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Lettuce (*Lactuca sativa L.* var. Rincon) Production Using Organic Nutrient Solution Under Hydroponics System

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ABSTRACT

Lettuce is one of the most widely hydroponically grown crops and studies showed that lettuce has a high yield and good quality under a soilless production. However, the nutrient solution used in hydroponic systems is based on chemical fertilizers. Recently, there has been an increased interest in organic hydroponics as the market for organic food continues to grow. The study was conducted to evaluate commercially available organic nutrient solutions (Vermitea, BioVoltin, Ramils, Healthynest) in comparison to conventional inorganic fertilizers (Snap) in hydroponic lettuce production with water as a negative control. The crop experiment was carried out in a plastic polyhouse with a mesh net at the Institute of Agriculture, Camiguin Polytechnic State College – Catarman Campus, Tangaro, Catarman, Camiguin, from November 1, 2021, to December 15, 2021, using a Randomized Complete Blocked Design with three replications. Results of the study showed that among organic nutrient solution, Treatment 5 (Ramils) and Treatment 7 (Healthynest,), showed comparable results to conventional inorganic fertilizer, Treatment 1 (Snap) in terms of horticultural characteristics, root development, survival rate, yield, and sensory quality attributes and cost and return analysis. However, different organic nutrient solutions exhibited no significant effects on nutrient solution consumption per plant and total nutrient solution consumption. Treatment 5 (Ramils) was considered best overall in terms of sensory quality attributes, overall acceptability, and marketability except for color, succulence and bitterness followed by T1 and T7. Also, Treatment 5 (Ramils) and Treatment 7 (Healthynest) has the highest yield, hence generated the highest net returns, net profit margin and return on investment.

INTRODUCTION

Lettuce (*Lactuca sativa L.*) belongs to the Asteraceae family, and in terms of crop value, it is widely recognized as one of the most important leafy vegetables. It is a delicious vegetable consumed due to its crispness, pleasant aroma, and high levels of phytonutrients, such as phenolic components and vitamins (C, K and folate) (Ahmed *et al.*, 2021). The world's average lettuce productivity is 22.14 tons/ha (Food and Agriculture Organization of the United Nations, 2019), and the average productivity of the Philippines is 8.74 tons/ha, while for Camiguin, it is estimated to be about 2.96 tons/ha (Philippine Statistics Authority, 2020a, 2020b).

Lettuce is one of the most widely hydroponically grown vegetables and several studies showed that lettuce has a high yield and good quality under a soilless production system (Ahmed *et al.*, 2021). Hydroponics production is a cultivation technique involving growing crops in water using mineral nutrients with a growing media other than soil. Some factors that made hydroponics an important alternative crop production system include easy control of composition, absence of soil contamination, faster plant growth, short duration of crop cycles, high quality produce, and good consumer acceptance. It was reported that in tropical climates, a lettuce crop cycle of 70 days in normal soil cultivation is shortened to 30 days in a hydroponic system (Sapkota *et al.*, 2019).

Although hydroponic culture can produce better yield and quality, the nutrient solution used in hydroponic systems is based on chemical fertilizers and recently, there has been an increased interest in organic hydroponics as the market for organic food continues to grow (Ezziddine *et al.*, 2021). Another reason for the increasing interest in using organic nutrient sources in hydroponics is that lowering the use of conventional nitrate-based fertilizer sources may potentially reduce nitrate levels in food crops consumed by humans (Williams & Nelson, 2016).

Organic production using hydroponic systems is still under investigation and presents only a small niche of the large organic industry. Because of its complexity and challenges, information on vegetable crop cultivation in hydroponic systems supplemented with organic nutrients, particularly in liquid forms, is limited (Ahmed *et al.*, 2021); hence, this study was conducted. Generally, this study was conducted to evaluate commercially available organic nutrient solutions in comparison to commercial inorganic fertilizers in the production of lettuce. Specifically, it aimed to 1.) evaluate the growth performance of lettuce, 2.) determine the yield and its components, 3.) assess the nutrient solution consumption and quality, 4.) evaluate sensory quality attributes of lettuce, and 5.) determine the profitability of lettuce production.

