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Performance of Different Lettuce *(Lactuca Sativa* L.*)* Varieties Using Two Commercialized Hydroponic Solutions

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Abstract

In this study, the performance of different lettuce *(Lactuca sativa L.)* varieties using two commercialized hydroponic solutions was investigated. Specifically, it aimed to 1) evaluate the suitability of growing different lettuce varieties using two different hydroponic nutrient solutions and 2) determine the effect of these nutrient solutions using three varieties of lettuce on the agronomic characteristics and its components parameters of lettuce, such as plant height (cm), number of leaves, length of roots (cm), average weight per plant (g), fresh biomass (g) total yield (g), and cost and return analysis. The factorial experiment in Completely Randomized was used with three replications to test the following treatments: Factor A – (Variety of Lettuce) V_1- ABC, V_2 - DEF and V_3 – GHI while Factor B (Solutions), T_1 – Solution A and T_2 – Solution B. Based on the results of the study, among the three (3) varieties tested, V_2 (DEF) obtained the heaviest weight of total yield and the average length, average height, and fresh biomass. In contrast, V_3 (GHI) obtained the most number of leaves and longest length of roots. On the other hand, among the nutrient solutions, solution A produced the tallest, most number of leaves, longest length of roots, and heaviest fresh weight while solution B produced the most number of leaves.

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Introduction

Hydroponic techniques have been developed to facilitate cultivation in diverse environments and to improve farming practices using soilless methods. In this novel world, hydroponic farming makes efficient use of fertilizers and water, increases productivity, and provides better crop quality through careful management of the nutrient composition, dissolved oxygen concentration, temperature, pH, and electrical conductivity (EC) of the nutrient solution. Also, due to the risks of soil and water contamination in urban areas, this technique has a potential alternative to agricultural production in cities. Hydroponic systems, irrespective of their scale, reduce dependence on the soil as a substrate as it derives nutrition directly from the hydroponic solution, which consists of water and nutrients.

Nutrient supply in hydroponics can significantly influence the nutrition, taste, texture, color, and other characteristics of fruit and vegetable crops. Essential nutrient elements are dissolved in appropriate concentrations and relative ratios to achieve the normal growth of plants.

It is well known that the productivity and quality of crops grown in hydroponic systems are markedly dependent on the extent of plant nutrient acquisition from the growing medium. Due to this, the nutrient solution and its management are the cornerstones of a successful hydroponics system and are the most important determining factors of crop yield and quality (Meselmani, 2022).

Even though hydroponic culture can produce optimal plant growth (better yield and quality), its efficiency depends on many factors, such as nutrient availability, crop genotype, growing method, and pest management. Although there have been established nutrient solutions to the hydroponic culture of lettuce, scientists are unceasingly developing other nutrient solutions for this purpose. Thus, this study was conducted to determine the effects of two available nutrient solutions on the growth and yield of three lettuce varieties.

Materials and methods

The materials used in the study were lettuce seeds (Variety (ABC), Variety (DEF), and variety (GHI), seedling tray, Styrofoam fruit crates, coconut coir, seedling plug (Styrofoam cups), culture pots, plastic cover, Solution A, Solution B, water, graduated cylinder, beaker, ruler, tape, sensitive weighing scale, pH meter, marker, cutter, built nursery, record book, and pencil.

Experimental design and procedures

The factorial experiment in Complete Randomized Design in two (2) factor experiments replicated three (3) was used in the study. The following factors were considered and replicated three (3) times:

Main Factor A (Lettuce Varieties) Sub-Factor (Nutrient Solution)

V_1 – ABC

T_1 – Solution A

V_2 – DEF

T_2 – Solution B

V_3 - GHI

Preparation of growing media

Coco coir was used as growing media for growing lettuce. The material was sterilized with boiling water before placing them into individual seedling plugs. The amount of growing distributed per seedling plug was equal to avoid biased results.

