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Application of POC Addition to Nutrients and its Effect on Planting Direction in Lettuce Plants in Vertical Hexagonal Aeroponics

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ABSTRACT

Aeroponics is cultivation that can produce lettuce optimally. This research aims to obtain the quality and quantity of lettuce using the vertical hexagonal aeroponics method with the influence of planting direction, sunlight and the addition of liquid organic fertilizer. This research used a factorial Randomized Group Design (RAK) and was repeated three times. The first factor is the Ab mix concentration and the second factor is the planting direction. The lettuce yield variables observed were plant length, number of leaves, harvest yield (root length, wet weight, dry weight) and organoleptic tests. The single factor of adding POC to nutrients influenced the variables wet weight, dry weight and root length, whereas the planting direction treatment only affected root length and the interaction of planting direction treatment and adding POC to nutrients affected organoleptic and stem variables. long. The root length parameters of 58.94 cm, wet weight of 90.59 grams, and dry weight of 8.40 grams are the best parameters if POC is added to nutrition, and treatment of northeastern plantings gives the highest root length, namely 68.73 cm.

1. INTRODUCTION

Aeroponics is a different method from hydroponics, using plant roots that hang in the air. The hexagonal vertical aeroponic method is one of the developments of aeroponics each side offering many advantages over hydroponics such as NFT (Nutrient Flow Technique), DFT (Deep Flow Technique), Wick System, and conventional farming techniques, especially in terms of water efficiency and higher productivity levels when compared to horizontal hydroponic models. A set of hexagonal vertical aeroponics installation can produce 60 plants with 2 meters of land area, but hexagonal vertical aeroponics can produce 4 times more plants with better quality. The principle of aeroponics is to spray a nutrient-rich aqueous solution onto the hanging roots and rootstock of plants to grow them in a closed or semi-closed environment (Dutta *et al*., 2023). Compared to hydroponics, aeroponic systems optimize root aeration, which is an important component in increasing yields (Sulichantini, 2021). Aeroponics can be done throughout the year in horticultural crops, one of which is green lettuce (*Lactuca sativa* L.) (Subandi *et al*., 2020).

Green lettuce is one of the most low-calorie types of vegetables and is full of antioxidants and has plenty of vitamins K, A, and C, as well as a compound called lactucarium, which can be consumed to make the body feel more refreshed. Lettuce is one of the most preferred vegetables worldwide because of the many advantages it offers. The need for horticultural crops, especially lettuce, in the export value of horticultural production such as lettuce tends to fluctuate (Kementerian Pertanian, 2020). The production of horticultural crops tends to fluctuate so that it has not fully met the needs of a high level of consumption and has a level of crispness, fresh taste or quality that is not directly proportional to the results obtained. This condition is due to the conversion of industrial areas, settlements and the

availability of water for irrigation which continues to decline (Marwanti, 2022). Efforts that can be made to improve the quality and quantity of lettuce plants are to improve the cultivation of plants that are efficient but produce high quality and quantity of plants. The solution to increase lettuce plants can be with hexagonal vertical aeroponics with the addition of POC on nutrients to get quality and quatity of plants compared to typical hydroponic models.

Liquid organic fertilizer is made from organic matter or dead living things that have been decomposed by microorganisms so that they have different physical properties. Some of the benefits of liquid organic fertilizer include the formation of leaf chlorophyll, which increases the photosynthetic ability of plants and the absorption of nitrogen from the air (Juliansyah *et al.*, 2022). One of them can be used for all types of food crops, horticulture, and perennial plants because it reduces pest attacks and increases plant polyphenol production, increasing plant resistance to disease (Fatah, 2021). The hexagonal vertical aeroponic shape provides different light intensities on each side of the aeroponics so as to provide different amounts of light obtained. In planting conditions with a slope between 15 and 30 degrees, which has better light reception than the perpendicular direction (Risky *et al*., 2019). In the research results of Kasana *et al*. (2023), with a combination of planting techniques and planting media had the best results at a height of 30-60 cm. Differences in light intensity and planting direction received by each plant will affect the physiological conditions of plants during the photoperiod. The purpose of this research is to increase the number of lettuce plants produced through the use of hexagonal vertical aeroponic techniques that maximize the number of plants that can be planted, as well as by adding POC to nutrition, which results in better quality lettuce plants.