MATERIALS AND METHODS

Study Area

The crop experiment was carried out in a plastic polyhouse with a mesh net at the Institute of Agriculture, Camiguin Polytechnic State College – Catarman Campus, Tangaro,

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Catarman, Camiguin, Philippines from November 1, 2021, to December 15, 2021. It was situated at 9º 07.019'N latitude and 124º41.240' E longitude, and 180 m above mean sea level. Natural solar radiation was the only light source inside the polyhouse with natural ventilation.

Materials

The materials used in the study are: lettuce seeds (Lactuva sativa L. var Rincon), seedling tray, hydroponics nutrient solution, sphagnum peat moss, coco peat, 34.5 in x 17 in x 7 in styro boxes, 20 cm x 30 cm x 0.003 mm polyethylene plastic sheets, plastic styrofoam cups, packaging tape, digital pH, TDS and EC meter, pH buffer solution, pH adjuster, 200 ml beaker, 25 ml graduated cylinder, digital weighing scale, pipette, stirring rod, vernier caliper, ruler, scissor, and plastic drum.

Methods

Experimental Design and Treatments

The experiment was laid out in a Randomized Complete Design (RCBD) with seven (7) treatments and three (3) replications at 8 plants per treatment. The following were the treatments:

T1 - Positive Control (Snap)
T2 - Negative Control (Water Only)
T3 - Vermitea
T4 - VegeGrow
T5 - Ramils
T6 - Biovoltin
T7 - Healthynest

The layout for Randomized Complete Block Design (Figure 2) was generated using the Statistical Tool for Agriculture Research (STAR) version 2.0.1 software.

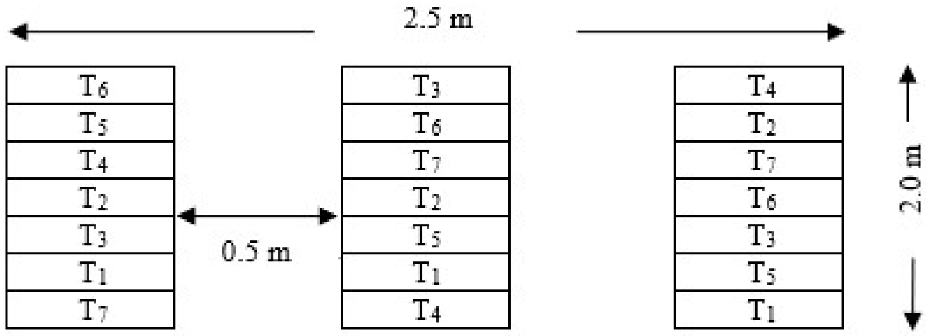

Figure 2: Lay-out of the experimental area

Cultural Management Practices

Seedlings Establishment

The seedling trays were filled with sphagnum peat moss, then it was packed and leveled. Seeds of lettuce (one seed per hole) was be sown in the seedling tray and placed under the shaded area. Watering was done liberally every day. After germination, around three to five days after seed sowing, the seedling was hardened by gradual exposure to sunlight (from day eight to fourteen). After 14 days, seedlings, the seedlings were transferred to individual growing cups (seedling plugs).

Seedling Plugs Preparation

Using a serrated knife or saw, four to six slits were made (about two-inch-long on the side and one-half inch at the bottom) on the Styrofoam cups. The growing cups was filled with the growing media about one inch thick. Growing media was sterilized either by solarization or adding boiled water to it. A hole was dug in the middle of the growing media in the cup.

Using a bamboo stick, the seedlings from the seedling tray was uprooted and transplanted into the seedling plug (one seedling per cup).

The growing media around the base of the transplanted seedling was lightly pressed and the seedling plug was watered carefully. For the foam, a one inch by one-inch dimension prepared and a cut of one-half inch will be made. Seedlings was inserted in the cut section of the foam.

