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NON-CIRCULATION HYDROPONIC LETTUCE *(Lactuca sativa* L. var. *Rincon)* PRODUCTION USING COMMERCIALLY AVAILABLE NUTRIENT SOLUTION

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ABSTRACT

This study assessed the production performance of lettuce using different simple nutrient addition programs (Yamasaki, MasterBlend, SNAP, Nutrihydro and Hydroplus) compared to organic fertilizer (Biovoltin) with water as a negative control in a Kratky hydroponic system. The crop experiment was conducted at the Institute of Agriculture, Camiguin Polytechnic State College – Catarman Campus, Tangaro, Catarman, Camiguin from January 25, 2022 to March 10, 2022. The study was laid in a Randomized Complete Block Design with seven (7) treatments and three (3) replications at eight plants per treatment. Tukey's Honest Significant Difference (HSD) was used to compare the significant differences between treatment means. Results showed a highly significant differences in the horticultural and root development characteristics, yield parameters, nutrient solution consumption and quality of nutrient solution, and sensory quality except for the survival rate, non-marketable head weight, and pH at 31 DAT. Our results showed that the use of SNAP solution could be used effectively to increase the overall production performance of lettuce. The use of Nutrihydro, Hydroplus, Yamasaki and Masterblend were also promising for its production performance. It can be concluded that the nutrient solution affects the production performance of lettuce in a hydroponic production system. However, the potential use of these various simple nutrient addition programs should be further tested for verification at different growing seasons to elicit substantial conclusions.

Keywords: Hydroponics, inorganic nutrient solution, lettuce, organic nutrient solution

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Volume: 10, Issue: 01 "January-February 2024"

1. INTRODUCTION

Lettuce (*Lactuca sativa* L.) is a leafy vegetable which is consumed as a fresh vegetable and the quality of lettucce is a crucial factor in increasing its market price (Frasetya *et al.*, 2019). The small-scale hydroponic grower usually buy its nutrient solution from a hydroponics shop. Mason (2005) reported that there were some choices of hydroponic nutrient solution available in a shop, however a large number of nutrient solution is sometimes confusing the farmer or grower of which will they choose. The choice of nutrient solution usually has a specific formula specific for leafy vegetables or fruits plant. Each nutrient solution has different formulas at a different price. The price and the nutrient formula of a nutrient solution does not always guarantee the grower to have a higher yield (Frasetya *et al.*, 2019).

According to Resh (2016), nutrient formulation have to consider five-factors, i.e., plant variety, plant growth stage, marketable yield, weather, and climate. Also it should be taken into consideration that the different hydroponics system affects the plant growth. Every nutrient solution has a different concentration of each element and information about effective and efficient hydroponics nutrient is still limited. Knowing this information is essential for farmers to increase productivity and maximize profitability (Sesanti & User, 2016).

A simple hydroponic system if combined with the application of suitable nutrient composition will result in a high-quality vegetable product (Nowaki *et al.*, 2017). The application of the appropriate nutrient formula for lettuce hydroponic production will increase productivity and reduce cost production, hence this study was conducted. Generally, the study was conducted to evaluate commercially available inorganic nutrient solution in comparison to commercial organic fertilizer in the production of lettuce. Specifically, the study aimed to: 1.) evaluate the growth performance of lettuce, 2.) determine the yield and its components, 3.) assess the nutrient solution consumption and water quality, and 4.) evaluate sensory quality attributes of lettuce.

2. METHODOLOGY

The crop experiment was carried out in a plastic polyhouse with mesh net at the Institute of Agriculture, Camiguin Polytechnic State College – Catarman Campus, Tangaro, Catarman, Camiguin from January 25, 2022 to March 10, 2022. It was situated at 9º 07.019’ N latitude and 124º41.240’ E longitude and an elevation of 180 m above mean sea level. Natural solar radiation is the only source of light inside the polyhouse with natural ventilation. The materials and tools used in this study were lettuce seeds, coco peat, styro boxes, 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.