2. MATERIALS AND METHODS

2.1. Research Location and Materials

This research was conducted in the Green House of the Faculty of Agriculture, Universitas Pembangunan "Veteran" Jawa Timur. This research was conducted from April to June 2024. The tools used are hexagonal vertical aeroponic installation consisting of impraboard, hexsagonal frame, irrigation spray pipes, pumps, labels, trays, small saws, analytical scales, luxmeter, pH meter, injections, water reservoirs, and stationery are all tools used in this study. This study used materials including Grand Rapid variety lettuce seeds, rockwoll, AB mix, and POC Nasa.

2.2. Research Design and Data Analysis

The experiment was designed using a factorial Randomized Group Design, with two factor treatments. The first factor, planting direction (P), consisted of six parts, and the second factor, nutrients (N), consisted of two types, namely 5 ml/L AB-mix nutrient and mixture of AB-mix (3.75ml/L) + 2.5ml/L liquid organic fertilizer (LOF). The treatment combinations was detailed in Table 1. Figure 1a shows that each treatment was randomized and then repeated in three replicate groups. The LSD (Least Significant Difference) test at the 5% level was used to analyze the observation data with the variance analysis (ANOVA) method using a linear model.

Table 1. Research factors and levels

Nutrition		Planting Direction	
AB-mix nutrient 5 ml/L	N1	Planting Direction 1 (East)	P1
		Planting Direction 2 (Northeast)	P2
		Planting Direction 3 (Northwest)	P3
AB-mix nutrient 3.75ml/L+ LOF 2.5ml/L (Zamani, 2022)	N2	Planting Direction 4 (West)	P4
		Planting Direction 5 (Southwest)	P5
		Planting Direction 6 (South)	P6

2.3. Installation Preparation

The hexagonal vertical aeroponic system consisted of a pipe having six sides (Figure 1b). The system was designed with 1.5 m high and each side of 30 cm wide. The distance between planting holes was 10 cm × 15 cm. The system was equipped with water reservoir of 30 L capacity, irrigation spraying pipe of 5/8 inch, and 160 psi pressure pump.

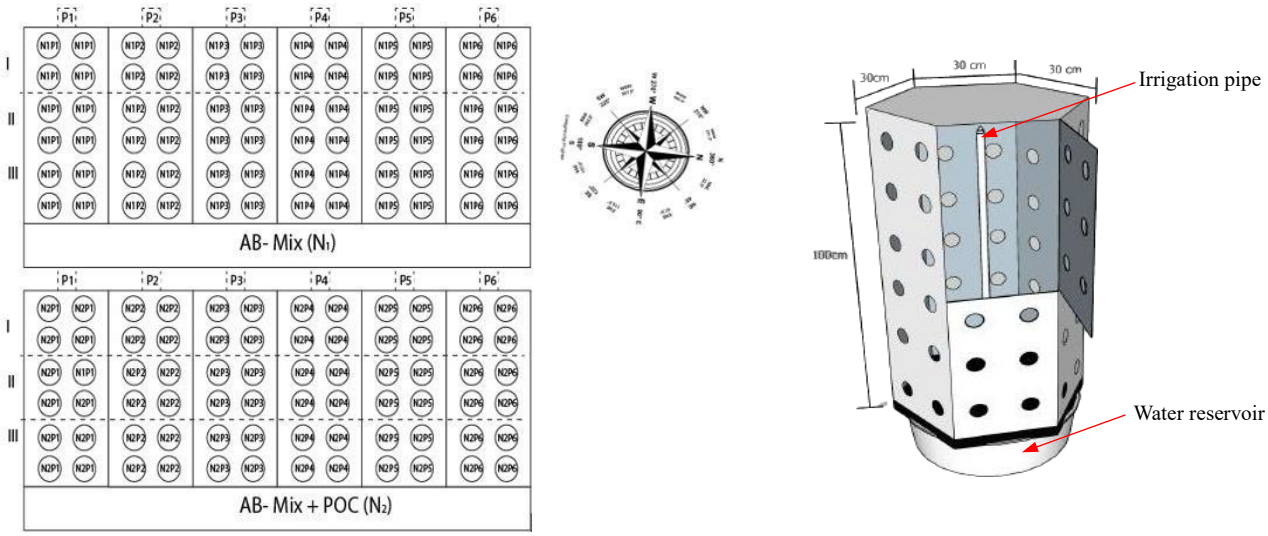

Figure 1. (a) Experiment layout, and (b) Detail hexagonal vertical aeroponic system

2.4. Cultivation of Curly Lettuce

Curly lettuce seeds were sown using rockwool media in trays for 14 days, with two curly lettuce seeds planted in each rockwool hole. After the seedlings were 14 days old, the plants were transferred to each net pot that would be placed in the planting holes of the prepared aeroponic system. The dose of POC for the addition of nutrients was given according to the treatment, namely 2.5ml/L once a week.

