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Performance of lettuce cultivars as affected by different nutrient concentrations under hydroponics production

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Abstract

Nutrient solution concentration is one of the most practical and effective ways of controlling and improving the yield and nutritional quality of crops for human consumption. The study was conducted to determine the effect of natural farming inputs as nutrient sources applied at different levels on hydroponically grown lettuce. It was conducted at Cagayan State University–Piat Campus from September to October 2019. A factorial experiment in Complete Randomized Design (CRD) was used and replicated four times using the 45 boxes with 8 plants in each planting box to test the following treatments: Factor A (Lettuce Cultivars) A_1 – Leafy Eton, A_2 – Leafy Red Solar, A_3–Altima; Factor B (Nutrient Management) F_1-25 ml SNAP Solution (Control) F_2–25 grams Master Blend (Control), F_3 - 40 ml Kuhol Amino Acid, F_4 – 40 ml Fish Amino Acid and F_5 – 20 ml KAA+20 ml FAA. Based on the result, lettuce cultivars did not show a significant effect on almost all the parameters measured; neither was there a significant interaction between the two factors tested in the experiment on all the data observed except for the root length, which showed a significant result. The following recommendations were formulated, the use of Leafy V1 (Leafy Eton) in all year round lettuce production supply can be achieved using a solution from SNAP and organic concoctions (KAA and FAA) as growing medium for urban hydroponics gardening and a follow-up study on the higher concentrations on KAA and FAA as a nutrient source in hydroponics production is also recommended.

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Introduction

One innovative technique of growing plants, a type of Horticulture and a subset of hydroculture, is the so-called hydroponics. Coined from the two Greek words *hydro* or water and *ponos* or labor—which means water work, hydroponics is a technique of growing plants, without soil, through nutrient solutions mixed in water. In other words, plants are cultivated on water-contained boxes and suitable containers, regardless of the use of inert media.

Known to have tested not just by reputable international researchers but verified locally as well, hydroponics has shown economy, efficiency, and effectiveness as an agricultural technique. It reduces and/or avoids excess water and fertilizer usage resulting in a conserved resource and lower farming cost without compromising the quality of the yield. Through such a technique, the usual problem of pests is controlled. Atrophied soil properties, weeds, and other adverse soil-related aspects are eliminated since it is soil-less. Hydroponically-grown plants are not susceptible to the challenges brought by climate; thus even off-season farming is feasible. Moreover, this technique is another way to compensate for the potential loss in crop production due to the conversion of some agricultural land for residential or industrial purposes.

In hydroponics production, farmers have been using commercial fertilizers as a nutrient source. Sometimes they opt to use natural farming inputs. In relation thereto, utilizing molasses as material for natural farming inputs could be an alternative nutrient source for hydroponics production. Molasses is readily accessible from the community with agro-industry factories and can be obtained for a minimal cost. To maximize the benefits that could be derived from this technique of farming, the study will be conducted incorporating the use of molasses (agricultural residue and waste from factories) as material for natural farming inputs, along with other nutrient sources, to come up with the treatment that is ideal for each of the different leafy vegetables. The positive result of this study will benefit lettuce growers and will also be introduced to areas with limited space. Hence, this study.

Generally, the study aimed to determine the performance of lettuce cultivars as affected by different organic nutrient concentrations in non-circulating hydroponics production. Specifically, it aimed to: (1) evaluate the nutrient composition of organic concoctions; (2) determine the agronomic characteristics and yield of lettuce cultivars, and (3) determine the interaction effect between three cultivars of lettuce and concentration of nutrients in the different treatments;

Materials and methods

The following materials were used in the study: lettuce seeds, SNAP solution, master blend, coco-coir, styro box, plastic styro cup, measuring device (graduated cylinder and ruler) cutter, water and fermented natural farm inputs (NFI's).

Experimental design and treatments

A factorial experiment in Complete Randomized Design (CRD) was used and replicated four times using the 32 boxes with 8 plants in each planting box to test the following treatments: Factor A (Lettuce Cultivars) A_1 – Leafy Eton, A_2 – Leafy Red Solar, A_3 – Altima; Factor B (Nutrient Management) F_1 - 25 ml SNAP Solution (Control) F_2 – 25 grams Master Blend (Control), F_3 - 40 ml Kuhol Amino Acid, F_4 – 40 ml Fish Amino Acid and F_5 – 20 ml KAA + 20 ml FAA.