Growing Boxes Preparation

Using a tin can borer, 8 holes were made on the Styrofoam (20 in x 16 in x 6 in). Polyethylene plastic was used as a liner to the bottom of the empty soda box (side plastic casing removed) and was fitted to hold the nutrient solution. Using a packaging tape, all the slits and end points were secured to prevent entry of mosquitoes.

Operation of Hydroponics System

The hydroponics system was located in an area where it received the morning sunlight (earlier and longer) under a polyethylene house. The growing boxes was linearly arranged on a level bench with covers removed. Each growing box was filled with tap water. Nutrient solution was added to each box according to the recommended dilution and stirred thoroughly. The cover/lid was placed over the boxes. Seedling plugs was inserted into the holes of the lid/cover to make it sure that all was properly plug in the holes. The bottom of the seedling plug was checked in order to ensure that it touched the nutrient solution by one-half inch, not deeper or shallower. If not, addition of tap water was done until the desired depth has reached. Leaks was examined and if there were the necessary troubleshooting has done.

Application of Treatment

Application rate of nutrition followed as prescribed by the manufacturer's guidelines as follows: a) SNAP (2.5 ml of SNAP A and SNAB solution per liter of water for), b.) Vermitea (15 ml per liter of water), c.) Vegegrow (8 ml per liter of water), d.) Ramil's (1 ml part A, 1 ml part B, and 0.5 ml part C per liter of water), e.) Biovoltin (1 g per liter of water), and f.) Healthynest (1 ml part A, 1 ml part B, and 0.5 ml part C per liter of water).

Pest and Disease Control

The researcher visited the experimental set-up daily, especially early in the morning to monitor the presence of insect pest and diseases. Insect pest that can be hand-picked was removed manually. Another option was to spray a mixture of food grade Hydrogen Peroxide (H_2O_2) to water (10 ml H_2O_2 to 1 L water).

Harvesting

Harvesting was done early in the morning or late in the afternoon where there is less transpiration and avoiding moisture loss of the leafy vegetable. Lettuce was harvested 45 days after seed sowing or 31 days after transplanting.

Data Gathered

The following data were gathered:

Growth Parameters

Plant height (cm)

This was done by stretching the leaves and then measuring from the stem base to the highest plant tip using a standard ruler (Poliquit *et al.* 2019; Safitri *et al.* 2019; Lau and Mattson 2021) from eight plants at harvest time.

Leaf width (cm)

This was taken by measuring the cross section of the three randomly selected fully expanded leaves per plant using a standard ruler (Lau and Mattson 2021; Poliquit *et al.* 2019; Safitri *et al.* 2019) from the lower, middle and upper sections of the leaves (leaves were divided equally into three sections) during harvest.

Leaf blade length (cm)

This was obtained by getting the length of the leaf from the bases to the tips of the largest, medium-size, and smallest leaf from three randomly selected fully expanded leaves per plant using a standard ruler (Poliquit *et al.* 2019; Gobilik *et al.* 2021) during harvest.

Canopy diameter (cm)

This was measured by a ruler through the widest vegetable canopy diameter position from a canopy edge on one side to the edge of the other side (Wiangsamut and Koolpluksee 2020) and it was done during harvest.

Number of leaves per plant

This was taken by counting the number of leaves produced per plant for all the samples per treatment during the termination of the study or harvest time (Mahlangu *et al.* 2016; Majid *et al.* 2021; Harahap *et al.* 2020; Wiangsamut and Koolpluksee 2020; Safitri *et al.* 2019; Poliquit *et al.* 2019; Gobilik *et al.* 2021).

Root length (cm)

This was obtained by measuring the longest roots of the lettuce at harvest (Gobilik *et al.* 2021; Lau and Mattson 2021; Poliquit *et al.* 2019; Gonzaga *et al.* 2018) during the termination of study or harvest time.

