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Hydroponic treatment of lettuce (*Lactuca sativa*) on different fertigations

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ABSTRACT

Lettuce plants were set into two factors A and B wherein A stands for the main plot aerated/non-aerated condition and B for sub-plot or the different nutrients used under greenhouse condition. Factor B consisted of T_1: Control (water only), T_2: SNAP (simple nutrient solution programme), T_3: Masterblend (lettuce), T_4: Masterblend (tomato) fertilizer and T_5: Humus plus foliar fertilizer under hydroponic condition. The research was carried out following the split-plot design with three replications. All treatments of the two sub-plots and two sub-plots (average all over main plot) were statistically significant according to the study's findings. In the main plot, both aerated and non-aerated lettuce conditions were found to have a significant impact on plant height at 35 days after transplanting and average weight per plant with the exception of the number of leaves which was found to be non-significant and did not tend to increase the number of leaves. Plants grown in treatment comprising masterblend for tomato also gained a higher weight per plant. When the solution was not aerated, the pH tended to be neutral however when it was aerated, it became alkaline. With 77.97 per cent, the plants produced in treatment masterblend for tomato under aerated yielded the highest investment return. This study represents a step forward in achieving higher yields in hydroponic lettuce grown in an aerated environment with masterblend (tomato) fertilizer.

Keywords: Fertigation; pH; treatment; alkaline, acidity

INTRODUCTION

The increasing population of the world has something to put on priority. More people means more food to produce with a very limiting and decreasing resources; the possible way to sustain the left resources for the next generation must have the combination of small production area and lower inputs on farming while at the same time making still a higher output as possible.

Hydroponics is one of the most successful and specific technologies for high-volume production. Controlling water supply, pH, ambient temperature, insect and disease infestation, reducing labour, wind velocity, increasing density spacing and yields due to less rivalry among roots and no requirement for soil sanitation are all important advantages of growing without soil. A nutrient solution for hydroponic systems is an aqueous solution containing mainly inorganic ions from soluble salts of essential elements for higher plants (Steiner 1968).

Synthetic (or refined mineral, or salt-based) and organic-based formulations are the two types of hydroponic fertilizer formulations. Humans have created soluble salts for plant uptake that are referred to as a synthetic nutrients. Because the structure and properties of all the components differ, they dissociate in the 'universal solvent' at various speeds resulting in a modest pH change. This is the most significant difference between synthetic and natural nutrient sources although it may be overcome with time and skill. There is no difference in the end ion product between synthetic and organic-based nutrition products. Just a different means of getting food to the plant is what it is. Plants consume ions in an inorganic form. In other words, when these things have been dissolved in water, plants ingest the inorganic elements of these materials such as guano and kelp ions.

Lettuce (*Lactuca sativa* L) is one of the most economically important leafy vegetables in the world and its production is currently increasing due to the growing interest in healthy food (Shatilov et al 2019). Since the concept of green products has been prevailing worldwide, lettuce has gained importance not only for food application but in various formations having other specific uses (Das and Bhattacharjee 2020). Hydroponic growth of lettuce is considered to be quite easy requiring less skill from the grower. This makes it a widely grown commercial hydroponic crop with many varieties performing well under a variety of conditions (Jenner 1980). The cultivation of lettuce in a hydroponic system requires a nutrient solution within specific target ranges for a multitude of water quality parameters.

In the present study, different fertilizers were used which were economically available in the market and had the potential for growing hydroponic lettuce plant like masterblend (for lettuce and tomato), SNAP (simple nutrient addition programme) solution and humus foliar fertilizer. Besides this study also focused on determining which would give a better quality crop between aerated and non-aerated conditions.

MATERIAL and METHODS

The research was carried out at Isabela State University's crop science laboratory area, Matusalem, Roxas, Isabela. In order to give some temperature control, prevent evaporative water loss, manage diseases and pests and shelter the crops against weather elements such as wind and rain, an improvised greenhouse was built.

Preparation of seedling plugs: For the seedling stage, lettuce seeds were placed in shallow plastic trays with drainage holes and a 25:75 ratio of vermicast and rice bran ash was utilized as growing media. Individual plants were pricked or transplanted into 8-oz styrofoam containers after 20 days of seeding. Six vertically sliced 3 millimeter wide cuts were made in the bottom of each cup for roots to grow down into the nutrition solution. For the entire study period, the cup was filled with chopped abaca fiber (approximately 1/3 full) which was utilized as a growing medium for the lettuce plants.