Water reservoir was monitored daily to determine the level of nutrients and pH. Normal plant need a pH of 6-7. If the nutrient level in the reservoir decreased, nutrient solution was reapplied according to the treatment design. If the pH was >7, then “pH-down” solution was added in step wise to lower the pH. On the other hand, when the pH is <6, the "pH-up" solution is added little by little until the pH rises to a value of 6-7.

Pest infestation such as caterpillar was controlled mechanically by catching the pests or cutting the affected plants. Harvesting was conducted manually when the plant age of 45 DAP (days after planting) or when the plants show physiological characteristics of ready for harvest.

2.4.1. Observation Parameters and Data Analysis

The parameters observed in this study were plant length, number of leaves observed every day and measured every 15 days and on the parameters of yield (root length, wet weight, dry weight) and organoleptic tests carried out at the time the plants were harvested with each treatment taken one sample with the best results for organoleptic tests.

3. RESULTS AND DISCUSSION

3.1. Plant Length

Figure 2 shows lettuce plant development under hexagonal vertical aeroponic system. The results from ANOVA showed that the combined treatment of planting direction and the addition of POC did not significantly affect plant length of lettuce until 30 DAP (Table 2). The interaction, however, is significant at 45 DAP (Table 3). Single factor plant direction did not significantly affect plant length until 30 DAP. While, single factor nutrition significantly affected plant length after 30 DAP. From Table 2, the use of 3.75ml/L AB-mix nutrient + 2.5ml/L LOF (N2) significantly increase lettuce size at 30 DAP. This nutrient also resulted in better plant length at 45 DAP in all planting direction as presented in Table 3. The tables reveal that the effect of nutrient compositions are more dominant in affecting plant size as compared to that of planting direction. This implies that the designed hexagonal vertical aeroponic system is capable of providing uniform lighting in all directions.

Figure 2. The development of lettuce plant growth under hexagonal vertical aeroponic system at 15 to 45 DAP

Plant growth occurs when plants that have just been moved from the nursery age of 14 DAP need time to adapt to their new environment. The recovery of new plants takes time because the root transfer has not been actively absorbing nutrients (Irawati & Widodo, 2017). As the age of the plant increases, the roots have begun to actively absorb available nutrients. The addition of LOF in nutrition provides protection to plants (with low intensity) but has a low content and combined with ab mix can provide a good growth response. According to Dewi (2024), the combination of poc and ab mix can optimize the use of ab mix for green lettuce growth and provide the same growth response if ab mix is used completely.

The highest treatment interaction is found at N2P2 (addition of POC to the nutrient and planting direction 2) with a plant length of 26.49 cm, while for nutrition factor there is a significant effect at the age of 30 DAP with the highest plant length of 22.19 cm in the N2 treatment. This is thought to be because the need for photosynthesis of plants has been met with AB mix and the addition of POC can increase the continuation of photosynthesis, by increasing the photosynthetic ability of plants and absorption of nitrogen from the air, liquid organic fertilizer can increase and increase the formation of leaf chlorophyll (Juliansyah *et al.,* 2022).

Table 2. Effect of single factor of planting direction and nutrient addition on average plant length (cm) at age 15 and 30 DAP

Treatment	15 DAP	30 DAP
Nutrition		
N1	7.80	19.79 a
N2	8.61	22.19 b
LSD 5%	tn	5.08
Planting Direction		
P1	2.56	6.59
P2	2.65	7.05
P3	2.58	7.46
P4	2.49	6.83
P5	2.99	7.16
P6	3.13	6.88
LSD 5%	tn	tn

Notes: Numbers followed by the same letter indicate no significant difference in the 5% LSD test; tn = not significant.

Table 3. Effect of interaction of planting direction and nutrients on the average plant length (cm) of curly lettuce at age 45 DAP

Treatment	P1	P2	P3	P4	P5	P6
N1	25.86 bcd	25.77 abcd	25.78 abcd	24.59 abc	23.97 a	24.54 ab
N2	25.57 abcd	26.49 d	26.41 cd	25.40 abcd	25.19 abcd	26.30 bcd
LSD 5%	1.82					

Notes: Numbers followed by the same letter indicate no significant difference in the LSD test with α = 5%.

