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Research Article

The Performance of Small And Large Leaf Plants In Aquaponics

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ABSTRACT

Comparing the performance of small and large leaf plants in an aquaponics system was carried out to address the challenges faced by aquaponics farmers in Hoima district-Uganda. The methodology involved a 4 months running treatment at Kyambogo University Biology Department Aquaponics System (KYUBDAS) between 29th March and July 20th to resonate with the preliminary study of the challenges faced by aquaponics farmers in Hoima. The KYUBDAS investigation helped this study identify the performance of fish and plants (1) Nile tilapia (*Oreochromis niloticus*) (2) African catfish (*Clarius gariepinus)* and vegetables which included: (1) Coriander (*Coriandrum sativa*) (2) Kale/ Sukuma wiki (*Brassica oleracea*), (3) Spinach (*Spinacia oleracea*), and (4) Lettuce (*Lectuca sativa*) in a Recirculating fish Aquaculture System (RAS). Methods and materials included lab tests on samples of Sukuma wiki (big leaf plants) and Coriander (small leaf plants) was done for differences in nutrient demands presence of Carbohydrates, proteins, moisture, dry and fresh weight at harvest. Data analysis was done using Minitab17 for quantitative data analysis. Results revealed that plants with small and simple leaves like coriander and lettuce take fewer days and effluent content to obtain maximum fresh and dry matter compared to the big leaf plants. Dry weight showed a significant difference (p=0.01) between the two plant varieties.

Keywords: Leaf Plants; Aquaponics; Farmers

INTRODUCTION

The study revealed that Small leaf plant varieties can grow well in shallow media beds compared to the big leaf plants like Sukuma wiiki and Spinach which may need supplemental N.P.K if the NO_3 absorbed from the fish effluent is lacking sufficient nutrients. Shallow (6″-8″) and clogged media beds affect performance of big leaf plants as they grow. Over 80% of aquaponics farmers face water availability problems and poor record keeping deprives their realization of over Ushs 37,000,000 for large scale and over Ushs 2,900,000 for small scale farmers per year in aquaponics business [1].

Data analysis was done using Minitab17 for quantitative data analysis. Results revealed that plants with small and simple leaves like coriander and lettuce take fewer days and effluent content to obtain maximum fresh and dry matter compared to the big leaf plants. Dry weight showed a significant difference (p=0.01) between the two plant varieties.

Aquaponic systems in equilibrium between the aquaculture and hydroponic components can be highly efficient in biomass production of fish and vegetables in every scale of development and without the need for inorganic fertilizers, herbicides or other biocides . Such systems are also able to secure food for small-scale family run producers even in dry periods or arid/desert zones.

Moreover, due to the lack of soil substrate such systems can be exploited in areas with poor or deteriorated soil quality or even in urban environments .

The aim of the present study was to assess the performance of a small-scale pilot modular aquaponic system for fish and green vegetables during the critical early phase of running.

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MATERIALS AND METHODS

Plant beds/ effluent filters.

PLANTS

Figure 1: Hydroponic plant beds.

(Figure 1) shows basins in the KYUBDAS treatment that were used for the hydroponic component of the system. Four of the plant beds had gravel media measured up to 12″ of thickness as a standard requirement for plant beds for deep root crops. Two basins had gravel measuring upto 6 ″ for shallow root crops. The control basin was in the 6 ″ category [2].

The green house

HYDROPHONIC TROUGHS

Source: Author

Figure 2: KYUBDAS Green house.

(Figure 2), plant containers are sheltered in a greenhouse to reduce the effect of rain. Water from the plants is filtered and taken back for fish use. The figure also shows plant containers using effluent and the control container. The blue pipes above the containers bring effluent from the fish tanks. The green house mesh is transparent enough to allow sunshine to penetrate to the crops so they can attain vitamin D. The plant beds containers are raised to allow the tapping of water and save them from animal pests [3].

Comparing of plant matter and nutrient content at harvest

Samples of the edible parts of the plant were taken to the Makerere University Food and Technology department Lab to do proximate analysis on fresh weight, dry matter content, proteins, and ash, carbohydrates and moisture. For all the nutrients, procedure was followed according to standard oven drying method (AOAC, 1995:965.40). To determine the plant fresh weight, plants were removed from the grow beds and the sand was washed off. A paper tissue was used to blot plant leaves gently to remove any free surface moisture [4]. The roots were cut off and the edible matter was weighed immediately to collect fresh weight data. Dry weight data was recorded when the leaves that had been used to capture fresh weight data were cut into small pieces and put in an oven set to low heat 37°C and left in the oven for 12 hours. The leaves were removed and let to cool at room temperature of ˜23°C they were then put on a weighing scale to capture the on a scale to capture the dry matter weight data. To determine the crude protein in the plant, the Kjeldhal method (AOAC, 1989:989.03) method was used on 10 grams of the best performing coriander (C. *sativa*) and Sukuma wiiki (B. *oleracea*). The plants were harvested, and the roots were cut off. At the Makerere food and technology laboratory the block digestion and team distillation Kjeltec™ 2055 auto distillation unit 2012 was used. To determine the Ash content, 10 grams of coriander (C. *sativa*) and Sukuma wiiki (B. *oleracea*) were dried by heating the in a muffle furnace as described in the standard method (AOAC, 1995; 923.03). The Unicam 919 Atomic Absorption Spectrophotometer (AAS) was used to ash the sample under gradual increase temperature of 50°C /hr [5].