Nutrient composition of different natural farming inputs

The samples of extracts were collected and submitted to the Cagayan Valley Integrated Agricultural Laboratory (CVIAL) at Tuguegarao City for analysis of each sample's total nitrogen, P-available, K-available and other micronutrients present as a basis for nutrient formulation.

Methods of analyzing the nutrient composition

The samples of extracts were collected and submitted to the Cagayan Valley Integrated Agricultural Laboratory at Tuguegarao City as a basis for nutrient formulation. Table 1 shows the mineral composition and concentration of the nutrient solution and they were analyzed using the different methods: Nitrogen –*Kjeldahl Jauber - Gunning*, Phosphorus - *Vanadomolybdate*, Potassium – *Flame Atomic Emission* while micronutrients were analyzed using *Atomic Absorption Spectrophotometric*.

Preparation of fermented natural farming inputs

Kuhol Amino Acid (KAA)

Collect the mollusk needed in extracting kuhol amino acid. Crush the mollusk into tiny pieces so that amino acids can be extracted easily. Put one (1) kg. of crushed mollusk in a pail; add 1 kg. of molasses, then mix thoroughly. Make sure that all crushed mollusk will be mixed with molasses so that the juice can be extracted easily.Cover the pail with paper or cloth, and secure it with a string or rubber. Use manila paper as cover to allow some air to get inside the pail and for the gas produced during the fermentation to escape. On the cover, write the date of processing and the expected date of harvest. Store the fermented kuhol amino acids in a safely chosen room.

Fish Amino Acid (FAA)

Collect a material needed in extracting fish amino acids, i.e., head or entrails of fresh fish, will be used because of its nutrient content. Crush the chosen material into pieces so that the juice will be extracted easily. Put 1 kg of chosen material in a pail, add 1 kg of molasses, then mix thoroughly. Make sure that all the chosen material will be mixed with molasses so that the juice can be extracted easily. Cover the pail with paper or cloth, and secure it with a string or rubber. Use paper or cloth as cover to allow some air to get inside the pail and for the gas produced during the fermentation to escape. On the cover, write the date of processing and the expected date of harvest. Store the fermented fish amino acids in a safely chosen room.

Preparation of seedlings and growing boxes

Prepare the Styrofoam cups. Use the serrated knife or saw to make 4-6 slits (about 2 inches long on the side and including about ½ inch at the bottom). Fill in the holding cups with the growing media (about 1 inch thick). Transplant a seedling from the sowing tray. "Dig" a hole in the middle of the growing media in the cup. Uproot with care the seedling from sowing tray using a bamboo stick—Transfer only one (1) seedling per cup. Press the media lightly around the base of the transplanted seedling. Water carefully the seedling plugs.

Preparation of growing boxes

Make 8 holes on the lid or cover of the box using the tin can borer. Use a plastic bag as a liner of the bottom half of the box to make it fit to hold the nutrient solution. Use packaging tape to close all open slits of the lid/cover to prevent the entry of mosquitoes.

Care and management of the crop

The nutrient solution to water ratio remained consistent. The pH was monitored for every replacement of the solution. Daily monitoring of the occurrence of insect pests was strictly monitored.

Harvesting

Harvesting was done 30 days after transplanting. Plant samples were tagged just at harvest to avoid intermixing of samples.

Data gathered

Plant Height (cm): Eight representative sample plants were used to measure the height of the plants at harvest. The total plant height was divided by eight to get the average height per plant.

Root Length (cm): The length of roots of the sample plants were measured from the base to the tip using the foot rule.

Length of Leaves (cm): The leaves were measured from the base up to the tip of the leaves and were divided by eight to get the average number of leaves per plant.

Number of Leaves: The leaves of the plants were counted at harvest. The total number of leaves of the sample plants was divided by eight to get the average number of leaves per plant.

Fresh Weight per Eight Sample Plants (g): The sample plants were immediately weighed after harvesting.

Statistical tool

The data will be analyzed using STAR, version 2.0.1 2014. Biometrics and Breeding Informatics, PBGB Division, International Rice Research Institute, Los Baños, Laguna following procedures for analysis of variance (ANOVA) for Complete Randomized Design (CRD) to test the significant differences among treatments. The Least Significance Difference (LCD) was used to analyze the mean comparison.

Results and discussion

Plant Height (cm)

Table 2 shows the performance of the three varieties of lettuce under a non-circulating hydroponics system in terms of plant height (cm). Results show that V_1 (Leafy Eton) obtained the tallest plants with a mean of 19.37, closely followed by V_3 (Altima) and V_2 (Leafy Red Solar) with corresponding means of 17.27 and 14.69 in the same order. Despite the numerical differences, no significant results were observed among the three varieties tested.