Preparation of culture troughs: A round black basin with a diameter of 62 centimeters was used in the mixing of the nutritional solutions with water. These basins served as containers of the growing nutrient source for the plants. Twelve holes equidistant from one another were made on the styroboard enough to hold in place the seedling plug by its neck.

Preparation of solution and treatments: The snap nutrient solution was prepared by mixing it with 19 liters of water likewise with the masterblend fertilizer (lettuce and tomato). Humus was diluted first in a small amount of water and served as liquid fertilizer. All fertilizers were used following the recommended rate.

The treatments were designated as follows:

Factor A (aerated) comprised Factor B treatments viz T_1 [Control (water only)], T_2 (RR- 50 ml SNAP solution + 19 liters of water), T_3 [RR- 25 g masterblend (lettuce) fertilizer + 19 liters of water], T_4 [RR- 30 g masterblend (tomato) fertilizer + 19 liters of water] and T_5 (RR- 30 g humus foliar fertilizer + 16 liters of water) whereas Factor A (non-aerated) comprised T_1 [Control (water only)], T_2 (RR- 50 ml SNAP solution + 19 liters of water), T_3 [RR- 25 g masterblend (lettuce) fertilizer + 19 liters of water], T_4 [RR- 30 g masterblend (tomato) fertilizer + 19 liters of water] and T_5 (RR- 30 g humus foliar fertilizer + 16 liters of water).

Proper care and management were done throughout the whole duration of the experiment to have accurate results. The occurrence of pests and diseases was minimized by applying proper sanitation. Fish net with small holes was installed in the greenhouse to prevent the entry of pests. Shading of the greenhouse was done to lessen much exposure of lettuce plants to heat of sunlight and to make the greenhouse a little bit cooler. To minimize the germination of weed seeds and water evaporation, the indoor ground of the greenhouse was mulched with rice straw.

After 35 days of planting, the harvest was completed. The entire plant was uprooted by hand and the stems were then pruned with a pruning shear just below the plant's lowest leaves. Ten sample plants in each treatment were used for the data. Height of each plant was measured at 35 days after planting. Measuring was done from the base of the plant up to the tallest leaf of the lettuce using meter stick.

The number of leaves per ten samples was counted and divided by ten to obtain the average number of leaves per plant. For calculating average weight of the whole plant, the weight of ten sample plants was determined with the use of digital weighing balance and divided by ten to obtain the weight per plant. The pH of the solution was recorded after the conduct of the study to determine the status of the solution. The cost and return analysis of using different fertilizers was computed after the conduct of the study.

RESULTS and DISCUSSION

Plant height: The height of the plants at 35 days after transplanting was significantly affected by the different treatments employed (Table 1). In the main plot, in the aerated condition, the plant height was 25.21 cm as against 18.07 cm in non-aerated condition. In aerated, the comparison in all treatment means showed that the different nutrients had influenced the height of the plants with means ranging from 8.46 to 37.01 cm. The tallest plants were in the treatment T_4 [Masterblend (tomato)] with a mean of 37.01 cm. Under non-aerated condition the means ranged from 6.63 to 26.60 cm and the tallest plants were produced in the treatment T_4 with a mean of 26.60 cm. In two sub-plots (average all over main plot), under aerated and non-aerated conditions, T_4 recorded taller plants (37.01 cm) than the non-aerated condition (26.60 cm) followed by T_3 [(Masterblend lettuce)] (35.11 and 25.17 cm in aerated and non-aerated conditions respectively) and T_2 (SNAP) (29.76 and 24.44 cm in aerated and non-aerated conditions respectively). The height of plants at 35 days after transplanting as affected by the two conditions was statistically significant based on the analysis of variance.

The reason behind it might be that plants grown hydroponically with aeration had a greater outcome when plants absorbed dissolved oxygen in water (Goto et al 1996), also to be a great method for keeping one's water and fertilizer mixed and preventing the fertilizer from settling to the bottom of the reservoir. When plants grown hydroponically and depletion of dissolved oxygen occurred, it affected the plant growth negatively (Roosta et al 2016).

