Journal of Smart Agriculture and Environmental Technology
e-ISSN:3021-8802
Vol. 3, No. 1, April 2025
https://josaet.com | https://doi.org/10.60105/josaet.2025.3.1.37-43

Research Paper

Effect of Different Nutrient Concentrations on the Growth and Yield of Curly Lettuce (*Lactuca sativa* L.) in Two Hydroponic System

Annisa Gita Febriani[1], Aisyah[2], Edi Minaji Pribadi[3]*, Bagas Elang Samudra[4]

[1] *Previuosly, Student of Agrotechnology, Faculty of Industrial Technology, Gunadarma University*
[2] *Studi Program of Agrotechnology, Faculty of Industrial Technology, Gunadarma University*
[3] *Studi Program of Agrotechnology, Faculty of Industrial Technology, Gunadarma University*
[4] *Studi Program of Agrotechnology, Faculty of Industrial Technology, Gunadarma University*
***Corresponding author**: edi_mp@staff.gunadarma.ac.id

Article History: Received: January 1, 2025, Accepted: February 22, 2025

Abstract
Lettuce (*Lactuca sativa* L.) is a widely consumed vegetable known for its nutritional benefits and economic potential. This study investigated the effects of two hydroponic systems Nutrient Film Technique (NFT) and Deep Flow Technique (DFT) and varyied nutrient concentrations on the growth and production of curly lettuce, conducted from March to June 2024 at the Smart Farming Zone of UG Technopark, the research utilized a Randomized Complete Block Design (RCBD) with two nested factors. The first factor comprised two hydroponic systems (H1: NFT and H2: DFT), while the second factor involved four nutrient combinations: AB Mix 0 ml + Liquid Organic Fertilizer (LOF) 10 ml (P1), AB Mix 5 ml + LOF 15 ml (P2), AB Mix 10 ml + LOF 20 ml (P3), and AB Mix 20 ml + LOF 25 ml (P4). Key growth parameters measured included plant height, number of leaves, leaf length, leaf width, stem diameter, root length, total fresh weight, fresh weight of roots, and total dry weight. Results indicated that the DFT hydroponic system with a nutrient concentration of AB Mix 20 ml + LOF 25 ml significantly enhanced plant height, number of leaves, root length, fresh weight of the crown, and dry weight. Additionally, the DFT system at AB Mix 10 ml + LOF 20 ml improved leaf length, leaf width, stem diameter, and fresh weight of curly lettuce. These findings underscore the potential of optimizing hydroponic systems and nutrient formulations for enhanced lettuce production.

Keywords
AB mix nutrition, DFT Hydroponics, Lettuce, Liquid organic fertilizer, NFT Hydroponics

1. INTRODUCTION

Lettuce (*Lactuca sativa* L.) is one type of vegetable crop that is widely consumed by the community because lettuce has high nutritional content and good economic and agribusiness potential. Lettuce has attractions such as having a short harvest period, a wide open market, relatively stable prices, and nutritional content so that it is widely consumed by the community. Based on the production of lettuce vegetables in Indonesia from 2017 to 2020, the total production of lettuce plants was 627,611 tons; 625,132 tons; 638,731 tons; and 663,832 tons (Badan Pusat Statistik, 2020).

The Badan Pusat Statistik (BPS) data proves that lettuce production continues to fluctuate but the level of public demand is getting higher. Lettuce cultivation is generally done conventionally. Conventional cultivation requires a large area of land and a large amount of fertilizer, which is one of the obstacles in the practice of lettuce cultivation. The conversion of agricultural land into residential and office buildings has caused a decrease in land. In the midst of society there are concerns about the high content of pesticide residues in agricultural products, it is necessary to develop an alternative agricultural system that is able to produce healthy products in sustainable quantities and quality, one way that can be done is to carry out an agricultural system that supports this concept is an organic farming system (Hardaningsih et al., 2024). Cultivation techniques with hydroponic systems can be a solution to increase the production of curly lettuce. According to Lonardy (2006), hydroponic systems can provide a more controlled growth environment such as water and nutrient flow, nutrient concentration, temperature, pests and diseases and so on. This makes plants cultivated with hydroponics of better quality and faster to harvest.

