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 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 overall acceptability, and marketability except for color, succulence and bitterness followed by T1 and T7.

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,
Catarman, Camiguin, Philippines from November 1, 2021, to December 15, 2021. It was situated at 9°07.019’N latitude and 124°41.240’E longitude, and 180 m above mean sea level. Natural solar radiation was the only light source inside the polyhouse with natural ventilation.

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.

Materials

The materials used in the study are: lettuce seeds (*Lactuca 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, scissors, and plastic drum.

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 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),

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[https://journals.e-palli.com/home/index.php/ajaset](https://journals.e-palli.com/home/index.php/ajaset)
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 (H₂O₂) to water (10 ml H₂O₂ 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 it 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).

\[
Harvest\ Index = \frac{Head\ fresh\ weight\ (g)}{Head\ fresh\ weight + Root\ fresh\ weight\ (g)} \times 100\% \tag{43}
\]
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:

\[
\text{Net Profit Margin} = \frac{\text{Net Income}}{\text{Total Sales}} 
\]

\[
\text{Return on Investment} = \frac{\text{Average Net Income}}{\text{Total Cost of Production}} \times 100
\]

\[
\text{Net Return} = \text{Total Return} - \text{Total Cost}
\]

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

<table>
<thead>
<tr>
<th>Hedonic Scale</th>
<th>Limits</th>
<th>Descriptive Equivalent</th>
<th>Verbal Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1-0.1</td>
<td>Almost white</td>
<td>Extremely dislike</td>
</tr>
<tr>
<td>2</td>
<td>1.00-1.80</td>
<td>Slightly green</td>
<td>Not dislike</td>
</tr>
<tr>
<td>3</td>
<td>1.81-2.40</td>
<td>Poor, slightly</td>
<td>Slightly dislike</td>
</tr>
<tr>
<td>4</td>
<td>2.41-4.20</td>
<td>Moderate, fair-slightly</td>
<td>Slightly dislike</td>
</tr>
<tr>
<td>5</td>
<td>4.21-5.60</td>
<td>Almost white</td>
<td>Excellent dislike</td>
</tr>
</tbody>
</table>

\( ^{1} \text{Chikpah et al. (2014), Alsadon (1993), Zurbano (2017), Holmes et al. (2019)} \)
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 T3 (Ramils) while T2 (Negative Control-Water) and T4 (Vegegrow) 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 & Riddoch (2019) in which using organic fertilizer for hydroponics 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

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Root length (cm)</th>
<th>Leaf width (cm)</th>
<th>Leaf blade length (cm)</th>
<th>Canopy diameter (cm)</th>
<th>Number of leaves</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1-Snap</td>
<td>17.07a</td>
<td>6.16a</td>
<td>9.82a</td>
<td>18.67a</td>
<td>18.88a</td>
</tr>
<tr>
<td>T2-Water</td>
<td>3.02c</td>
<td>0.58d</td>
<td>2.65b</td>
<td>1.89d</td>
<td>3.00b</td>
</tr>
<tr>
<td>T3-Vermitea</td>
<td>6.72c</td>
<td>2.25cd</td>
<td>4.76ab</td>
<td>5.64cd</td>
<td>5.38ab</td>
</tr>
<tr>
<td>T4-VegeGrow</td>
<td>6.56c</td>
<td>1.62cd</td>
<td>5.21ab</td>
<td>5.73cd</td>
<td>6.25b</td>
</tr>
<tr>
<td>T5-Ramils</td>
<td>15.44ab</td>
<td>4.27abc</td>
<td>9.28a</td>
<td>17.05ab</td>
<td>17.29a</td>
</tr>
<tr>
<td>T6-BioVoltin</td>
<td>7.68bc</td>
<td>3.24bed</td>
<td>7.92ab</td>
<td>10.28bc</td>
<td>7.12b</td>
</tr>
<tr>
<td>T7-Healthynest</td>
<td>17.50a</td>
<td>3.90ab</td>
<td>9.73a</td>
<td>18.54a</td>
<td>18.28a</td>
</tr>
<tr>
<td>HSD0.05**</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>CV (%)</td>
<td>27.97</td>
<td>27.49</td>
<td>27.16</td>
<td>24.72</td>
<td>25.87</td>
</tr>
</tbody>
</table>

