The effect of hydroponics systems on the growth of lettuce

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Abstract. Shifting patterns of consumption in urban communities to consume pesticide-free and clean vegetables encourage the development of hydroponic cultivation in urban areas. In hydroponic lettuce cultivation, resource efficiency in the production stage is vital to be implemented so that the profits of hydroponic farmer increase. This study aims to provide recommendations for a more efficient hydroponic system to increase the growth of lettuce plants. The research method used in this study was a complete randomized design consisting of five treatments that were replicated five times. The treatment consists of five types of hydroponic installation systems, namely: A = Nutrient Film Technique System (NFT), B = Deep Film Technique System (DFT), C = EBB and FLOW Systems (EFS), D = Aeroponic Systems (AS), and E = Floating Raft System (RFS). The parameters observed to measure the effectiveness of each system in increasing the growth of lettuce plants are plant height, leaf number, fresh weight, and shoot-root ratio. The observational data were then analyzed using analysis of variance at 5% significance level and Duncan's test at 5% level. The results showed that the NFT hydroponic system of lettuce plants was 6%-10% more efficient compared to the floating raft system and DFT system in increasing yields.

1. Introduction

Urbanization that occurs in urban areas does not only have an impact on population growth. An increase in population plays a significant role in the social and economic change of society. Transfer of land functions from agriculture to non-agriculture causes food needs to be met from other regions. The impact of land conversion is not only on the reduction in the area of cultivated land but on the loss of farmers' income sources. Farmers must switch professions to work outside their area of expertise.

The concept of urban farming in Indonesia basically adopts the local wisdom of the people who have always used the yard to be planted. Various types of crop commodities that are quickly harvested but do not require a large area are generally planted in the yard. The application of the concept of urban farming has many advantages, namely: the availability of healthy food, increasing social ties, and improving the economic level of the community, especially low-income people [1]. Urban agriculture can be carried out conventionally by planting in the ground or using pots or other containers using the soil or using mixed planting media. Cultivation systems using soil media have limitations in the aspect of production, so it is necessary to apply cultivation technology that can produce high on a limited area of land [2]. Changes in the consumption patterns of urban communities to consume food that is free of pesticide residues have contributed to the development of hydroponics in cities.

Lettuce (Lactuca sativa L.) is a vegetable plant that is commonly consumed directly in fresh conditions so that cleanliness in the production process is a top priority [3]. The use of hydroponic
technology in lettuce cultivation has advantages compared to conventional cultivation in the soil, namely lettuce plants produced are more hygienic, plant growth is more uniform and can be planted at close planting distances [4]. Hydroponic systems commonly used for hydroponic lettuce cultivation include aeroponics, nutrient film technique (NFT), deep flow technique (DFT), ebb-flow system (EFS), and float raft system (FRS) [5]. The advantages of each system are: aeroponics can provide higher dissolved oxygen compared to four other systems, NFT systems can be installed vertically because the water flow height in the installation system is relatively shallow + 3-5 mm so it is relatively lighter than DFT, the DFT system can provide water and nutrients in the condition of the pump nutrient solution is not functioning.

Hydroponic systems have many variations, which makes it difficult for beginner farmers and ordinary people to determine the right hydroponic system following the commodity planted. Different hydroponic systems are basically developed with the same goal, which is to provide water and nutrients to plants [6]. An excellent hydroponic system can supply water and nutrients, must also be able to supply oxygen to the rooting zone. The results showed that lettuce plants that were given dissolved oxygen 20-30 mg l-1 could increase plant growth [7]. The choice of the hydroponic system needs to consider the following factors: place, productivity produced, availability of suitable growing media, and expected crop quality [8]. This study aims to produce recommendations for a more efficient hydroponic system to increase the growth of lettuce plants.

2. Methods
This research was conducted in July 2018 to August 2018 at the Screen house of Cipedes Village, Paseh District, Bandung Regency. The research location has a height of + 700 m above sea level (asl). The tools and materials used in this study are EC-meter, pH-meter, hygrometer, aerator, water pump, digital scale, lettuce seeds cultivar Red Rapid, rock wool, AB Mix.

The research method used was an experimental method using a completely randomized design consisting of 5 treatments. Namely: A = Hydroponic Installation of the Nutrient Film Technique (NFT) System; B = Hydroponic Installation of Deep Film Technique (DFT) System; C = Hydroponic Installation of EBB and FLOW or Tidal Systems; D = Installation of Aeroponic Hydroponic Systems; and E = Installation of Floating Assembling Hydroponic System each treatment was repeated five times. The parameters observed to measure the effectiveness of each system in increasing the growth of plant growth are plant height, leaf number, fresh weight, dry weight, and shoot-root ratio. Data from observations were then analyzed using analysis of variance of 5% significance level. The average value of each treatment in each parameter was tested differently using Duncan multiple range analysis of the 5% significance level.