There are many types of hydroponic systems, such as NFT hydroponics, DFT hydroponics, floating raft hydroponics, and Dutch Bucket hydroponics. Each hydroponic system has a different way of working and advantages. NFT and DFT systems are both fertigation systems, but the difference is the height of the nutrients flowing through

the installation. The height of nutrients flowing in the NFT system is around 2-3 mm (thin layer), while the height of nutrients in the DFT system is 3-4 cm (Sesanti and Sismanto, 2016). One of the most important things in a hydroponic system is the nutrient solution. The usual plant nutrient solution used in hydroponic systems is AB mix, where mixtures A and B each include macro elements and micro elements or can use Liquid Organic Fertilizer (LOF). Banana waste such as banana peel and stem can be used as an ingredient to make LOF. Based on the analysis conducted, it was found that the nutrient content in the kepok banana peel liquid fertilizer was 0.18% N-total; 0.043% P_2O_5; 0.55% C-organic; pH 4.5; 3.06% C/N; and 1.137% K_2O (Nasution, 2013). The purpose of this study was analized the effect of a combination of nutrient concentrations in two hydroponic systems, as well as to determine the type of hydroponic system and the best combination of nutrients on the growth and yield of curly lettuce plants.

2. RESEARCH METHOD

2.1 Time and Location

The research of curly lettuce cultivation with the comparison of nutrient concentrations in two hydroponic systems was carried out on March 15 - June 16, 2024 at the Bheta UG Technopark Greenhouse, Jamali Village, Mande Subdistrict, Cianjur, West Java, Indonesia.

2.2 Tools and Material

The tools used in this research are NFT hydroponic installation, DFT hydroponic installation, container box, tray, netpot, flannel, water pump, writing tools, injection, measuring cup, ruler, hanging label, sticky label, writing label, tweezers, mesh filter, TDS (Total Dissolve Solid), pH meter, and digital scale. The materials used were green curly lettuce seeds var. Grand Rapids, rockwool, pH down, ab mix, and Banana Waste POC.

2.3 Experiment Design

The research was conducted using the nested pattern Randomized Complete Group Design (RCGD) method which consist of 2 factors. The first factor (mainplot) are NFT hydroponic system (H1) and DFT hydroponic system (H2), while the second factor consists of 4 levels, namely AB Mix 0 ml + LOF 10 ml (P1), AB Mix 5 ml + LOF 15 ml (P2), AB Mix 10 ml + LOF 20 ml (P3), and AB Mix 20 ml + LOF 25 ml (P4). Thus there are 8 treatment combination: H1P1; H1P2; H1P3; H1P4; H2P1; H2P2; H2P3; H2P4. Each treatment is repeated 5 times to make effective use of the available system so that there are 40 experimental units. Each experimental unit will use 3 plant samples so that the total number of experimental units is 120 plants.

2.4 Data Collection

The data obtained are primary data derived from direct measurements of the growth and production of curly lettuce, and the parameters observed include: plant height (cm) and number of leaves (strands) observed starting from 7 Days After Planting (HST) until the plants are ready to harvest at the age of 35 HST. Measurements were taken at 7-day intervals. While leaf length (cm), leaf width (cm), stem diameter (mm), root length (cm), plant fresh weight (g), crown fresh weight (g), and plant dry weight (g) were observed at the end of the experiment or at harvest, when the plants were 35 HST.