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The experiment was laid out in a Randomized Complete Block Design (RCBD) with seven (7) treatments and three (3) replications at 8 plants per treatment. The following were the treatments: The treatments were: Biovoltin (Positive Control); Water (Negative Control); Yamasaki; Masterblend; SNAP; Nutrihydro; and Hydroplus. The parameters observed in the evaluation of production performance of lettuce using commercially available nutrient solutions were plant height, leaf width, leaf blade length, canopy diameter, number of leaves per plant, root length, root volume, root fresh weight, total fresh weight, percentage roots per plant, survival rate, number of marketable and non-marketable head, head fresh weight (marketable and non-marketable), total yield, harvest index, nutrient solution consumption per plant, total nutrient solution consumption, pH, total dissolved solids (TDS), and sensory quality attributes and marketability (Solis & Gabutan, 2023), All data gathered was analyzed using analysis of variance (ANOVA) of RCBD 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.

The research was divided into several parts, namely the seedling establishment, seedling plugs preparation, growing boxes preparation, transplanting, crop maintenance, insect pest and disease control and harvesting was done 45 days after seed sowing or 31 days after transplanting. Data collection was done during the harvest period.

3. RESULTS AND DISCUSSION

The different type of nutrient solutions significantly affects the horticultural characteristics of lettuce (Table 1). Using commercially available nutrient solution for lettuce production produced taller plants, broader leaves, longer leaf blade, wider canopy, and a greater number of leaves as compared to the organic nutrient source Biovolt in which produced narrower leaves, shorter leaf blade, narrower canopy and lesser number of leaves. The result confirms the study of Santiago (2021), Ramos (2022), Borres *et al.* (2022) and Solis and Gabutan (2023) which reported that utilization of commercially available inorganic nutrient solution (Nutrihydro, SNAP, Masterblend, Hydroplus, & Yamasaki) provided an optimum level of nutrients readily available for horticultural growth and development of lettuce. In the studies of Omid *et al.* (2019), Phibun watthanawong and Riddech (2019), and Santiago (2021) comparing organic nutrient solution to commercial inorganic nutrient solution, showed that lettuce grown in organic nutrient solution exhibited poor growth and development.

ISSN: 2455-6939

Volume: 10, Issue: 01 "January-February 2024"

Table 1: Horticultural characteristics of lettuce 31 days after transplanting as affected by different commercially available nutrient solution.

Treatment	Plant height (cm)	Leaf width (cm)	Leaf blade length (cm)	Canopy diameter (cm)	Number of leaves
BioVoltin	4.00[b]	0.53[c]	1.39[e]	2.19[b]	5.21[b]
Water	5.42[b]	0.69[c]	1.79[d]	3.34[b]	5.92[b]
Yamasaki	17.67[a]	7.41[ab]	12.10[c]	16.90[a]	17.21[a]
Masterblend	18.73[a]	7.14[b]	12.34[ab]	16.56[a]	18.17[a]
Snap	19.62[a]	8.08[a]	12.30[ab]	17.51[a]	18.21[a]
NutriHydro	20.35[a]	7.94[ab]	12.48[a]	17.70[a]	19.12[a]
Hydroplus	18.12[a]	7.13[b]	12.15[bc]	16.88[a]	18.33[a]
$HSD_{\alpha 0.05}$	**	**	**	**	**
CV (%)	10.04	5.35	0.7349	7.83	7.65

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 2 shows that a highly significant variation was observed in the length, volume, fresh weight of the roots, total fresh weight, and percentage of root per plant of lettuce while survival rate was not significantly affected by the different nutrient solution. Nutrihydro exhibited longer roots, Yamasaki with higher root volume, SNAP with heavier root and total fresh weight, and Masterblend with higher percentage root per plant as compared to Biovoltin. All treatment exhibited a 100% survival rate.

Table 2: Horticultural root development characteristics and survival rate of lettuce 31 days after transplanting as affected by different commercially available nutrient solution.

Treatment	Root length (cm)	Root volume (mL)	Root fresh weight (g)	Total fresh weight (g)	Percentage root per plant (%)	Survival rate (%)
BioVoltin	5.21[b]	0.63[b]	0.62[b]	1.52[c]	0.5133[a]	100
Water	5.92[b]	3.75[b]	1.32[b]	2.22[c]	0.6100[a]	100
Yamasaki	17.21[a]	42.63[a]	22.66[a]	125.03[ab]	0.1833[b]	100
Masterblend	18.17[a]	42.00[a]	26.30[a]	123.51[ab]	0.2133[b]	100
Snap	18.21[a]	39.83[a]	29.47[a]	163.62[a]	0.1800[b]	100
NutriHydro	19.12[a]	41.13[a]	19.63[a]	144.54[ab]	0.1367[b]	100
Hydroplus	18.33[a]	37.63[a]	19.50[a]	118.16[b]	0.1633[b]	100
$HSD_{\alpha 0.05}$	**	**	**	**	**	ns
CV (%)	12.38	26.43	27.14	15.59	34.28	NaN

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.