3.2. Number of Leaves

The results of *analysis of variance* (ANOVA) showed that there was no significant relationship between the treatment of planting direction and the addition of POC in hexagonal aeroponic nutrition and the number of leaves parameter. In addition, the single factor of planting direction treatment and the addition of POC in hexagonal aeroponic nutrition had no significant impact on the number of leaves during observation. Table 4 shows the average value of the number of leaves for the treatment of planting direction and POC addition for hexagonal aeroponic nutrition.

Table 4 shows the addition of POC at 2.5 ml/L nutrients and the treatment of planting direction and planting direction did not give significantly different results on the number of leaves. The addition of POC in nutrients increased the number of leaves of the highest pod lettuce plants by 27 strands (45 DAP) however, these results were not significantly different those without the addition of POC, while the treatment of planting direction 3 (northwest) gave the highest results with a total of 5.14 and also not significantly different from other planting directions.

Table 4. Effect of single factor of planting direction and nutrient addition on the average number of leaves at 15-45 DAP

Treatment	15 DAP	30 DAP	45 DAP
Nutrition			
N1	5.97	7.94	11.36
N2	6.03	7.47	13.50
LSD 5%	tn	tn	tn
Planting Direction			
P1	2.00	2.39	4.78
P2	1.97	2.44	3.89
P3	2.00	2.89	5.14
P4	2.00	2.36	4.11
P5	2.03	2.75	3.19
P6	2.00	2.58	3.75
LSD 5%	tn	tn	tn

Notes : Numbers followed by the same letter indicate difference in the 5% LSD test; tn = not significant.

Research conducted by Kasana *et al*. (2023), with vertical garden planting techniques on red lettuce planting also did not show a significantly different response. The highest number of leaves in the east planting direction with an average of 43.06. Research conducted by Zamani (2022), on Substitution of AB mix nutrients using liquid organic fertilizer in mustard plants using a wick system hydroponic system shows that the addition of 2.5 ml/L to ab mix is an effective dose to increase the number of mustard leaves.

The difference in the effectiveness of nutrition and planting direction on the parameter of the number of leaves between this study and other research references is thought to be due to differences in the type of nutrition and planting direction, which are used and differences in the response of each plant in research by Hasrin (2023), has results that are not significantly different in the paramepert number of leaves of lettuce plants with the treatment of adding POC to Nutrition. Liquid organic fertilizer besides functioning as a fertilizing companion, also functions as a natural protection for plants. The unique aroma of POC nasa will reduce pest attacks and increase polyphenol compounds in plants, increasing plant resistance to disease.

3.3. Harvest Yield

The treatment interaction of the effect of planting direction and POC addition on hexagonal vertical aeroponic nutrition was not found in the parameters of wet weight and dry weight. The single factor of POC addition to nutrients and planting direction gave a significant effect on root length parameters, the yield parameters can be seen in Table 5. The treatment of POC addition to nutrients was not significantly different on plant yield parameters, namely root length, wet weight and dry weight of plants. The root length parameter is the only plant yield parameter that does not show any effect on each single factor. This can be caused by differences in the amount of light intensity received in each replication and the length of irradiation obtained. Based on the results of the study, the addition of POC to nutrition

Table 5. Effect of single factor of planting direction and nutrient addition on average root length, wet weight, and dry weight

Treatment	Root Length (cm)	Wet Weight (g)	Dry Weight (g)
Nutrition			
N1	51.91	63.59	6.64
N2	58.93	90.59	8.40
LSD 5%	8.01	31.14	1.97
Planting Direction			
P1	48.93 a	65.84	6.22
P2	68.73 b	102.79	6.32
P3	58.20 ab	92.27	10.38
P4	54.45 a	72.73	8.24
P5	51.95 a	65.02	6.94
P6	54.94 a	63.91	7.03
LSD 5%	13.88	tn	tn

Notes: Numbers followed by the same letter indicate no significant difference in the 5% LSD test; tn = not significant.

gave the highest results but was not significantly different from without addition, in the parameters of root length (58.93 cm), wet weight (90.59 grams), and dry weight (8.40 grams). These results are in line with those conducted by Nurhidayati *et al*. (2024), which showed that the addition of Nasa liquid organic fertilizer 6 ml and ab mix 10 ml gave the best results in the parameter of root length of pakcoy plants. Another study showed that the addition of 25% liquid organic fertilizer to 75% ab gave the best results for plants in terms of wet and dry weight. caisim mustard greens (Marginingsih *et al*., 2018). The higher the use of POC doses given does not guarantee a better response and higher yields in plants. According to Nuryani *et al*. (2019), increasing the dose of fertilizer will not always have an impact on increasing plant yield, especially after the fertilization dose reaches the optimal point. Plant wet weight shows how much nutrient composition in plant tissue (Evelyn *et al*., 2018).

