The evaluation of various nutrient formulation on the growth of lettuce (*Lactuca sativa* Var. Arista) in hydroponic raft system at tropic region

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Abstract. Lettuce (*Lactuca sativa* Var. Arista) is leaf vegetable which consumes as a fresh vegetable. The quality is a crucial role in increasing the market price of lettuce. A large number of nutrient solution is sometimes confusing the farmer or grower which will they choose. The research objectives evaluate five nutrient formulation from local formulator and global formulator. This research conducted in June to July 2018 at Greenhouse of Universitas Padjadjaran, Jatinangor, Indonesia. The experimental design used in this research was completely randomized design with five treatments of nutrient formulation e.g., Sutiyoso (local formulator), Hoagland & Snyder, Hoagland, Shive & Robbins, and Resh Lettuce Anguila. The parameters of lettuce growth (plant height, leaves a number, leaf area, fresh weight of the plant, dry weight of the plant) observe and measure. The data of lettuce plant growth than analyzed with variance analysis α=5% and post hoc test analysis use Duncan multiple range test α=5%. Each of the treatment replicate five times. The results showed that different of nutrient formulations for lettuce have a different effect on growth parameters such as of plant height, number of leaves, leaf area, fresh weight of the plant, dry weight of the plant. The Sutiyoso nutrient formula effective for tropical lettuce hydroponics in Indonesia.

1. Introduction

Lettuce (*Lactuca sativa* Var. Arista) is leaf vegetable which consumes as a fresh vegetable. The quality is a crucial role in increasing the market price of lettuce. The small-scale hydroponic usually buy a nutrient solution from hydroponics shop equipment. Mason in 2014 reported there some choices of hydroponic formulas already sell at a shop [1]. A large number of nutrient solution is sometimes confusing the farmer or grower which will they choose. Each nutrient solution usually has a specific formula for leafy vegetables or fruits plant. Every nutrient solutions sometimes have different formulas and a different price. The price and the nutrient formula of a nutrient solution are not always guaranteed the plant growth higher.

According to Resh in 2013 nutrient formulation have to consider five-factors, i.e., plant variety, plant growth stage, marketable yield, weather, and climate [2]. Sesanti and Siswanto in 2016 also reported that different hydroponics system affected the plant growth [3]. Every nutrient solution has a different concentration of each element. Information about effective and efficient hydroponics nutrient is still
limited. This information is essential for urban farmers to increase productivity and maximize profitability [4].

Hydroponic is an alternative to raise production and utilize urban environment. The hydroponics raft system has advantages as a simple hydroponics system for urban farmer which is compared with nutrient film technique (NFT) and aeroponic. The raft system also has weakness namely low dissolved oxygen (DO) and nutrient sediment. The low oxygen concentration in a nutrient solution affects plant root growth, indirectly affect plant nutrient uptake [5]. Currently, hydroponic raft system is assembled with the aerator to increase dissolved oxygen. A simple hydroponic system if combined with the application of suitable nutrient composition will result in a high-quality vegetable product [6].

This research evaluated five nutrient formulation (Table 1) from local formulator and global formulator, namely Sutiyoso (local formulator), Hoagland & Snyder, Hoagland, Shive & Robbins, and Resh Lettuce Anguila. Macro elements have a different concentration in each other and composition of some microelement are omitted.

### Table 1. Red Lettuce Nutrients Formula.

| Nutrients | N  | P  | K  | Ca | Mg | S  |
|-----------|----|----|----|----|----|----|
| A         | 250| 75 | 350| 200| 75 | 135|
| B         | 210| 31 | 234| 200| 48 | 64 |
| C         | 158| 44 | 284| 200| 99 | 125|
| D         | 56 | 46 | 117| 60 | 53 | 70 |
| E         | 185| 50 | 210| 200| 50 | 66 |

### Table 2. Macro elements ratio to Nitrogen (N).

| Nutrients | N  | P  | K  | Ca | Mg | S  |
|-----------|----|----|----|----|----|----|
| A         | 1  | 0.30| 1.40| 0.80| 0.30| 0.54|
| B         | 1  | 0.15| 1.11| 0.95| 0.23| 0.30|
| C         | 1  | 0.28| 1.80| 1.27| 0.63| 0.79|
| D         | 1  | 0.82| 2.09| 1.07| 0.95| 1.25|
| E         | 1  | 0.27| 1.14| 1.08| 0.27| 0.36|

**Remarks:** *) Formulator: A= Sutiyoso; B= Hoagland & Snyder; C= Hoagland; D= Shive & Robbins; E= Dr. H. Resh Lettuce Anguila, B.W.I

Sources: [2, 7].