Mean followed by the same letter in the same column are not significantly different at the level of α = 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 root 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

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Root length (cm)</th>
<th>Root volume (mL)</th>
<th>Root fresh weight (g)</th>
<th>Total fresh weight (g)</th>
<th>Percentage root weight per plant (%)</th>
<th>Survival rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1-Snap</td>
<td>31.11</td>
<td>(mL)</td>
<td>6.50a</td>
<td>99.33a</td>
<td>6.33b</td>
<td>100.00</td>
</tr>
<tr>
<td>T2-Water</td>
<td>22.12</td>
<td>1.00c</td>
<td>1.00c</td>
<td>2.00c</td>
<td>50.00a</td>
<td>100.00</td>
</tr>
<tr>
<td>T3-Vermitea</td>
<td>22.13</td>
<td>1.25c</td>
<td>1.71c</td>
<td>9.58c</td>
<td>11.33b</td>
<td>100.00</td>
</tr>
<tr>
<td>T4-VegeGrow</td>
<td>27.22</td>
<td>1.67bc</td>
<td>2.38bc</td>
<td>10.00c</td>
<td>49.00a</td>
<td>100.00</td>
</tr>
<tr>
<td>T5-Ramils</td>
<td>20.38</td>
<td>4.13abc</td>
<td>4.79ab</td>
<td>63.33b</td>
<td>7.33b</td>
<td>100.00</td>
</tr>
<tr>
<td>T6-BioVoltin</td>
<td>33.71</td>
<td>3.21abc</td>
<td>3.50bc</td>
<td>19.62c</td>
<td>17.67ab</td>
<td>100.00</td>
</tr>
<tr>
<td>T7-Healthynest</td>
<td>27.47</td>
<td>5.04a</td>
<td>7.62a</td>
<td>100.79a</td>
<td>7.33b</td>
<td>100.00</td>
</tr>
<tr>
<td>HSD0.05**</td>
<td>ns</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>CV (%)</td>
<td>30.49</td>
<td>36.99</td>
<td>26.14</td>
<td>16.43</td>
<td>61.89</td>
<td>22.91</td>
</tr>
</tbody>
</table>

Mean followed by the same letter in the same column are not significantly different at the level of α = 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-marketable 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**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fresh head weight plant-1 (g)</th>
<th>Marketable head (g)</th>
<th>Non-marketable head (g)</th>
<th>Total Yield (g box-1)</th>
<th>Harvest Index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1-Snap</td>
<td>46.65</td>
<td>7.33a</td>
<td>686.00a</td>
<td>0.67b</td>
<td>56.67</td>
</tr>
<tr>
<td>T2-Water</td>
<td>1.00</td>
<td>0.00b</td>
<td>8.00a</td>
<td>5.33ab</td>
<td>63.00</td>
</tr>
<tr>
<td>T3-Vermitea</td>
<td>7.88</td>
<td>0.00b</td>
<td>5.33ab</td>
<td>8.00a</td>
<td>8.00c</td>
</tr>
<tr>
<td>T4-VegeGrow</td>
<td>7.63</td>
<td>0.00b</td>
<td>6.00a</td>
<td>61.00</td>
<td>61.00c</td>
</tr>
<tr>
<td>T3-Ramils</td>
<td>1.67</td>
<td>0.00b</td>
<td>1.00b</td>
<td>13.33</td>
<td>468.33b</td>
</tr>
<tr>
<td>T6-BioVoltin</td>
<td>16.12</td>
<td>0.00b</td>
<td>8.00a</td>
<td>8.00</td>
<td>8.00c</td>
</tr>
<tr>
<td>T7-Healthynest</td>
<td>2.50</td>
<td>0.00b</td>
<td>20.00</td>
<td>74.53a</td>
<td>92.42</td>
</tr>
<tr>
<td>HSDα0.05</td>
<td>ns</td>
<td>**</td>
<td>**</td>
<td>ns</td>
<td>ns</td>
</tr>
<tr>
<td>CV (%)</td>
<td>207.67</td>
<td>13.68</td>
<td>22.87</td>
<td>42.40</td>
<td>17.84</td>
</tr>
</tbody>
</table>