Average number of leaves: The number of leaves per plant is shown in Table 2. Under main plot, there was no difference between aerated and non-aerated conditions with respect to number of leaves. The number of leaves produced by the plants applied with different fertilizers had significant differences with means ranging from 4.60 to 12.20 under aerated condition; T_4 resulted in the highest number of leaves with a mean of 12.20 and T_5 with a mean 4.60 as the least. In non-aerated condition, T_4 had maximum number of leaves (8.07) and T_1 (Control) the least

Table 1. Average plant height of lettuce at 35 days after transplanting

Treatment	Plant height (cm)	
Main plot		
Aerated	25.21[a]	
Non-aerated	18.07[b]	
$LSD_{0.01}$	4.00	
Result	**	
	Aerated (A)	Non-aerated (B)
Two sub-plots		
T_1: Control (water only)	8.46[e]	6.63[d]
T_2: SNAP	29.76[c]	24.44[c]
T_3: Masterblend (lettuce)	35.11[b]	25.17[b]
T_4: Masterblend (tomato)	37.01[a]	26.60[a]
T_5: Humus foliar fertilizer	15.69[d]	7.53[d]
$LSD_{0.01}$	-	2.94
Result	-	**
Two sub-plots (average all over main plot)		
T_1: Control (water only)	8.46[g]	6.63[g]
T_2: SNAP	29.76[b]	24.44[de]
T_3: Masterblend (lettuce)	35.11[a]	25.17[cd]
T_4: Masterblend (tomato)	37.01[a]	26.60[c]
T_5: Humus foliar fertilizer	15.69[f]	7.53[g]
$LSD_{0.01}$	-	2.08
Result	-	**
CV (a) (%)	-	5.10
CV (b) (%)	-	5.70

Means within a row represented by common letters are not significant at 1% LoS; **Highly significant

(4.23). In case of two sub-plots (average all over main plot), the T_4 treatment under aerated condition was having the maximum number of leaves (12.20) which was significantly higher than the non-aerated (8.07) followed by T_3 [Masterblend (lettuce)] with 9.37 and 7.63 leaves in aerated and non-aerated conditions respectively. Based on the analysis of variance, all treatments of factor B were statistically significant but non-significant for Factor A (main plot). But in the main plot, aerated or non-aerated condition did not tend to increase the number of leaves per plant.

Average weight of the whole plant: The effect of different fertilizers under aerated and non-aerated showed better efficiency in terms of the weight of whole plant (Table 3). The analysis of variance revealed significant differences. In the main plot the average weight was higher in aerated condition (71.04 g) as compared to non-aerated (50.08 g). In two sub-plots, T_4 resulted in more average weight of whole plant (116.93 g) as compared to non-aerated (69.32 g) followed by 112.13 and 75.94 g in T_3 in aerated and non-aerated conditions respectively which were statistically significant. Based on the analysis of variance, all treatments of factor A and B were statistically significant.

In these findings, aerated plants gained more weight than non-aerated plants implying that when plants absorb the necessary nutrients and are given a favorable environment, they gain more fresh weight. Aeration of the nutrient solution promoted plant development in several species; a lack of aeration has also been found to be a limiting factor in plant growth (Durell 1941).

pH of the solution: The pH is a parameter that measures the acidity or alkalinity of a solution. This value indicates the relationship between the concentration of free ions H^+ and OH present in a solution that ranges between 0 and 14. In this study, a hydroponic pH indicator was used to determine the pH of the solution. pH of the solution in aerated and non-aerated was taken before and after the conduct of the study (Table 4). The same trend of pH was obtained by aerated and non-aerated before the conduct of the study. While non-aerated obtained uniform pH after the conduct of the study, aerated

Table 2. Average number of leaves of lettuce per plant

Treatment	Number of leaves	
Main plot		
Aerated	7.75^a	
Non-aerated	6.37^a	
$LSD_{0.01}$	3.27	
Result	NS	
	Aerated (A)	Non-aerated (B)
Two sub-plots		
T_1: Control (water only)	5.10^d	4.23^d
T_2: SNAP	7.50^c	7.57^c
T_3: Masterblend (lettuce)	9.37^b	7.63^b
T_4: Masterblend (tomato)	12.20^a	8.07^a
T_5: Humus foliar fertilizer	4.60^d	4.35^d
$LSD_{0.01}$	-	1.97
Result	-	**
Two sub-plots (average all over main plot)		
T_1: Control (water only)	5.10^g	4.23^g
T_2: SNAP	7.50^{cd}	7.57^{cd}
T_3: Masterblend (lettuce)	9.37^b	7.63^{cd}
T_4: Masterblend (tomato)	12.20^a	8.07^{bc}
T_5: Humus foliar fertilizer	4.60^g	4.35^g
$LSD_{0.01}$	-	1.39
Result	-	**
CV (a) (%)	-	12.76
CV (b) (%)	-	11.67