RESULTS

Plant performance

(Figure 3) Observes the performance of hydroponic grown plants with ammonia NO_3 verses those using regular water and the performance of soil based plants using ammonia water. A foot ruler was used to measure leaves, and height of plants in the different hydroponic setting and the length of fish to ascertain plant performance and growth.

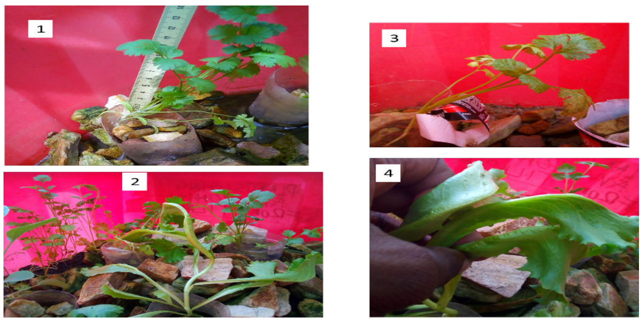

Figure 3: Coriander and lettuce plants.

Plant nutrients

(Figure 3), photo 1, 2,3 and 4 show plants using effluent compared to the coriander plant in photo 3 that was in the control basin using only water. The coriander (C. *sativa*) leaves among were totaling to 25 in the best grown plants using effluent compared to only 5 leaves on the plants using water alone. Plants like C. *sativa* and L. *sativa* performed best because they needed much less nutrients than the big leaf plants. The difference in the nutrient consumption arose from the amount of NO_3 water applied to the plants. Plants using effluent grow better and produce more leaf cover compared to those that use only regular water be it in the soil or in the hydroponic setting [6]. An added advantage is gained by soil-based plants that utilize NO_3 because they gain more potassium and ion from the soil. This study found out that the minimal presence of Potassium and Magnesium macronutrients in the biofilter and effluent enabled the C.*sativa* to get leaf numbers upto 26 leaves and 18-19 cm height per plant and upto 4 leaves per lettuce plant and stronger presence of chlorophyll in the hydroponic beds. The big leaf plants like B. *oleracea*, and S. *oleracea* in the biofilter grew 5-7 leaves measuring 7-9 cm leaf midrib length and less chlorophyll strength compared to those in the soil using effluent that attained 18 cm of leaf midrib length and stronger chlorophyll presence by observation [7].

Plant nutrients in KYUBDAS experiment

(Table 1) shows the results of nutrients in B. *Oleracea* & C. *Sativa* plants that were grown in the aquaponics system. The nutrients analysed were Proteins, carbohydrates, moisture, fresh and dry weight. Table 1 shows that B. *oleracea* gained dry matter content of 12.79 percent compared to C. *sativa* that gained a dry matter content of 11.64 percent.

PLANT SPECIES	CRUDE PROTEIN %	FRESH WT%	DRY WT%	Moisture%
B. oleracea	33.375 ± 0.25^a	44.87 ± 6.1 ^{a}	14.42 ± 0.73 ^{a}	79.87 ±3.3 ^{a}
C. *sativa*	32.435 ± 0.17 ^{a}	23.415 ± 2.7 ^{a}	8.935 ± 1.2 ^{b}	83.61 ± 2.1 ^{a}

*α=p=0.05,

Table 1: Levels of nutrients in plants that were grown with fish tank effluents

Results also indicated that there was a significant difference (p=value 0.01.) in the plant dry matter weight parameters.