Root volume (mL)

This was measured by using graduated cylinder by putting the roots inside water contained graduated cylinder, the volume difference before and after roots inserted then became the roots volume (Harahap *et al.* 2020; Gonzaga *et al.* 2018) during harvesting time.

Root fresh weight (g)

This was determined by weighing the roots using a digital analytical balance (Jordan *et al.* 2018; Abd-Elmoniem *et al.* 1996; Gonzaga *et al.* 2018; Gobilik *et al.* 2021; Mahlangu *et al.* 2016; Safitri *et al.* 2019) at harvesting time.

Total fresh weight (g)

This is the total fresh matter weight and was measured by adding the fresh weight of lettuce head and root fresh weight (Jordan *et al.* 2018) during harvest.

Percentage of roots per plant (%)

This was calculated as the ratio between the root fresh weight and total fresh weight (Jordan *et al.* 2018).

Survival rate (%)

This was measured by counting the number of live plants divided by the total number of plants per treatment (Gonzaga *et al.* 2018).

Yield and Its Component

Number of marketable and marketable head

This was done by counting the number of marketable and non-marketable head of lettuce (Diputado *et al.* 2005; Gonzaga *et al.* 2018) and it was done during harvest.

Head fresh weight (g)

This was measured by weighing the marketable and non-marketable head of lettuce using a digital analytical weighing scale during the harvest. Average values was taken by dividing the total fresh weight of lettuce head to the total number of plants per treatment (Diputado *et al.* 2005; Gonzaga *et al.* 2018) and is was done after harvest.

Total yield (g)

This refers to the total weight of marketable and non-marketable yield of lettuce head (Poliquit *et al.* 2019; Diputado *et al.* 2005)

Harvest index

This was calculated by comparing economical and biological values of the plant (Harahap *et al.* 2020).

$$Harvest\ Index = \frac{Head\ fresh\ weight\ (g)}{Head\ fesh\ weight + Root\ fresh\ weight\ (g)}\ x\ 100\% \quad .....(1)$$

Nutrient Solution Consumption and Water Quality

Total nutrient solution consumption (L)

This was done by measuring the total nutrient solution added to the growing box for the whole duration of the study less the remaining nutrient solution at the termination of the study (Harahap *et al.* 2020).

Nutrient solution consumption per plant (L)

This was measured by dividing the total water consumption of the plant to the total number of plants per box per treatment (Harahap *et al.* 2020).

pH, TDS

The pH and TDS for the nutrient solution was measured at 7, 21, 28, and 35 days after transplanting using a portable pH and TDS meter.

Sensory Quality Attributes and Marketability

Visual (intensity of color), Aroma (typical lettuce aroma), Texture (Succulence, Crispness), Bitterness, Overall Flavor (typical lettuce flavor), Overall Acceptability, and Marketability

At harvest, 3 heads from each treatment was selected randomly, washed, air-dried, wrapped, and distributed to 30 untrained panel members for evaluation (Alsadon 1993). Evaluation was based on the following scale below:

Cost and Return Analysis

The cost and return analysis were based on the actual record of the cost and the computed gross sale. Simple accounting was used to wit:

a) $Net\ Profit\ Margin = \frac{Net\ Income}{Total\ Sales}\ x\ 100$ (2)

b) $Return\ on\ Investment = \frac{Average\ Net\ Income}{Total\ Cost\ of\ Production}\ x\ 100$ (3)

c) $Net\ Return = Total\ Return - Total\ Cost$ (4)

Statistical Tools and Analysis

The data gathered was analyzed using ANOVA by the Statistical Tool for Agricultural Research (STAR) version 2.0.1 software and it was compared using Tukey's Test at 5% level of significance.