Table 1. Mineral composition and concentration of the nutrient solution used in Different Treatments.

	Nutrient Content						
Materials	N (%)	P (%)	K (%)	Zinc (ppm)	Copper (ppm)	Manganese (ppm)	Iron (ppm)
SNAP Solution A	0.07	0.64	3.84	1	2.5	17.5	1
SNAP Solution B	0.04	1.89	0.01	12.5	10	3225	160
Master Blend	0.88	1.28	5.19	3.0	10	550	65
Kuhol Amino Acid (KAA)	2.23	0.58	2.82	7.5	3	413	30
Fish Amino Acid (FAA)	1.90	0.33	1.03	7.5	1	442.5	195

The plant height as affected by different nutrient concentrations is presented in Table 3. The plants are grown in F_1 (25 ml SNAP solution) produced the tallest plants with a mean of 26.05 centimeters and the plants cultured in F_2 (25 ml Master Blend) are the shortest, producing a mean of 17.55 centimeters. Analysis of variance reveals a highly significant difference among treatments tested. On comparison among means, when F_3, F_4 and F_5 compared with each other, no significant difference existed but not when they were compared with F_1 and F_2 where the significant result was noted. Such differences in plant height were attributed to the effect of organic solution as a growing medium.

Table 2. Summary of statistical analysis of different cultivars of lettuce on hydroponics production.

Cultivars	Plant Height (cm)	Root Length (cm)	Length of Leaves (cm)	Number of Leaves	Fresh Weight per Plant (g)
V1	19.37	18.87	19.37	7.23	37.33
V2	14.69	22.79	14.7	7.46	19.33
V3	17.27	14.96	17.27	7.08	26.67
Result	Ns	**	ns	ns	ns
CV (%)	3.57	12.28	3.43	3.84	8.94

ns - not significant

** - highly significant.

The availability of all essential nutrients and their presence in appropriate ratios, and favorable external conditions as cited by Resh (2012); Sonneveld & Voogt (2010). Moreover, no interaction effect was observed between varieties and nutrient concentrations (Table 4).

Root Length (cm)

The root length (cm) of the three varieties of lettuce under a non-circulating hydroponics system was presented in Table 2. Results show that V_2 (Red Solar) obtained the longest roots with a mean of 18.87 cm, closely followed by V_1 (Leafy Eton) and V_3

(Altima) with a means of 18.87 and 14.96, respectively. Statistical analysis reveals a highly significant difference among treatments. These findings may be attributed that different environments can lead to the diversity of morphological structures and anatomical structures as a form of adaptation. The average length of roots as affected by different nutrient concentrations is shown in Table 3. Results reveal no significant differences among treatment means.

The plants are grown in F_1 (25 ml SNAP) produced the longest roots and the shortest F_2 (Master Blend) with a means of 21.46 cm and 16.17 cm in the same order. This means that different concentrations do not affect the plants in producing roots.

Table 3. Summary of statistical analysis on the effects different nutrient management on hydroponically grown lettuce.

Cultivars	Plant Height (cm)	Root Length (cm)	Length of Leaves (cm)	Number of Leaves	Fresh Weight per Plant (g)
F1	26.05	21.46	19.72	10.29	53.33
F2	17.55	16.17	13.22	5.51	16.67
F3	22.54	20.67	17.41	6.97	25.56
F4	22.33	16.95	16.82	6.6	20
F5	22.95	19.11	14.39	6.92	23.33
Result	**	ns	**	**	*
CV (%)	15	3.04	1.59	1.97	4.38

ns - not significant

* - significant

** - highly significant.

No significant effect was noted between the varieties of lettuce and nutrient concentrations (Table 4).