The nutrient A from Sutiyoso formula has the highest macro element concentration, namely N, P, K, and S. Nutrient D from Shive & Robbins formula has the lowest macro element concentration, namely N, P, K, and Ca. The nutrient N : K ratio affect the balance between vegetative and generative phases. The lettuce is a leaf vegetable so that at vegetative phase lettuce will be harvest. Ratio macro elements to Nitrogen (N) (Table 2) in each element different between other formula [8].

The application of the appropriate nutrient formula for lettuce hydroponic will be increase productivity and reduce cost production. Previous research reported that application proper hydroponic nutrient on lettuce production would increase hydroponic nutrient efficiency [9]. The N ratio to the other macro elements is essential information for grower or beginner formulator.
2. Methods
This research was carried out at greenhouse of Universitas Padjadjaran, Indonesia from April to July 2018. The materials used in this research e.g., lettuce seed variety of Arista, rice husk charcoal, plastic container, rockwool, netpot, styrofoam, salt fertilizer compounds (Ca(NO$_3$)$_2$.NH$_4$; Ca(NO$_3$)$_2$; KNO$_3$; Fe-EDTA; K$_2$HPO$_4$; K$_2$SO$_4$; MgSO$_4$.7H$_2$O; NaCl; MnSO$_4$.4H$_2$O; CuSO$_4$.5H$_2$O; ZnSO$_4$.7H$_2$O; H$_3$BO$_3$; (NH$_4$)$_6$Mo$_7$O$_24$.4H$_2$O). The research method used experimental research which use complete randomized design. The treatment of this research are nutrient formulation namely: A=Sutiyoso, B=Hoagland & Snyder; C=Hoagland; D=Shive & Robbins; E=Resh.

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The growth parameters observed and measure in this research were plant height, number of leaves, leaf area, fresh weight of the plant, and dry weight of the plant. The secondary parameter observed to support data analyze of main parameter. The secondary parameters were temperature and humidity of greenhouse, pH nutrients, EC nutrient and Dissolve Oxygen. The data of growth parameters or main parameter then analyze with anlayze of variance $\alpha=5\%$, if the result of F test was significant, then the data analyzed with Duncan Multiple Range Test (DMRT) $\alpha=5\%$. The data from secondary parameter then shown as a table or a graphic.

The stages of the implementation of the research in this study are the making of floating raft hydroponic systems, making nutrients according to treatment by referring to the nutrition formulation (Table 1) and take care the plant from transplanting until harvest.

3. Result and Discussion

3.1. Temperature and Humidity
The measurement results of observations of the greenhouse temperature averaged 26.16°C and humidity averages 57.87% (Figure 1). In the tropics, daily temperature fluctuations are relatively constant while daily humidity fluctuates following the sawtooth pattern [10]. Temperature that meets the needs of lettuce plants between 15-20°C [11].

The temperature conditions in the greenhouses used cannot be maximally controlled because of the limited facilities in the greenhouses used. In situations of low humidity plant growth, especially leaf area and lengthening of plant canopy is inhibited otherwise at high humidity can increase leaf area and overall plant growth [12].

![Temperature and Humidity in Greenhouse](image)

**Figure 1.** Temperature and humidity in greenhouse during research.

3.2. Dissolve Oxygen (DO), Electrical Conductivity (EC) and Acidity of Nutrient solutions
Measurements of dissolved oxygen (DO) in floating raft hydroponic systems averaged 9.6 mg L$^{-1}$. The results showed that DO 20-30 mg L$^{-1}$ of plant growth was better [5]. The addition of aerators in each
nutrient tank has not been able to increase dissolved oxygen. Plant growth in addition to being affected by dissolved oxygen in nutrient tanks, the concentration of nutrients given to plants needs to be adjusted accordingly.