Mean followed by the same letter in the same column are not significantly different at the level of α = 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**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Nutrient solution consumption plant-1 (L)</th>
<th>Total nutrient consumption (L)</th>
<th>pH</th>
<th>TDS (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7 DAT</td>
<td>14 DAT</td>
<td>21 DAT</td>
<td>31 DAT</td>
</tr>
<tr>
<td>T1-Snap</td>
<td>3.93</td>
<td>31.40</td>
<td>6.76c</td>
<td>6.34c</td>
</tr>
<tr>
<td>T2-Water</td>
<td>4.10</td>
<td>32.77</td>
<td>7.42a</td>
<td>7.25a</td>
</tr>
<tr>
<td>T3-Vermitea</td>
<td>2.84</td>
<td>33.50</td>
<td>6.90c</td>
<td>6.86abc</td>
</tr>
<tr>
<td>T4-VegeGrow</td>
<td>4.15</td>
<td>33.20</td>
<td>7.29ab</td>
<td>6.79abc</td>
</tr>
<tr>
<td>T5-Ramils</td>
<td>3.72</td>
<td>29.70</td>
<td>6.99bc</td>
<td>6.60bc</td>
</tr>
<tr>
<td>T6-BioVoltin</td>
<td>4.21</td>
<td>33.70</td>
<td>7.31ab</td>
<td>7.09ab</td>
</tr>
<tr>
<td>T7-Healthynest</td>
<td>4.05</td>
<td>32.40</td>
<td>6.96c</td>
<td>6.56bc</td>
</tr>
<tr>
<td>HSDα0.05</td>
<td>ns</td>
<td>ns</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>CV (%)</td>
<td>24.41</td>
<td>6.89</td>
<td>1.64</td>
<td>3.06</td>
</tr>
</tbody>
</table>

Mean followed by the same letter in the same column are not significantly different at the level of α = 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.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Color</th>
<th>Appearance</th>
<th>Aroma</th>
<th>Crispness</th>
<th>Succulence</th>
<th>Overall Texture</th>
<th>Bitterness</th>
<th>Overall Flavor</th>
<th>Overall Marketability</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1-Snap</td>
<td>4.83c</td>
<td>4.07b</td>
<td>4.07b</td>
<td>3.82c</td>
<td>4.07c</td>
<td>4.32c</td>
<td>3.82c</td>
<td>4.32c</td>
<td>4.32c</td>
</tr>
<tr>
<td>T2-Water</td>
<td>1.01a</td>
<td>1.01a</td>
<td>1.01a</td>
<td>1.01a</td>
<td>1.01a</td>
<td>1.01a</td>
<td>1.01a</td>
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</tr>
<tr>
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<td>2.26d</td>
<td>2.26d</td>
<td>2.01d</td>
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<td>2.26d</td>
<td>2.26d</td>
<td>2.51c</td>
<td>1.76c</td>
</tr>
<tr>
<td>T4-VegeGrow</td>
<td>1.01c</td>
<td>1.01c</td>
<td>1.01c</td>
<td>1.01c</td>
<td>1.01c</td>
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<tr>
<td>T5-Ramils</td>
<td>4.03b</td>
<td>4.78a</td>
<td>4.53c</td>
<td>4.03c</td>
<td>3.78b</td>
<td>4.33c</td>
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</tr>
<tr>
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<td>2.78a</td>
<td>2.78c</td>
<td>1.78c</td>
<td>1.78c</td>
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<td>2.53c</td>
</tr>
<tr>
<td>T7-Healthynest</td>
<td>3.78c</td>
<td>4.03b</td>
<td>4.03b</td>
<td>4.03c</td>
<td>3.53c</td>
<td>4.28b</td>
<td>4.28c</td>
<td>4.53b</td>
<td>4.53b</td>
</tr>
<tr>
<td>HSDα0.05</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
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<td>**</td>
<td>**</td>
</tr>
<tr>
<td>CV (%)</td>
<td>1.37</td>
<td>1.33</td>
<td>1.37</td>
<td>1.50</td>
<td>1.57</td>
<td>1.33</td>
<td>1.42</td>
<td>1.33</td>
<td>1.33</td>
</tr>
</tbody>
</table>

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.

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.

Acknowledgements

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REFERENCES