Means within a row represented by common letters are not significant at 1% LoS; **Highly significant

Table 3. Average weight of the whole lettuce plant

Treatment	Weight (g)	
Main plot		
Aerated	71.04[a]	
Non-aerated	50.08[b]	
$LSD_{0.01}$	10.40	
Result	**	
	Aerated (A)	Non-aerated (B)
Two sub-plots		
T_1: Control (water only)	18.50[d]	17.78[d]
T_2: SNAP	82.98[c]	62.83[c]
T_3: Masterblend (lettuce)	112.13[b]	75.94[a]
T_4: Masterblend (tomato)	116.93[a]	69.32[b]
T_5: Humus foliar fertilizer	24.65[d]	24.54[d]
$LSD_{0.01}$	-	16.31
Result	-	**
Two sub-plots (average all over main plot)		
T_1: Control (water only)	18.50[g]	17.78[g]
T_2: SNAP	82.98[b]	62.83[de]
T_3: Masterblend (lettuce)	112.13[a]	75.94[bc]
T_4: Masterblend (tomato)	116.93[a]	69.32[cd]
T_5: Humus foliar fertilizer	24.65[g]	24.54[g]
$LSD_{0.01}$	-	11.53
Result	-	**
CV (a) (%)	-	4.74
CV (b) (%)	-	11.29

Means within a row represented by common letters are not significant at 1% LoS; **Highly significant

Table 4. pH of the solution after conducting the study

Treatment	Water pH			
	Aerated		Non-aerated	
	Before	After	Before	After
T_1: Control (water only)	7	7	7	7
T_2: SNAP	6	8	6	7
T_3: Masterblend (lettuce)	6	8	6	7
T_4: Masterblend (tomato)	6	8	6	7
T_5: Humus foliar fertilizer	7	8	7	7

Table 5. Cost and return analysis as per 7 x 3 m^2 greenhouse (Rs)

Treatment	Total cost of production	Gross income	Net income	Return on investment (%)
Aerated				
T_1: Control (water only)	9,772.75	3,174.60	-6,598.15	-67.52
T_2: SNAP	11,059.75	14,239.94	3,180.19	28.75
T_3: Masterblend (lettuce)	10,952.50	19,242.08	8,289.58	75.69
T_4: Masterblend (tomato)	11,274.25	20,064.62	8,790.37	77.97
T_5: Humus foliar fertilizer	14,062.75	4,230.51	-9832.23	-69.92
Non-aerated				
T_{1-} Control (Water only)	8,322.75	3,050.48	-5,272.27	-63.35
T_{2-} Snap	9,609.75	10,782.20	1,172.45	12.20
T_{3-} Masterblend (Lettuce)	9,502.50	13,030.73	3,528.23	37.13
T_{4-} Masterblend (Tomato)	9,824.25	11,895.88	2,071.63	21.09
T_{5-} Humus Foliar Fertlizer	12,612.75	4,211.06	-8,401.69	-66.61

The cost of production and yield per basin were multiplied by 143 to get the RoI of an area of 21 m^2 greenhouse treatment obtained neutral pH of 7 and treatments T_2, T_3, T_4 and T_5 obtained the same pH of 8 (means alkaline).

Cost and return analysis: The cost and return analysis of growing hydroponics lettuce is shown in Table 5. This was taken by converting the circumference of the basin into an area of 0.1225 m^2, the size of the greenhouse which was 7 x 3 m^2 less the 0.5 meter alleyway with the total of 17.5 m^2 divided by the area of the basin with 0.1225 m^2. The quotient is 143 sets of 0.1225 m^2 to occupy the area of the greenhouse. In descending order, plants grown in aerated condition, T_4 attained the highest return on investment with 77.97 per cent. It was followed by the plants grown in T_3 with 75.69 per cent and T_2 with 28.75 per cent and the rest obtained negative return of investment. In non-aerated, T_3 obtained the highest return of investment with 37.13 per cent followed by T_4 with 21.09 per cent and T_2 with 12.20 per cent and the rest obtained negative return on investment.

CONCLUSION

The study showed that the growth performance of lettuce was highly affected by the fertilizer masterblend (tomato) as source of nutrients under aerated condition. Using humus foliar fertilizer was not suitable for hydroponic growing of plants in both conditions. It is further concluded that masterblend (tomato) fertilizer had a greater advantage over the other fertilizers for growing hydroponic lettuce thus attaining higher return on investment.

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