Table 1: Sensory Attribute Quality and Marketability Scale

Hedonic Scale	Limits	Descriptive Equivalent										Verbal Interpretation
		Color1	Appearance[2]	Aroma[3]	Crispness[2]	Succulence[2]	Overall Texture[2]	Bitterness[4]	Overall Flavor[3]	Overall Acceptability[3]	Marketability[4]	
5	4.21-5.00	Extremely green	Excellent- Essentially free from defects	Like Extremely	Extremely crisp	Extremely succulent	Extra-hard, over mature, may have cracked ribs	Not bitter	Extremely like	Excellent	Extremely Likely to buy	Extremely like
4	3.21-4.20	Very green	Good- minor defects; not objectionable	Like Moderately	Very Crisp	Very Succulent	Hard, compact and solid	Slightly bitter	Moderately like	Very Good	Moderately likely to buy	Moderately like
3	2.41-3.20	Green	Fair-slightly to moderately objectionable defects; lower limit of sales appeal	Neither like or dislike	Crisp	Succulent	Firm, compact but may yield slightly to moderate pressure	Bitter	Neither like nor dislike	Fair	Neither likely nor unlikely to buy	Neither like nor dislike
2	1.81-2.40	Slightly green	Poor, excessive defects, limit of salability	Dislike moderately	Slightly crisp	Slightly succulent	Fairly firm, neither soft nor firm, good head formation	Very Bitter	Moderately dislike	Poor	Moderately unlikely to buy	Moderately dislike
1	1.00-1.80	Almost white	Extremely Poor, not usable	Dislike extremely	Not crisp	Not succulent	Soft, easily compressed or spongy	Extremely bitter	Extremely dislike	Dislike	Very unlikely to buy	Extremely dislike

[1]*Chikpah et al. (2014),* [2]*Alsadon (1993),*[3]*Zurbano (2017),* [4]*Holmes et al. (2019)*

RESULTS AND DISCUSSION

Horticultural Characteristics

The type of nutrient solutions had significantly affected the horticultural characteristics of lettuce plants (Table 2). Lettuce grown on Healthynest (T7) produced taller plants, closely followed by T1 (Snap) and T5 (Ramils) while T2 (Negative Control-Water) and T4 (Vegerow) produced shorter plants. T1 exhibited broader leaves, longer leaf blade, wider canopy, and greater number of leaves followed by T7 and T5. T2 produced narrower leaves, shorter leaf blade, narrower canopy and lesser number of leaves. This result confirms the study of Borres *et al.* (2022) who reported that plant height, leaf width, leaf blade length and number of leaves grown using chemical nutrition solution T1 (Snap) had the optimum level of nutrients for horticultural growth and development. However, using organic nutrient solution T5 and T7 did not differ significantly to using chemical nutrient solution, T1. This was reported by Phibunwatthanawong & Riddech (2019) in which using organic fertilizer for hydroponic systems had similar growth effect as chemical fertilizers.

Table 2: Horticultural characteristics of lettuce 45 days after seed sowing as affected by different organic nutrient solution

Treatment	Plant height (cm)	Leaf width (cm)	Leaf blade length (cm)	Canopy diameter (cm)	Number of leaves
T1-Snap	17.07a	6.16a	9.82a	18.67a	18.88a
T2-Water	3.02c	0.58d	2.65b	1.89d	3.00b
T3-Vermitea	6.72c	2.25cd	4.76ab	5.64cd	5.38b
T4-VegeGrow	6.56c	1.62cd	5.21ab	5.73cd	6.25b
T5 -Ramils	15.44ab	4.27abc	9.28a	17.05ab	17.29a
T6-BioVoltin	7.68bc	3.24bcd	7.92ab	10.28bc	7.12b
T7-Healthynest	17.50a	5.90ab	9.73a	18.54a	18.28a
HSDα0.05	**	**	**	**	**
CV (%)	27.97	27.49	27.16	24.72	25.87

*Mean followed by the same letter in the same column are not significantly different at the level of a = 0.05 based on Tukey's' Honest Significant Difference (HSD) Test *significant, **highly significant, non-significant.*