2.5 Data Analysis

The data obtained were analyzed in The SAS System for Windows 9.0 program by using Analysis of Variance (ANOVA) with a level $\alpha = 5\%$. ANOVA (Analysis of Variance) is one of the parametric tests used to distinguish the average value of more than two groups of data by comparing the variance between groups. If the results of the analysis show that there is a significant effect (F count $\leq$ F table) then a further test will be conducted with the Duncan Multiple Range Test (DMRT) at the 5% level.

3. RESULTS AND DISCUSSION

3.1 Plant Height

The effect of different hydroponic systems and nutrient concentrations on the height of curly lettuce plants for 5 weeks of planting tends to increase, as in Figure 1.

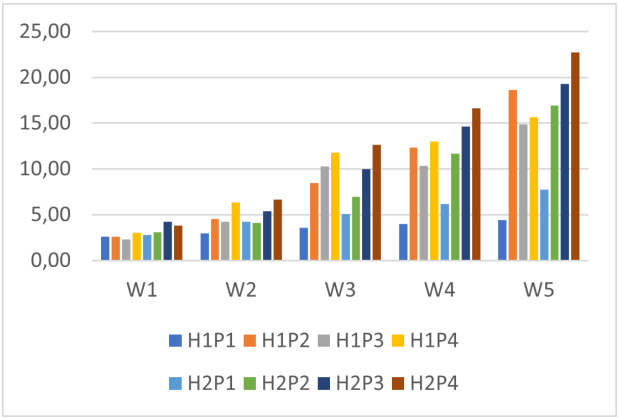

Figure 1. Height growth diagram of curly lettuce plants in NFT and DFT hydroponics with concentration comparison 1-5 WAT (Week After Transplanting)

The results showed that at week 5th, the DFT hydroponic system treated with AB Mix nutrient concentration of 20 ml + LOF 25 ml showed the tallest lettuce plants (H2P4), while the NFT system treated with AB Mix nutrient concentration of 0 ml + LOF 10 ml showed the smallest lettuce plant height (H1P1).

3.2 Number of Leaves

The effect of different hydroponic systems and nutrient concentrations on the number of leaves of curly lettuce for

5 weeks of planting tends to increase, as in Figure 2.

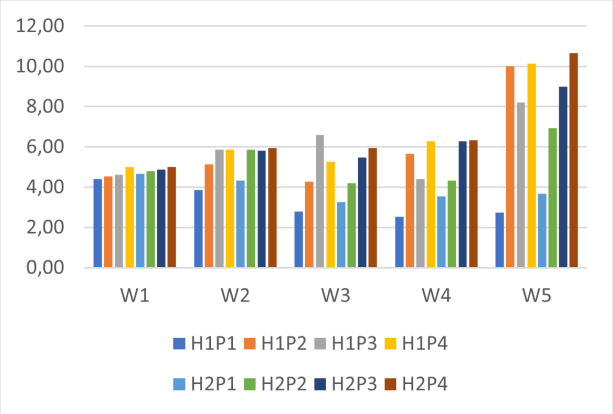

Figure 2. Growth diagram of curly lettuce plants against the number of leaves at 1-5 WAT

The results showed that at week 5th, the DFT hydroponic system treated with AB Mix nutrient concentration of 20 ml + LOF 25 ml showed lettuce plants that had the highest number of leaves (H2P4), while the NFT system treated with AB Mix nutrient concentration of 0 ml + POC 10 ml showed the least number of lettuce leaves (H1P1).

3.3 Leaf length and Leaf width

Table 1. Effect of different hydroponic systems and nutrient concentrations on leaf length of curly lettuce plants at 5 WAT.

Nutrient Concentration	Leaf length (cm)	
	NFT(H1)	DFT(H2)
AB Mix 0 ml + LOF 10 ml (P1)	2.86 d	4.00 c
AB Mix 5 ml + LOF 15 ml (P2)	15.10 a	15.68 b
AB Mix 10 ml + LOF 20 ml (P3)	13.00 b	17.01 a
AB Mix 20 ml + LOF 25 ml (P4)	10.78 c	16.24 ab
Average	10.43^{B}	13.23^{A}

Note: Numbers followed by different uppercase letters in the same row indicate significantly different effects at the 5% DMRT level, while numbers followed by different lowercase letters in the same column indicate significantly different effects at the 5% DMRT level.