In this study, the EC value was given between 1-1.5 mS cm\(^{-1}\). Application EC values that are following the plant growth phase can increase yields by 33% higher than those given higher or lower EC [8]. The pH value of nutrient solutions from various formulators has an average pH of 6.7. The optimal pH value for hydroponic plants ranges from 5.6 - 6.2 [13].

### 3.3 Plant height

The height of the lettuce plants of Arista cultivars based on the descriptive values of varieties between 17.98 - 20.32 cm in 35 DAP nutritional formulations A = Sutiyoso and E = Dr. H. Resh Lettuce Anguilla, B.W.I produced a height of 20.23 cm and 22.73 while in nutrition B = Hoagland & Snyder, C = Hoagland, and D = Shive & robbins the plant height produced was below 20 cm. Plant height is influenced by nutrient availability, availability of water and sunlight imbalance between the availability of nutrients, water and sunlight will cause high growth is not optimal, namely showing symptoms of dwarf and etiolation symptoms [14].

In this study, the availability of water and sunlight in each treatment was relatively homogeneous so that the influence of plant height in this study was dominant because it influenced the nutritional composition of each formulator. Nutrition formulations A and E based on Table 1 have a composition of macro and micronutrients wholly compared to other treatments. The optimal growth of plant height can improve the quality of the crop so that it is more attractive when displayed on a modern market.

![Figure 2](image)

**Figure 2.** Plant height at 14, 21, 28, and 35 Day after Plant (DAP).

### 3.4. Leaf area, plant fresh weight, plant dry weight, and shoot-root ratio of lettuce plant

Based on observations of Leaf Area, Plant Fresh Weight, Plant Dry Weight, and Shoot-root Ratio of Lettuce Plant (Table 3) application of nutrients A = Sutiyoso & E = Dr. H. Resh Lettuce Anguilla consistently yielded the highest growth results in all observed parameters compared to the nutritional treatment B = Hoagland & Snyder; C = Hoagland; D = Shive & Robbins. Formulation A (Total N 250 ppm) has a higher total N concentration than formulation E (Total N 185 ppm), but in E nutrition there are additional elements of micro Cl and Na. The Cl and Na elements in this study were also added to the nutritional formulas C and D, but both of these formulas removed the contents of several microelements. Formulation C without microelements Fe, Mn, Cu, Zn, B, and Mo while formulation D without
microelements Fe, Cu, and Mo. Formulations C and D produced the lowest growth compared to nutritional formulas A, B and E.

Nutrition B (Total N 210 ppm) based on the content of total N is higher than the nutrient E, but on the nutrient B element, Fe is not added to the nutritional formula. The results of this study indicate that the balance of nutrients and the availability of complete macro and micronutrients can improve plant growth. At the same EC value, the composition of different nutrient nutrients will cause different plant growth.

Table 3. Leaf area, plant fresh weight, plant dry weight, and shoot-root ratio of lettuce plant.

| Treatment | Leaf Area* (cm²) | Plant Fresh Weight* (g) | Plant Dry Weight* (g) | Shoot-root Ratio* |
|-----------|-----------------|------------------------|----------------------|------------------|
| A         | 2461.02 c       | 97.28 c                | 4.27 c               | 1.43 b           |
| B         | 1154.67 ab      | 62.19 ab               | 2.82 ab              | 0.78 a           |
| C         | 752.77 a        | 45 a                   | 2.36 ab              | 0.57 a           |
| D         | 675.75 a        | 44.39 a                | 2.11 a               | 0.62 a           |
| E         | 1837.42 bc      | 74.82 bc               | 3.19 bc              | 1.29 b           |

Remarks:* The number followed by the same letter (lower case) indicate significant difference based on post hoc test Duncan Multiple Range test α=5%

4. Conclusions
The application of different nutritional formulas on the same electrical conductivity (EC) value 1.5 mS cm⁻¹ has a significant effect on the growth of lettuce plants on floating hydroponic systems. The Sutiyoso nutrient formula is useful for tropical lettuce hydroponics in Indonesia.

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