Horticultural root development characteristics and survival rate

Table 3 shows that a highly significant variation was observed on the root volume, root fresh weight, total fresh weight and percentage root per plant while no significant variation found on root length and survival rate. T3 (BioVoltin) exhibited longer roots, T7 with higher root volume, root fresh weight, and total fresh weight, T2 with higher percentage root per plant and a 100% survival rate for all treatments. T5 exhibited shorter root length, T2 with lighter root volume, root fresh weight, and total fresh weight, and T1 with lower percentage root per volume. The root formation and root growth are greatly affected by availability of dissolved oxygen (Soffer & Burger, 1998). Using an organic nutrient solution in a hydroponics system, the root zone will have a high oxygen biological demand due to the presence of organic carbon compounds (Ezzidine *et al.*, 2021). Under a Kratky hydroponics set-up, where there is limited aeration, hence, reduces root formation and development.

Table 3: Horticultural root development characteristics and survival rate of lettuce 45 days after seed sowing as affected by different organic nutrient solution

Treatment	Root length (cm)	Root volume (mL)	Root fresh weight(g)	Total fresh weight (g)	Percentage root per plant (%)	Survival rate (%)
T1-Snap	31.11	(mL)	6.50a	99.33a	6.33b	100.00
T2-Water	22.12	1.00c	1.00c	2.00c	50.00a	100.00
T3-Vermitea	22.13	1.25c	1.71c	9.58c	11.33b	100.00
T4-VegeGrow	27.22	1.67bc	2.38bc	10.00c	49.00a	100.00
T5-Ramils	20.38	4.13abc	4.79ab	63.33b	7.33b	100.00
T6-BioVoltin	33.71	3.21abc	3.50bc	19.62c	17.67ab	100.00
T7-Healthynest	27.47	5.04a	7.62a	100.79a	7.33b	100.00
HSDα0.05	ns	**	**	**	**	ns
CV (%)	30.49	36.99	26.14	16.43	61.89	22.91

*Mean followed by the same letter in the same column are not significantly different at the level of a = 0.05 based on Tukey's' Honest Significant Difference (HSD) Test *significant, **highly significant, non-significant.*

Yield Parameters

The type of organic nutrient solution had a highly significant effect on number of marketable and non-market head of lettuce, weight of marketable head per box and total yield per box. However, no significant difference was observed on fresh head weight per plant, non-marketable head per box and harvest index. T1 had higher fresh head weight per plant and harvest index, T7 higher number of marketable head, weight of marketable head, and total yield per box, T2 and T6 with higher number of non-marketable head, and T6 with higher non-marketable head weight per box. T2 had lower fresh head weight per plant, non-marketable head weight per box, total yield and harvest index, T2-T4 and T6 with lesser number of marketable head and marketable head weight per box, and T7 the lower number of non-marketable head. The studies of Shinohara *et al.*, 2021, Kawamura-Aoyama *et al.*, 2014, and Phibunwatthanawong & Riddech, 2021 have reported the possibility of growing vegetables using organic nutrient solutions. It was reported by William and Nelson (2014) that lettuce grown in organic nutrient solution under a nutrient film technique had a lower fresh and dry weights compared to conventional inorganic fertilizer cultivation. Additionally, most of the nutrients in organic sources, are not in ionic forms and, hence, are not directly available for plants (Ezziddine, Liltved, & Seljasen, 2021). However, Phibunwatthanawong & Riddech (2021) reported similar growth effect on chemical fertilizers.

Nutrient solution consumption and quality

Different organic nutrient solution exhibited no significant effects on, nutrient solution consumption per plant and total nutrient solution consumption (Table 5). T6 has highest nutrient solution consumption and total water consumption with T3 and T5 the lowest nutrient solution consumption per plant and total nutrient solution consumption, respectively. The pH and total dissolved solids (TDS) changes over time during the lettuce production. T1 has the lowest pH and TDS while T2 has the lowest pH and TDS. The pH of the nutrient solution controls the availability of the fertilizer salts and TDS on the other hand refers to the available salts and nutrients in the water. For lettuce, a pH value of 5.6-5.8 is considered optimum and a TDS of Nutrient deficiencies may occur at ranges above or below the acceptable range (Brechner &.Both, 2013).

