. ½" PVC pipe	300.00
3. ½" PVC tee	100.00
4. ½" PVC elbow	40.00
5. ½" threaded coupling	100.00
6. Pump	500.00
7. Bamboo	100.00
8. Tilapia fingerlings	135.00
9. Lettuce seedlings	150.00
10. Fish feed (pellet)	750.00
11. Hydroponic solution	5,250.00
12. pH meter	500.00
TOTAL COST	P 13,925.00
GROSS INCOME	P 14,472.00
NET INCOME	P 574.00
RETURN ON INVESTMENT	3.93%

SUMMARY, CONCLUSION AND RECOMMENDATION

Summary

The study was conducted to design and evaluate the performance of different material as planting bed in for aquaponic system. Specifically, the study aims to determine the growth and yield of lettuce *(Lactuca sativa L.)* using different materials as planting bed and to determine the growth of tilapia *(Oreochromis niloticus)* in aquaponic system under BPSU Abucay Campus condition. This was conducted at the Center for Sustainable Upland Agricultural Development, Bataan Peninsula State University, Abucay Campus from October 2013 to March 2014. Treatments are used were; Treatment 1 (PVC), treatment 2 (Styrofoam) and Treatment 3 (Bamboo). Study was arranged in a single factor experiment with 3 treatments and 3 replicates under Completely Randomized Design.

The study findings are as follows:
First batch and second batch of lettuce production

1. Plants height from first week up to harvest of the first batch was highly significant among treatments. Tallest height was obtained from treatment 3 (Bamboo) with a mean of 23.77

cm, followed by Treatment 2 (Styrofoam) with a mean of 22.76 cm. treatment 1 (PVC) gained lowest average height during harvest with a mean of 21.39 cm. results showed that temperature and nutrient solution and fish waste is conductive for the growth of lettuce.

2. Number of leaves during harvest on the first batch was highly significant among the treatments. The average most numbered of leaves was found from treatment 3 (Bamboo) with a mean of 6.53 which is comparable to Treatment 2 but significantly different from Treatment 1.
3. Furthermore, the average weight of plants during first batch was highly significant among treatments. The highest weight during the first batch of lettuce was obtained from Treatment 3 (Bamboo) with a mean of 31.52 grams. Besides, fish growth during three weeks (21 days) of culturing gained at average weight of 2.03 grams from the average initial of 1.5 grams throughout the first batch of lettuce production.
4. There was a highly significant difference among treatments. Treatment 2 (Styrofoam) attained highest average height during second batch with a mean of 24.40 cm, followed by Treatment 3 and Treatment 1 with means of 23.53 cm and 21.61 cm respectively.
5. Number of leaves during harvest of the second batch was also highly significant among treatments. Treatment 3 (Bamboo) still has the highest average number of leaves produced with a mean of 6.19.
6. At final weight of plants on batch 2, Treatment 2 (Styrofoam) achieved the highest weight with a mean of 27.29 grams, followed by Treatment 3 with a mean of 26.36 grams and T1 gained the lowest weight with a mean of 19.76 grams. It was found out that there is a significant difference among treatments.
7. Finally, there was a significant difference among treatment means on growth of fish during first batch and second batch and number of fish mortality.

Conclusion

Concluded findings based on the study proved that Bamboo and Styrofoam are comparable with each other in terms of height and weight of plants during the first batch. Using different planting material the growth and yield of plants were affected. On the other hand, bamboo material has a significant effect to the water when temperature decreases. As the temperature drop off the bamboo material recorded the lowest level of temperature compared to other treatments. Nevertheless, in this study the plants on Treatment 1 (Styrofoam) dominantly responded in the prepared growing material than to other treatment.

Recommendation

Based on the result of the study using different planting materials for aquaponically grown lettuce and tilapia, following recommendations were as follows.

1. It is suggested to build or manage an aquaponic system during the suitable seasons for better production because fish and plant growth is affected by low and high temperature (warmed blooded fish) that will also favour with the plant needs.

2. It is suggested to use either bamboo or Styrofoam as planting bed in aquaponic system. But in terms of viability and environmental concern, bamboo is highly recommended.
3. If bamboo is the preferred choice as planting bed in aquaponic system, it is recommended to establish a clearance or border from the depth of pumice or maybe the growing bed higher than the fish tank to keep in contact with the lettuce leaves to the water surface. Because tilapia tends to eat those of leaves when hang down into water.
4. It is recommended to maintain the water quality to promote the best growth of fish. Proper aeration is also important to consider in maintaining oxygen levels of water.
5. Development of other aquaponic designs that will eliminate the maintenance and cost is also suggested.

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