Length of Leaves (cm)

Table 2 presents the length of leaves (cm) of the three cultivars of lettuce under a non-circulating hydroponics system. Results reveal that V_1 (Leafy Eton) garnered the longest leaves with a mean of 19.37 cm, followed by V_3 (Altima) with 18.87 cm and V_2 (Red Solar) with14.7 cm. Statistical analysis reveals no significant difference among treatments despite numerical differences. Adaptation test for lettuce varieties is one alternative that can be conducted to determine how far lettuce plants can grow and adapt well to suboptimal environmental conditions so that later can be determined the type of lettuce varieties that are adaptive to local agro-climate (Calabria *et al.*, 2019). The length of leaves (cm) as affected by different nutrient concentrations is shown in Table 3. Results show highly significant differences among treatment means. The plants are grown in F1 (25 ml SNAP) produced the longest leaves and the shortest F2 (Master Blend) with a means of 19.72 cm and 13.22 cm, respectively. The significant differences in the study were attributed to the nutrient composition of the medium solution. The nutrient composition of solution can stimulate the growth and development of plants which can compensate for the toxic effects of other elements or may replace essential nutrients in a less specific role, as cited by Trejo-Téllez *et al.* (2007). No significant effect was noted between the varieties of lettuce and nutrient concentrations Table 4.

Number of Leaves

Table 2 presents the number of leaves of the three cultivars of lettuce under a non-circulating hydroponics system. Results show that V_2 (Red Solar) produced the most number of leaves, followed by V_1 (Leafy Eton) and V_3 (Altima) with a means of 7.46, 7.23 and 7.08, respectively. Analysis of variance reveals no significant difference among treatments. The number of leaves (cm) as affected by different nutrient concentrations is shown in Table 3. The plants are grown in F1 (25 ml SNAP) produced the most number of leaves and the least was F2 (Master Blend) with a means of 10.29 and 5.51, respectively. Statistical analysis reveals a highly significant difference among treatments. The significant differences in the study were attributed to the nutrient composition of the medium solution.

Table 4. Summary of interaction effect of cultivars of lettuce and nutrient management on hydroponics production.

Cultivars	Plant Height (cm)	Root Length (cm)	Length of Leaves (cm)	Number of Leaves	Fresh Weight per Plant (g)
V1F1	30.13	21	20.72	11.27	80
V1F2	21.95	16.83	16.61	5.72	16.67
V1F3	25.77	20.88	18.63	6.39	33.33
V1F4	25.5	16.94	19.02	6.0	26.67
V1F5	27.33	18.72	21.89	6.78	30
V2F1	22.98	26.08	18.32	9.33	26.67
V2F2	15.5	19.14	11.38	5.8	23.33
V2F3	18.64	27.0	15.33	7.52	16.67
V2F4	19.89	19.71	13.91	7.56	13.33
V2F5	18.94	22.03	14.55	7.08	16.67
V3F1	25.03	17.32	20.14	10.28	53.33
V3F2	15.2	12.54	11.66	5.0	10.0
V3F3	23.2	14.15	18.27	7.0	26.69
V3F4	21.59	14.21	17.52	6.22	20.0
V3F5	22.59	16.6	18.74	6.89	23.33
Result	ns	ns	ns	ns	*

ns - not significant
*significant.

The increasing number of plant leaves will eventually increase the overall leaf area; this means that the ability of plants to carry out photosynthesis increases so that the photosynthetic (photosynthate) results available will also increase and be used for further plant growth and development (Adams *et al.*, 2018). Bugbee (2003) stated that plants could grow equally well at pH between 4.0 and 7.0 if the required nutrients are available in the solution. The pH of the nutrient solution affects the availability of certain elements, particularly micronutrients (Bugbee, 2003). No interaction effect was noted between the varieties of lettuce and nutrient concentrations Table 4.

Fresh Weight of Leaves per Plant (g)

Table 2 presents the weight of fresh leaves per plant as affected by the three cultivars of lettuce. The plants are grown in V_1 (Leafy Eton) obtained the heaviest with a mean of 37.33 grams, followed by V_3 (Altima) and the least produced in V_2 (Red Solar) with a means of 26.67 grams and 19.33 grams, respectively. Despite numerical differences, no significant result was observed.

The fresh weight per plant as affected by the different concentrations is shown in Table 3. Results revealed significant differences among treatment means in the fresh weight per plant. The plants are grown in the SNAP (F1) solution produced the heaviest plant with a mean value of 53.33 grams, followed by the 40 ml KAA (T3) with 25.56 grams and the least in fresh weight was produced from the 20 ml KAA and 20 ml FAA (F5), 40 ml FAA (F4) and 40 ml FAA (F2) solutions with a comparable mean value of 25.33 grams, 20 grams and 16.67 grams, respectively. The yield of the crop from the essential elements is obtained from the growing medium. The most basic nutrient solutions consider in their composition only nitrogen, phosphorus, potassium, calcium, magnesium and sulfur and they are supplemented with micronutrients (Trejo-Téllez *et al.*, 2007). An important feature of the nutrient solutions is that they must contain the ions in solution and in chemical forms that can be absorbed by plants, according to Tyson *et al.* (2007). According to Santiago (2019), as cited by Uy *et al.*, 2021, reported in his study that plants grown in SNAP solution consistently produced the tallest, number of leaves, longest roots and the heaviest fresh weight per plant.