Table 4: Yield parameters of lettuce 45 days after seed sowing as affected by different organic nutrient solution

Treatment	Fresh head weight plant-1 (g)	Marketable head		Non-marketable head		Total Yield (g box^{-1})	Harvest Index (%)
T1-Snap	46.65	7.33a	686.00a	0.67b	56.67	742.67a	93.36
T2-Water	1.00	0.00b	0.00c	8.00a	8.00	8.00c	50.00
T3-Vermitea	7.88	0.00b	0.00c	5.33ab	63.00	63.00c	55.45
T4-VegeGrow	7.63	0.00b	0.00c	8.00a	61.00	61.00c	51.22
T5-Ramils	1.67	7.00a	455.00b	1.00b	13.33	468.33b	92.36
T6-BioVoltin	16.12	0.00b	0.00c	8.00a	129.00	129.00c	82.22
T7-Healthynest	2.50	8.00a	725.33a	0.00b	20.00	745.33a	92.42
HSDα0.05	ns	**	**	**	ns	**	ns
CV (%)	207.67	13.68	22.87	42.40	125.54	17.84	28.56

*Mean followed by the same letter in the same column are not significantly different at the level of a = 0.05 based on Tukey's' Honest Significant Difference (HSD) Test. *significant, **highly significant, non-significant*

Table 5: Nutrient solution consumption and quality of nutrient solution of lettuce 45 days after seed sowing as affected by different organic nutrient solution

Treatment	Nutrient solution consumption plant-1	Total nutrient consumption	pH				TDS (ppm)			
	(L)	(L)	7 DAT	14 DAT	21 DAT	31 DAT	7 DAT	14 DAT	21 DAT	31 DAT
T1-Snap	3.93	31.40	6.76c	6.34c	6.30c	6.79	261.67bc	211.67bc	226.67cd	200.00b
T2-Water	4.10	32.77	7.42a	7.25a	7.59ab	8.07	58.33c	50.00c	48.67d	49.33b
T3-Vermitea	2.84	33.50	6.90c	6.86abc	6.80abc	6.94	770.33a	653.00a	740.67bc	731.67a
T4-VegeGrow	4.15	33.20	7.29ab	6.79abc	7.80a	7.02	644.33a	541.00ab	579.67bc	498.67a
T5-Ramils	3.72	29.70	6.99bc	6.60bc	6.57bc	6.82	144.33c	472.33ab	1442.33a	184.67b
T6-BioVoltin	4.21	33.70	7.31ab	7.09ab	7.35abc	7.22	611.33a	510.33ab	753.33b	611.00a
T7-Healthynest	4.05	32.40	6.96c	6.56bc	6.61bc	7.04	520.00ab	465.33ab	404.00bcd	247.67b
HSDα0.05	ns	ns	**	**	**	ns	**	**	**	**
CV (%)	24.41	6.89	1.64	3.06	5.87	7.17	21.07	33.49	30.52	22.77

*Mean followed by the same letter in the same column are not significantly different at the level of a = 0.05 based on Tukey's Honest Significant Difference (HSD) Test. *significant,*
***highly significant, non-significant.*

Table 6: Sensory quality attributes of lettuce and marketability45 days after seed sowing as affected by different organic nutrient solution