Preparing the growing boxes

Styrofoam fruit crates were used as the culture pots. The bottom part of the box was lined with a polyethylene sheet to prevent the solution from leaking. On the lid or box cover, eight (8) holes equidistant from one another were cut off. Every Styrofoam fruit crate was sterilized with a 10% solution of Sodium Hypochlorite and sundried the whole day.

Preparation of lettuce seedlings

Lettuce seeds were sown in a seedlings tray using coco coir as growing media. In order to hasten the seed germination, water was sprinkled on the seed sown and continued to maintain its moisture state

until it reached 15 days old. During this time, lettuce seedlings were already mature enough for transplanting.

Transplanting

Lettuce seedlings were transplanted early time in the morning. One (1) seedling per seedling plug was transplanted to have uniformity with all other treatments.

Preparation of nutrient solution

The preparations of nutrient solutions were based on the procedure given by the manufacturer's instructions. The non-circulating method of the hydroponic system was used in the experiment wherein the roots of the plants were dipped in the nutrient solution. An equal amount of prepared solution was provided per treatment.

The amount of nutrient solution left in the container per day was also measured to assess the rate of absorption. In addition, the pH of the solution was also maintained to permit the absorption of nutrients. pH ranging from 5.8 to 6.5 was observed throughout the growing period.

Pest control

Pests such as vinegar flies and large bulging eyes were controlled with the use of physical methods. This was done by picking the pest with the use of bare hands and pinching them to death.

Harvesting

Lettuce was harvested 30 days after transplanting. This was done by uprooting the entire plant in the styrofoam cup. Plant samples were tagged just at harvest to avoid intermixing of samples. During this time, agronomic attributes such as root length, root weight, and herbage yield as also accounted.

Data Gathered

Ten (10) sample plants were randomly selected from each treatment for data collection. The selected sample plants were marked for identification. The following data gathered from the study were:

1. *Average Plant height* –The height of each sample plant was measured from the base to the tip-most part of the longest leaf. This data was collected prior to harvesting.
2. *Average Numbers of leaves* – This data was collected by counting the leaves that emerged from the sample plants at harvest time.
3. *Average Length of roots* – This was done by measuring the length of the roots in centimeters after harvesting.
4. *Average weight per plant* – the average weight was taken by weighing all the sample plants in each treatment.
5. *Fresh Biomass* – this was taken upon harvesting, weighed the plant with roots.
6. *Total yield per treatment (g)* - This was taken by weighing all plants in each treatment during harvest time.
7. *Cost and Return Analysis* –this was done by computing the expenses incurred during production minus the sales and multiply it by 100.

Results and discussion

Plant height (cm)

Table 1 shows the plant height (cm) of three lettuce varieties. Analysis of Variance (ANOVA) revealed that there exist highly significant differences at 1% level, among the different treatments. On comparison of treatments, V2 (DEF.) obtained the tallest among the three varieties of lettuce with a mean of 34.96 cm followed by V3 (GHI), 33.16 cm, and the smallest was V1 (ABC) with a mean of 20.52 cm.

The morphological characteristics of lettuce genetic resources of various lettuce types exhibit significant morphological and genetic variety differences, which affect the height of a plant. (Křístková *et.al.*, 2008).

Table 2 shows the height of lettuce varieties as affected by the two nutrient solutions. Analysis of variance showed a significant difference between Solution A and Solution B.

The Solution A obtained the tallest with a mean of 30.88 cm while Solution B produced 28.21 cm.

Table 1. Summary of statistical analysis of different varieties of lettuce under hydroponics production.