ISSN: 2455-6939

Volume: 10, Issue: 01 "January-February 2024"

Table 3 presents the mean effect of the various nutrient solution on the yield of lettuce on the yield parameters of lettuce. Statistical analysis showed a highly significant difference among different nutrient solutions in terms of fresh head weight per plant, the weight of marketable and non-marketable head, number of non-marketable head, total yield and harvest index. However, statistical analysis showed no significant difference among nutrient solutions on the weight of non-marketable heads. SNAP has the heaviest fresh head weight per plant, highest weight of marketable head, and highest total yield, Hydroplus has the number of marketable head, Biovoltin and Water with highest number and weight of non-marketable heads, and Nutrihydro with the highest harvest index. Biovoltin and Water has the lowest fresh head weight per plant, the weight of marketable and non-marketable head, number of non-marketable head, total yield and harvest index.

Table 3: Yield parameters of lettuce 31 days after transplanting as affected by different commercially available nutrient solution.

Treatment	**Fresh head weight plant^{-1}** (g)	**Marketable head**		**Non-marketable head**		**Total Yield** (g box^{-1})	**Harvest Index** (%)
		Number	**Weight** (g box^{-1})	**Number**	**Weight** (g box^{-1})		
BioVoltin	0.90^{b}	0.00^{b}	0.00^{b}	8.00^{a}	7.17	7.17^{b}	0.4901^{b}
Water	0.90^{b}	0.00^{b}	0.00^{b}	8.00^{a}	7.17	7.17^{b}	0.3897^{b}
Yamasaki	102.37^{a}	7.00^{a}	715.40^{a}	1.00^{b}	103.53	818.93^{a}	0.8157^{a}
Masterblend	97.22^{a}	7.00^{a}	687.67^{a}	1.00^{b}	90.07	777.73^{a}	0.7869^{a}
Snap	134.15^{a}	7.67^{a}	1027.37^{a}	0.33^{b}	45.80	1073.17^{a}	0.8208^{a}
NutriHydro	124.91^{a}	7.67^{a}	965.03^{a}	0.33^{b}	34.23	999.27^{a}	0.864 ^{a}
Hydroplus	98.67^{a}	8.00^{a}	789.33^{a}	0.00^{b}	-0.00	789.33^{a}	0.8342^{a}
$HSD_{\alpha 0.05}$	**	**	**	**	ns	**	**
CV (%)	16.79	9.74	20.36	19.48	138.49	16.79	13.65

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 4 shows that a highly significant variation was observed on nutrient solution consumption and quality except for pH at 31 DAT (Table 4). Biovoltin has the highest nutrient solution consumption per plant and total nutrient solution consumption with Nutrihydro and Hydroplus the lowest, respectively. The pH and total dissolved solids (TDS) vary over time during the lettuce production. 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 560-840 ppm. Nutrient deficiencies may occur at ranges above or below the acceptable range (Brechner & Both, 2013).

ISSN: 2455-6939

Volume: 10, Issue: 01 "January-February 2024"

Table 4: Nutrient solution consumption and quality of nutrient solution of lettuce 31 days after transplanting as affected by different commercially available nutrient solution.