Treatment	Color	Appearance	Aroma	Crispness	Succu-lence	Overall Texture	Bitterness	Overall Flavor	Overall cceptability	Marketability
T1-Snap	4.83[a]	4.07[b]	4.07[b]	3.82[b]	4.07[a]	4.32[b]	3.82[b]	4.32[b]	4.32[c]	4.32[c]
T2-Water	1.01[f]	1.01[e]	1.01[e]	1.01[e]	1.01[e]	1.01[e]	1.01[e]	1.01[e]	1.01[f]	1.01[f]
T3-Vermitea	2.26[e]	2.26[d]	2.01[d]	2.01[c]	1.76[d]	2.26[d]	2.26[d]	2.51[c]	1.76[e]	1.51[e]
T4-VegeGrow	1.01[f]	1.01[e]	1.01[e]	1.01[e]	1.01[e]	1.01[e]	1.01[e]	1.01[e]	1.01[f]	1.01[f]
T5-Ramils	4.03[b]	4.78[a]	4.53[a]	4.03[a]	3.78[b]	4.53[a]	3.78[b]	4.53[a]	4.78[a]	4.78[a]
T6-BioVoltin	2.53[d]	2.78[c]	2.78[c]	1.78[d]	1.78[d]	2.53[c]	2.53[c]	2.28[d]	2.53[d]	2.28[d]
T7-Healthynest	3.78[c]	4.03[b]	4.03[b]	4.03[a]	3.53[c]	4.28[b]	4.28[a]	4.28	4.53[b]	4.53[b]
HSDα0.05	**	**	**	**	**	**	**	**	**	**
CV (%)	1.37	1.33	1.37	1.50	1.57	1.33	1.42	1.33	1.33	1.37

*Mean followed by the same letter in the same column are not significantly different at the level of a = 0.05 based on Tukey's Honest Significant Difference (HSD) Test. *significant,*
***highly significant, non-significant.*

Sensory quality attributes and marketability of lettuce
Table 6 shows a highly significant variation was observed on the sensory quality attributes and marketability of lettuce. T5 was considered best overall which had higher mean values of appearance aroma, crispness, overall texture, overall flavor, overall acceptability and overall marketability except for color, succulence and bitterness. This is followed by T1 and T7.

Cost and Return Analysis of Lettuce
Cost and return analysis of lettuce using different organic nutrient solution is presented in Table 7. Lettuce production using organic nutrient solution has a higher cost of production particularly T4 due to the cost of organic nutrient solution used. Gross income, net return, net profit margin, and return on investment were higher in T7, followed by T5 and T1. Treatment 6 obtained the lowest net return, as well as lowest net profit margin, and return on investment together with T2 and T3 due to its high production cost and lower yields.

Table 7: Yield parameters of lettuce 45 days after seed sowing as affected by different organic nutrient solution

Treatment	Gross Income (PhP)	Total Expenses (PhP)	Net Return	Net Profit Margin	Return on Investment (%)
T1-Snap	5132.82[a]	4416.2250	716.59[a]	12.37[ab]	16.00[a]
T2-Water	0.00[b]	3756.2250	-3756.22[b]	0.00[b]	-1.00[b]
T3-Vermitea	0.00[b]	4194.0250	-4194.02[b]	0.00[b]	-1.00[b]
T4-VegeGrow	4899.51[a]	4680.2250	340.28[a]	5.66[ab]	7.00[a]
T5-Ramils	5366.13[a]	4636.2250	949.90[a]	17.37[ab]	22.00[a]
T6-BioVoltin	0.00[b]	4438.2250	-4438.23[b]	0.00[b]	-1.00[b]
T7-Healthynest	5599.44[a]	4196.2250	1403.21[a]	25.06[a]	33.00[a]
HSDα0.05	**	ns	**	*	**
CV (%)	15.56	0.00	36.38	101.09	33.03

*Mean followed by the same letter in the same column are not significantly different at the level of a = 0.05 based on Tukey's Honest Significant Difference (HSD) Test. *significant, **highly significant, non-significant.*

CONCLUSIONS

This study shows that hydroponics lettuce production using organic nutrient solution is comparable to conventional nutrient solutions. However, among the different organic nutrient solution, hydroponics lettuce production using T5 (Ramils) and T7 (Healthynest) performed well as it significantly increased yield and is economically viable. Results imply that hydroponics lettuce production using organic nutrient solution will perform similarly under favorable conditions. It is recommended that the same study be conducted during the dry season to verify the performance of lettuce at a different time of the year.

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