Variety	*Plant height (cm)*	*Number of leaves*	*Length of roots (cm)*	*Weight per plant (cm)*	*Fresh biomass (g)*	*Computed yield (g)*
V1 – ABC	*20.52^{c}*	*10^{b}*	*30.44^{a}*	*36.57^{b}*	*44.21^{b}*	*494.33^{b}*
V2 – DEF	*34.96^{a}*	*13^{a}*	*29.31^{a}*	*59.95^{a}*	*70.45^{a}*	*874.17^{a}*
V3 - GHI	*33.16^{b}*	*14^{a}*	*19.95^{b}*	*57.88^{a}*	*66.54^{a}*	*828.17^{a}*
Statistical Result	**	*	*	*	*	*

ns - not significant

** - significant at 1%*

*** - highly significant at 5%*

According to Uy *et al.*, (2021), the plants grown in SNAP solution produced the tallest plants compared to plants under other nutrient solutions, which means that the difference between treatments was attributed to the nutrient content of the nutrient solutions used.

In terms of the interaction effect (Table 3), significant differences were also observed between the two factors tested. This means that the different varieties have different trends of response to the nutrient solutions used.

Number of leaves

Table 1 shows the number of leaves of three lettuce varieties. Analysis of Variance (ANOVA) revealed that there exist significant differences among the different treatments. V3 (GHI) and V2 (DEF) were significantly different from V1 (ABC), with an average of 14, 13, and 20, respectively. On comparison among means, no significant difference existed between V3 (GHI) and V2 (DEF) respectively. As the number of leaves expanded, the total leaf area also increased, which enhanced the plant's capacity for photosynthesis, which was then used for further growth and development of the plant (Wani *et al.*, 2019). Table 2 shows the number of leaves as affected by the two nutrient solutions. Analysis of variance showed no significant differences between Solution A with a mean of 13 and Solution B with a mean of 12 in the same order.

Table 2. Summary of statistical analysis on the performance of lettuce as affected by the two commercialized nutrient solutions.

Solution	*Plant height (cm)*	*Number of leaves*	*Length of roots (cm)*	*Weight per plant (cm)*	*Fresh biomass (g)*	*Computed yield (g)*
Solution A	*30.88*	*13*	*25.35b*	*53.36*	*62.48*	*760.56*
Solution B	*28.21*	*12*	*29.11a*	*49.70*	*58.31*	*703.89*
Statistical Result	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*

ns – not significant.

In terms of interaction effect (Table 3), the analysis of variance showed significant differences between the two factors tested. This result was attributed to the nutrient composition of the solution that 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 Trejo-Téllez *et al.* (2007).

Length of roots (cm)

Table 1 shows the length of roots of lettuce per variety. Analysis of Variance (ANOVA) showed that variety (DEF) produced the longest roots of 32.44 cm followed by variety GHI with 29.3 cm and variety (ABC) with 19.95 cm, respectively. The numerical differences observed between varieties were due to the characteristics of the three (3) varieties used in the study (Křístková *et al.*, 2008).

Table 2 shows the length of the roots of lettuce as affected by the two nutrient solutions. Statistical analysis reveals that Solution B produced the longest roots with 29.11 cm Solution A obtained a 25.35 cm. This result is in contrast with the study of (Uy *et al.*, 2021), indicating that the difference between treatments was due to the nutrient content of the nutrient solutions utilized.

However, despite the numerical differences, analysis of variance showed no significant differences between the varieties and nutrient solutions tested (Table 3).

Table 3. Summary on the interaction effect of lettuce varities and two commercialized nutrient solutions.

Interaction (A X B)	*Plant height (cm)*	*Number of leaves*	*Length of roots (cm)*	*Weight per plant (cm)*	*Fresh biomass (g)*	*Computed yield (g)*
V1A	*20.28*	*10*	*18.56*	*35.23*	*42.36*	*481.33*
V1B	*20.75*	*11*	*21.34*	*38.27*	*46.06*	*507.33*
V2A	*37.82*	*15*	*27.78*	*58.90*	*75.99*	*926.00*
V2B	*32.10*	*11*	*30.84*	*56.87*	*63.99*	*822.33*
V3A	*34.54*	*14*	*29.73*	*65.93*	*69.09*	*874.33*
V3B	*31.78*	*13*	*35.15*	*53.97*	*64.90*	*782.00*
Statistical Result	*	*ns*	*ns*	*ns*	*ns*	*ns*

ns – not significant.