DISCUSSION

Big leaves against small leaf plants

According to Table 1, although the plant nutrient percentages were relatively different between pants B. *oleracea* and C. *sativa* the results in showed no significant difference in the Fresh weight (p=0.077), Moisture (p=0.352), Proteins with (p=0.176). However, Dry weight had a significant difference of (p=0.01). A similar study carried out a t-test on the weight of spinach leaves in aquaponics that was recorded biweekly in two different seasons realized significant ($P<0.05$) differences in leaves weight among the treatments that was found at 26th August but there was no significant difference of leaves weight in dates within the months of July and September. This study reveals in Table 1 that the significant (p=0.01) difference in that dry matter weight of the plants depicts a difference in need of nutrients. B. *oleracea* (big leaf plant) needed a total of 30 days compared to C. *sativa* (small leaf plants) need less than 20 days to gain as much moisture (77 and 79 g/100g). This finding avails statistical data to justify the theoretical categorization (FAO, 2014) that Kale (B.*oleracea*) and spinach (S.*oleracea*) are medium aquaponics nutrient demand plants compared to coriander and lettuce that are categorized as low nutrient demand plants. KYUBDAS treatment used totally 50 fish and over 5 liters of effluent 60 plants. Small leaf plants grew better than big leaf plants in the hydroponic media while the big leaf plants watered with effluent while emptying fish containers of the used water. The nitrates would be both trapped in the soil allowing the macro and micro bacteria to decompose the effluent for easy absorption of nutrients into the plants. Ammonium NH_4+ from animal deposits, waste food and dead plants is fixed in the soil by biological fixation (prokaryotic conversion of N_2 to ammonia) The results were clear as big leaf plants grew better in the soil garden. In Hoima, a R3 had a Concrete large scale aquaponic system pond area of 10 X 5 X 1.5 m^3 containing over 7000 catfish and supplying a non-reversed water garden of 50 square meters. The bananas, carrots and cabbages and beans grew comparably well. Without using non-organic fertilisers, the plants were relatively healthy. Otherwise the farmer using less than 100 fish would not benefit from crop yield on the second planting before replacing the fish or ensuring the steady growth of the available fish for production of quality effluent [8].

Feeding of fish (FCR)

Food conversion ratios of fish are relative to the age of the fish which in turn provides the necessary concentration of effluent to be used by the hydroponic garden. In the Kyambogo investigation, catfish were fed on juvenile feed pellets as tilapia was fed on fry mash powder given to fish weighing 5.0 g./pc for the first 8 weeks and later juvenile pellets given to fish weighing 90.0 g./pc as recommended by the Bureau of Fisheries and Aquatic Resources National Fresh water Fisheries Technology Center CLSU Compound, Muñoz, Nueva Ecija Department of Agriculture. The feeding was 3 tablespoons for tilapia per 15 tilapia per day and 20-40 grams for 20 catfish per day to attain a good feed conversion ratio (FCR) and deposit more effluent. This was not the case on Hoima where only 100 grams of pellets was given to over 100 catfish per day as feed. Despite the lack of sufficient fish feed, over 120 crops in the hydroponic gardens would not attain enough nutrients with such little effluent unless there are additional fertilizers. The improvisation of organic fish feed like maggots, earthworms, poultry and piggery intestines waste for fish feed helped the farmers in Hoima supplement the fish diet with proteins Also the use of boiled banana leaves to mulch the hydroponic gardens would supplement the bio filter nutrients for the plants however as the boiled leaves take longer to decay, the plant beds would be affected [9].

Water change effect

Water changes and air bubbling were done on a daily basis for the first 2 months [10]. 20-60% water changes were made daily to mitigate challenges of pH instability and ensure the acquisition of Ammonal NH_3 deposit extraction to the flood/ sump container for the nitrification cycle to be completed out of the fish tanks [11].

CONCLUSION

Plant performance

This study tries to analyse the performance of plants in aquaponics through determining the dry and fresh weight obtained from effluent. It was concluded that big leaf plants like B.*oleracea* need more effluent or nitrites and time to gain full fresh and dry matter weight compared to small leaf plants like C.*sativa*. However, recommendations for more research on the amount of nutrients provided to the plants through dissolved NO_3 are necessary to resonate with this study's current findings of fresh and dry matter obtained from the effluent. Vegetables are high in vitamins, protein, carbohydrates and ash; these are some of the nutrients that are deficient in most malnourished and stunted children in Uganda. It is necessary to recommend that use of the right ratios of fish and plants are applied in Uganda's aquaponics structures. Large plants like pawpaw/ papaya can be harvested in aquaponics. The food markets require standard healthy crops that woo investors and international consumers therefore every aquaponics system should produce crops that are not stunted or showing lack in nutrients.

Plant media beds and water testing equipment

For better aquaponics plant yield, laying larger pebbles in the first layer will allow sunlight to penetrate through the stones, dry the forming algal blooms and reduce rotting of plant bases. Loose lake sand and the plant roots in the second layer will allow filtration of the effluent helped by good nitrogen bacteria to break down more effluent material in their de-nitrification cycle. The testing of water from the plant grow beds using reliable machinery will ensure better performance of the grow beds. It can also be recommended that in the absence of reliable water testing equipment, farmers can opt to flash the grow beds with fresh water as soon as they realize a poor performance of yield. Otherwise, it will be even better if the government, private sector or organisations can pool funds for a communitywater testing equipment.

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