The research was divided into several parts, namely the establishment of hydroponic system installation according to treatment, manufacture of AB mix, seeding, transplanting, crop maintenance (5-10 days after transplanting (DAT) electrical conductivity (EC) nutrition 1.2 mS cm-1, 10-15 EC DAT = 1.8 mS cm-1 and 15-30 EC DAT = 2.1 mS cm-1 The last crop is harvested on the 30th day after transplanting.

3. Result and discussion
The results of the analysis of variance (Table 1) showed that the hydroponic system affected all plant growth parameters, namely plant height, number of leaves, fresh plant weight, plant dry weight, and shoot-root ratio.
### Table 1. Variance analysis of plant growth parameters.

| No. | Parameters               | p-value      | CV (%) |
|-----|--------------------------|--------------|--------|
| 1   | Plant Height 28 DAT      | 7.295E-05*   | 5.87   |
| 2   | Leaf Number 28 DAT       | 3.055E-08*   | 13.53  |
| 3   | Fresh Weight 35 DAT      | 4.695E-08*   | 12.40  |
| 4   | Dry Weight 35 DAT        | 1.982E-04*   | 23.35  |
| 5   | Shoot-root ratio 35 DAT  | 5.412E-04*   | 26.49  |

Remarks: *= The treatment significant affect the parameter based on analysis of variance (P≤0.05); DAT= Day after transplanting; CV= Coefficient of Variance

#### 3.1. Plant height

Plant height is more influenced by external factors, especially the availability of water and light [9]. The height of the lettuce variety of Red Rapid is between 17 cm - 20 cm. The results of the study (Fig. 1) obtained the plant height of each treatment at intervals of 17-20 cm. The Duncan test results show that the height growth of treatment plants B, C, and E is higher compared to treatments A and B.

Different hydroponic systems affect the availability of water, nutrients and dissolved oxygen needed by plants. Components of water, nutrients, and dissolved oxygen must be available proportionally. If one component does not meet sufficient condition can inhibit plant growth [7, 10]. The aeroponic system (Treatment D) allows plant roots to get enough oxygen because the aeroponic system provides water and nutrients in the form of fine water droplets that are sprayed directly on the roots.

#### 3.2. Leaf number

The floating raft system (Treatment E) gives the highest number of leaves (Fig. 2) compared to other treatments. Lettuce is a vegetable that is consumed by the leaves so that more leaves will increase the selling price. Lettuce plants that have more leaves besides increasing plant weight will also increase the appearance of plants more attractive when displayed on supermarket shelves. The number of leaves in the floating raft system was 13 leaves close to the number of leaves produced in the previous study, which was 14 leaves [11].

The floating raft system compared to other systems has advantages in the continuous supply of water and nutrition. The availability of water and nutrients that are maintained continuously helps reduce the negative impact of water and nutrient stress on plant growth. Plants that experience water shortages during the growing period can inhibit growth and reduce crop yields [12].

![Figure 1. Graph of plant height lettuce.](image-url)
3.3. Fresh weight and dry weight

The fresh weight of lettuce produced (Fig. 3) from the NFT, DFT, and Raft floating system (RFS) systems is not significantly different but compared with Ebb Flow System (EFS) and Aeroponic System (AS) results in higher fresh plant weight. The NFT system yields 6% -10% higher yield compared to RFS.

The NFT system has the advantage of being arranged vertically because the volume of water flow in the installation gutters is smaller compared to RFS. The results of this study show that different systems affect the availability of water, oxygen, and nutrients sufficient to increase plant growth [3,13]. The dry weight measurement results show that the NFT and DFT systems can provide the best environment for the formation of plant biomass.

![Figure 2. Graph of leaf number.](image)

![Figure 3. Graph of fresh weight and dry weight of lettuce plant.](image)
3.4. **Shoot-root ratio**

The shoot root ratio parameter is a parameter to measure whether the plant grows larger to the shoot or more significant to the formation of roots. Plants with higher root growth will cause smaller ratio values, which means higher root formation compared to canopy formation [9].

The results showed that the shoot-root ratio of RFS and NFT was not different. Both of these systems can support the formation of plant canopy as a component of plant yields higher than the formation of roots. Plants that experience environmental stresses such as lack of water, nutrients, and oxygen will form more roots than plants that have water, nutrients, and oxygen availability in their root zones. The root canopy ratio in this study was higher than in other studies, which was 2.9 [12].

![Figure 4. Graph of the shoot-root ratio lettuce plant.](image)

### 4. Conclusion

Different hydroponic systems affect the growth of lettuce, namely plant height, number of leaves, fresh plant weight, plant dry weight, and shoot-root ratio. The NFT hydroponic system is 6% -10% more efficient in increasing the yield of lettuce. The NFT and RFS systems are recommended for use in hydroponic lettuce production.

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