Treatment	Nutrient solution consump-tion plant^{-1} (L)	Total nutrient solution consump-tion (L)	pH					TDS (ppm)				
			0 DAT	7 DAT	14 DAT	21 DAT	31 DAT	0 DAT	7 DAT	14 DAT	21 DAT	31 DAT
BioVoltin	3.83^{a}	30.62^{a}	6.98^{a}	6.74^{a}	7.38^{a}	6.92^{ab}	6.83	192.75^{c}	261.67^{bc}	211.67^{bc}	226.67^{cd}	200.00^{b}
Water	3.58^{a}	28.67^{a}	6.92^{a}	6.76^{a}	7.13^{ab}	7.42^{a}	6.94	47.83^{d}	58.33^{c}	50.00^{c}	48.67^{d}	49.33^{b}
Yamasaki	1.37^{b}	10.94^{b}	6.54^{b}	6.42^{b}	6.19^{c}	6.54^{bc}	7.15	539.92^{a}	770.33^{a}	653.00^{a}	740.67^{bc}	731.67^{a}
Masterblend	1.55^{b}	12.40^{b}	6.52^{b}	6.47^{ab}	6.05^{c}	6.68^{b}	7.33	571.17^{a}	644.33^{a}	541.00^{ab}	579.67^{bc}	498.67^{a}
Snap	1.27^{b}	10.15^{b}	6.36^{b}	6.38^{b}	5.72^{c}	6.02^{c}	5.95	424.58^{b}	144.33^{c}	473.33^{ab}	1442.33^{a}	184.67^{b}
NutriHydro	0.92^{b}	7.38^{b}	6.41^{b}	6.45^{ab}	5.79^{c}	6.82^{ab}	6.72	524.50^{a}	611.33^{a}	510.33^{ab}	753.33^{b}	611. 00^{a}
Hydroplus	1.48^{b}	11.8^{b}	6.51^{b}	6.62	6.36^{bc}	6.69^{b}	7.21	417.75^{b}	520.00^{ab}	465.33^{ab}	404.00^{bcd}	247.67^{b}
HSD$_{\alpha 0.05}$	**	**	**	**	**	**	ns	**	**	**	**	**
CV (%)	16.33	16.25	1.63	1.70	4.42	3.23	9.81	6.43	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 α = 0.05 based on Tukey's Honest Significant Difference (HSD) Test. *significant,**highly significant, non-significant.

Table 5 shows a highly significant variation was observed on the sensory quality attributes and marketability of lettuce. SNAP was considered best overall which had higher mean values of color, appearance, crispness, overall texture, overall flavor, overall acceptability, and overall marketability except for aroma, succulence and bitterness.

Table 5: Sensory quality attributes of lettuce and marketability 31 days after transplanting as affected by different commercially available nutrient solution.

Treatment	Color	Appearance	Aroma	Crispness	Succulence	Overall Texture	Bitterness	Overall Flavor	Overall Acceptability	Marketability
BioVoltin	1.86^{c}	1.58^{c}	1.77^{e}	1.95^{d}	2.13^{c}	1.77^{d}	1.86^{c}	1.86^{d}	1.86^{d}	1.58^{b}
Water	1.83^{c}	1.65^{c}	2.01^{d}	2.01^{d}	2.10^{c}	2.01^{c}	1.92^{c}	1.92^{d}	1.92^{d}	1.74^{b}
Yamasaki	4.28^{b}	4.10^{b}	4.28^{bc}	4.46^{bc}	4.46^{a}	4.28^{b}	4.10^{ab}	4.19^{c}	4.37^{bc}	4.55^{a}
Masterblend	4.59^{a}	4.59^{a}	4.31^{bc}	4.40^{c}	4.59^{a}	4.31^{b}	4.04^{b}	4.40^{b}	4.40^{bc}	4.59^{a}
Snap	4.65^{a}	4.65^{a}	4.46^{ab}	4.65^{a}	4.55^{a}	4.55^{a}	4.10^{ab}	4.65^{a}	4.65^{a}	4.55^{a}
NutriHydro	4.62^{a}	4.52^{a}	4.52^{a}	4.43^{bc}	4.52^{a}	4.52^{a}	4.25^{a}	4.43^{b}	4.43^{b}	4.62^{a}
Hydroplus	4.40^{b}	4.22^{b}	4.22^{c}	4.59^{ab}	4.13^{b}	4.40^{ab}	3.95^{b}	4.31^{bc}	4.22^{c}	4.49^{a}
HSD$_{\alpha 0.05}$	**	**	**	**	**	**	**	**	**	**
CV (%)	1.73	1.79	1.77	1.71	1.71	1.75	1.87	1.76	1.75	1.73

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.

4. CONCLUSION

This study has shown that hydroponics lettuce production using commercially available nutrient solution is feasible. However, among the different nutrient solution, hydroponics lettuce production using SNAP performed well and gains the highest consumer's acceptance and marketability. Results imply that under favourable conditions, hydroponics lettuce production using commercially available nutrient solution will perform similarly. 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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