Average weight per plant (g)

Table 1 shows the average weight per plant (g) of lettuce per variety. Plants under variety (DEF) obtained the heaviest weight of 59.95 grams closely followed by variety (GHI) and variety (ABC) with 57.88 grams and 36.75 grams respectively. Statistical analysis reveals significant differences among varieties tested.

Table 2 shows the average weight (g) of lettuce per variety as affected by the two nutrient solutions. Analysis of Variance (ANOVA) showed no significant effect between the two nutrient solutions tested.

Lettuce under Solution A has an average mean weight of 53.36 grams, while lettuce on Solution B has 49.7 grams.

In terms of the interaction effect between the two factors tested, there was no significant difference (Table 3). The increase in weight of lettuce was influenced by an increase in plant height, number of roots and etc. The higher the lettuce plant and the more the number of leaves, the heavier the fresh weight of the lettuce plant also. The fresh weight of plants results from photosynthate accumulation in the form of plant biomass and water/moisture content in leaves (Nurmayulis *et al.,* 2018).

Fresh biomass (grams)

Table 1 shows the fresh biomass (g) of lettuce per variety. Analysis of variance shows significant difference among the varieties tested. Plants under variety (DEF) obtained the heaviest with 70.75 grams followed by variety (GHI) with 66.54 grams and the lightest was obtained in variety (ABC) with 44.21 grams. Numerical differences between treatments were due to the different morphological characteristics of each variety (Křístková *et al.*, 2008).

Table 2 shows the average weight (g) of lettuce as affected by the two nutrient solutions. Plants under Solution A produced the heaviest with 62.48 grams while plants under Solution B has 58.31 grams. No significant differences between the two (2) nutrient solutions tested. This means that using either Solution A or Solution B does not affect the weight of lettuce varieties used.

On the other hand, no interaction effect was observed between the two factors tested. (Table 3).

Computed yield (g)

Table 1 shows the total yield (g) of lettuce per variety. Analysis of Variance (ANOVA) showed significant differences among the three varieties tested. Plant

under variety (DEF) produced 874.17 grams followed by variety (GHI) had 828.17 grams and variety (ABC) with 494.33 grams respectively.

Table 2 shows the average weight (g) of lettuce as affected by the two nutrient solutions. Plants produced in Solution A has a total weight of 760.56 grams, while lettuce in Solution B has 703.89 grams. However, no significant differences between the two (2) nutrient solutions were observed.

In terms of an interaction effect, analysis of variance showed no significant difference among the two (2) factors tested (Table 3).

Table 4. Cost and return analysis on hydroponic production of different lettuce varieties using a nutrient solution.

TREATMENT	GROSS INCOME PER TREATMENT	TOTAL COST OF PRODUCTION	NET INCOME PER TREATMENT	ROI (%)
		SOLUTION A		
V1 – ABC	1125	483.32	641.68	132.77
V2 - DEF	1610	483.32	1126.68	233.11
V3 - GHI	1645	483.32	1161.68	240.35
		SOLUTION B		
V1 – ABC	1050	453.05	596.95	131.76
V2 - DEF	1505	453.05	1051.95	232.19
V3 - GHI	1540	453.05	1086.95	239.92

Cost and return analysis

The cost and return analysis of lettuce production under hydroponics system is presented in Table 4. The return on investment in every treatment is arranged in descending order. For factor A (Vavieties), variety (GHI) – 240.35, variety (DEF) – 233.11 and variety (ABC) – 132.77. For factor B (Nutrient solution), variety (GHI) – 239.22, variety (DEF) – 232.19, and variety (ABC) – 131.76.

Recommendations

Based on the results of the study, the following conclusions were drawn: Among the varieties tested, variety (GHI) and variety (DEF) can be used for hydroponics production since it has the highest return on investment. The used of solution A and Solution B can be used since no significant result was observed.

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