Table 4 presents the interaction effect between the two factors tested. Results further show that significant result was observed. This means that an increase in the fresh weight of plants was influenced by an increase in plant height, the number of leaves and root wet weight. The higher the lettuce plant and the more number of leaves, the fresh weight of the lettuce plant will also increase.

Conclusions

Based from the result of the study, the lettuce cultivars as a single factor did not show a significant effect on almost all the parameters measured; neither was there a significant interaction between the two factors tested in the experiment on all the data observed except for the root length, which showed the significant result. Results also revealed highly significant differences among treatment means in the fresh weight per plant, plant height (cm), length of leaves, and the number of leaves.

Recommendations

Based from the results and findings of the study, the use of Leafy V1 (Leafy Eton) in all year round lettuce production supply can be achieved using a solution from SNAP and organic concoctions (KAA and FAA) as growing medium for urban hydroponics gardening. A follow-up study on the higher concentrations of KAA and FAA as a nutrient source is in hydroponics production.

References

Adams WW, Stewart JJ, Demmig-Adams B. 2018. Photosynthetic Modulation in Response to Plant Activity and Environment. In The Leaf: A Platform for Performing Photosynthesis p 493-563. Springer, Cham. https://doi.org/10.1007/978-3-319-93594-2_18

Calabria JL, Lens PN, Yeh DH. 2019**.** Zeolite Ion Exchange to Facilitate Anaerobic Membrane Bioreactor Wastewater Nitrogen Recovery and Reuse for Lettuce Fertigation in Vertical Hydroponic Systems. Environmental Engineering Science. https://doi.org/10.1089/ees.(2018).0439

Bugbee B. 2003. Nutrient Management In Recirculating Hydroponic Culture. Acta Hortic. **648,** 99-112. https://doi.org/10.17660/ActaHortic.2004.648.12

Hatti SS, Londonkar RL, Patil SB, Gangawane AK, Patil CS. 2010. “Effect of Eisenia fetida vermiwash on the growth of plants.” Journal of crop Science **1(1),** 6. Retrieved on November 13, 2020 from https://bit.ly/2tTUND3

Michael Uy M, Florentino Tomaneng M, Gerald Seridon L. 2021. Effect of Natural Farming Inputs as Nutrient Source Applied at Different Levels on Hydroponically Grown Lettuce. International Journal of Biosciences **18(1),** 60-67. https://innspub.net/ijb/effect-natural-farming-inputs-nutrient-source-applied-different-levels-hydroponically-grown-lettuce/

Resh HM. 2016. Hydroponic food production: a definitive guidebook for the advanced home gardener and the commercial hydroponic grower. CRC Press. Retrieved on November 13, 2020 from http://bit.ly/31ccNEA

Santiago RT. 2019. Performance of Hydroponic Lettuce Using Organic Medium Solutions. International Journal of Ecology and Conservation,

29(1), 56-82. Retrieved on November 13, 2020 https://ejournals.ph/issue.php?id=1217

Sonneveld C, Voogt W. 2009. Nutrient management in substrate systems. In Plant nutrition of greenhouse crops (pp. 277-312). Springer, Dordrecht. Retrieved on November 13, 2020 from http://bit.ly/2S3kzwC

Trejo-Téllez LI, Gómez-Merino FC, Alcántara G. 2007. Elementos benéficos. Nutrición de cultivos. G. Alcántar, L. I. Trejo-Téllez (eds.). México, DF: MundiPrensa y Colegio de Postgraduados, 59-101. Retrieved on November 13, 2020. http://bit.ly/2RHZWqR

Tyson RV, Simonne EH, Davis M, Lamb EM, White JM, Treadwell DD. 2007. Effect of nutrient solution, nitrate-nitrogen concentration, and pH on nitrification rate in perlite medium. Journal of plant nutrition **30(6),** 901-913. Retrieved on November 13, 2020 from http://bit.ly/37EMg5o

Zambare VP, Padul MV, Yadav AA, Shete TB. 2008. Vermiwash: biochemical and microbiological approach as ecofriendly soil conditioner. ARPN Journal of Agricultural and Biological Science **3(4),** 1-5. Retrieved on November 13, 2020 from https://go.aws/37MMZS0