The results showed that the single factor of planting direction treatment showed significant results on root length parameters but did not show significant differences on wet weight and dry weight. This is because the vertical planting position with the hanging root position causes the influence of hydrotropism, geotropism and chemotropism. Hydrotropism is the direction of plant root growth towards the water source, which allows the roots to grow actively towards the water source and geotropism is influenced by the earth's gravity, the main driver that determines the direction of root growth towards the center of the earth (Dietrich, 2018). Chemotropism on the roots to find and get a source of nutrients (Henke *et al*., 2014). Through the influence of this motion, it forces the plant to get a source of nutrients so that the roots of the plant become long. In addition, there is a growth hormone, namely cytokinin in POC, which can increase the growth of lettuce plant roots. Elements CA and P in ab and POC mixtures can accelerate healthy root growth, increasing root wet weight (Munthe *et al*., 2018).

3.4. Organoleptic Test (Lettuce Leaf Crispness Level)

The results of the analysis of variance (ANOVA) on the observation parameter of the organoleptic test of the level of crispness there is a real interaction of the combination of the effect of planting direction and the addition of POC on hexagonal aeroponic nutrition. Organoleptic test of crispness level after being tested with LSD 5% is presented in Table 6. The interaction of planting direction and the addition of POC to the nutrient dose gave a response to the organoleptic test parameters. Based on the results of the study, the highest average level of crispness of lettuce was found in the interaction of N2P3 at 3.89 (P3 planting direction and the addition of POC in nutrition) and N2P5 (P3 planting direction and the addition of POC in nutrition) at 3.78 while the lowest average level of crispness was found in the interaction of N1P6 at 3.00 (P6 planting direction and no addition) level. The organoleptic test of the crispness level of lettuce plants is influenced by the nutrients used for plant growth. The best treatment is found in N2P3 and N2P5, this is due to Nasa liquid organic fertilizer has a high calcium content. Fauzi *et al*. (2013) because calcium is a structural component that builds plant cell walls. The concentration of calcium accumulated in the cell walls that make up the leaf organs increases along with the level of crispness of the leaves of lettuce plants.

Table 6. Effect of planting direction and addition of hexagonal vertical aeroponic nutrients on organoleptic score

Treatment	P1	P2	P3	P4	P5	P6
N1	3.44abcd	3.67cd	3.11ab	3.67cd	3.56bcd	3.00a
N2	3.22abc	3.44abcd	3.89d	3.67cd	3.56bcd	3.78d
LSD 5%			1.43			

Notes: Numbers followed by the same letter indicate no significant difference in the 5% LSD test.

Macro essential nutrient calcium (Ca) in POC Nasa showed that significant addition of POC Nasa will increase the calcium content in lettuce plants, wich can be used to produce very leaf quality. POC Nasa with medium-high doses contains humate which can produce a sweet taste in lettuce. In accordance with the results of research (Tehranifar & Ameri, 2014), the application of humic acid resulted in an increase in the sweetness content of strawberry fruit cultivated in a green house and by giving it has a sweet taste.

4. CONCLUSION

The conclusion of this study stated that the interaction of planting direction treatment and the addition of POC in nutrition affected the plant length and crispiness of the produced lettuce but not significant to other growth and yield parameters (number of leaves and harvest weight). Treatment of N2P2 (addition of POC to the AB mix nutrient and planting direction Northeast) resulted the highest plant length (26.49 cm) at the plant age of 45 DAP. The combination treatment also affected the crispness level of lettuce with highest organoleptic score of 3.89 for lettuce produced under N2P3 treatment (addition of POC to the AB mix nutrient and planting direction Northwest). The single factor of planting direction also significantly influenced root length ole lettuce plant with the highest 68.73 cm resulted from P2 (Northeast). POC addition in nutrition influenced the root length, wet weight, and dry weight of lettuce plant, but not significantly different from those without the addition of POC in the nutrition.

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