Based on the results of the Duncan Multiple Range Test (DMRT) analized at the 5% level, it shows that the DFT hydroponic system treatment has a significant effect on the parameters of leaf length and leaf width. The nutrient concentration treatment showed significantly different results on the parameters of leaf length and width of curly lettuce leaves with the highest average value of leaf length found in the AB Mix 10 ml + LOF 20 ml (H2P3) nutrient concentration of 17.01cm and the highest average value of leaf width found in the AB Mix 10 ml + LOF 20 ml (H2P3) nutrient concentration of 18.68 cm (Table 1).

Table 2. Effect of different hydroponic systems and nutrient concentrations on width of curly lettuce plants at 5 WAT

Nutrient Concentration	Leaf width (cm)	
	NFT(H1)	DFT(H2)
AB Mix 0 ml + LOF 10 ml (P1)	1.56 d	2.45 c
AB Mix 5 ml + LOF 15 ml (P2)	17.51 a	16.13 b
AB Mix 10 ml + LOF 20 ml (P3)	13.41 b	18.68 a
AB Mix 20 ml + LOF 25 ml (P4)	11.54 c	18.11 ab
Average	11.00^{B}	13.84^{A}

Note: Numbers followed by different uppercase letters in the same row indicate significantly different effects at the 5% DMRT level, while numbers followed by different lowercase letters in the same column indicate significantly different effects at the 5% DMRT level.

3.4 Stem Diameter and Root Length

Table 3. Effect of different hydroponic systems and nutrient concentrations on width of curly lettuce plants at 5 WAT

Nutrient Concentration	Stem diameter (mm)	
	NFT(H1)	DFT(H2)
AB Mix 0 ml + LOF 10 ml (P1)	1.52 c	1.76 c
AB Mix 5 ml + LOF 15 ml (P2)	8.44 a	9.08 b
AB Mix 10 ml + LOF 20 ml (P3)	6.32 a	11.10 a
AB Mix 20 ml + LOF 25 ml (P4)	7.70 b	9.20 b
Average	5.99^{B}	7.78^{A}

Note: Numbers followed by different uppercase letters in the same row indicate significantly different effects at the 5% DMRT level, while numbers followed by different lowercase letters in the same column indicate significantly different effects at the 5% DMRT level.

Based on the results of the Duncan Multiple Range Test (DMRT) analized at the 5% level, it shows that the DFT hydroponic system treatment has a significant effect on the parameters of stem diameter and root length of curly lettuce plants. The treatment of nutrient concentration AB Mix 10 ml + LOF 20 ml (H2P3) showed a significant effect on the parameters of stem diameter with the highest mean value of 11.10 cm and the treatment of nutrient concentration AB

Table 4. Effect of different hydroponic system and nutrient concentrations on root length of curly lettuce plants at 5 WAT.

Nutrient Concentration	Root length (cm)	
	NFT(H1)	DFT(H2)
AB Mix 0 ml + LOF 10 ml (P1)	9.02b	10.59c
AB Mix 5 ml + LOF 15 ml (P2)	22.38a	16.47b
AB Mix 10 ml + LOF 20 ml (P3)	18.45a	22.38a
AB Mix 20 ml + LOF 25 ml (P4)	12.62b	24.80a
Average	15.62^{B}	18.56^{A}

Note: Numbers followed by different uppercase letters in the same row indicate significantly different effects at the 5% DMRT level, while numbers followed by different lowercase letters in the same column indicate significantly different effects at the 5% DMRT level.

Mix 20 ml + LOF 25 ml (H2P4) showed a significant effect on root length with the highest mean value of 24.80 cm (Table 2).

3.5 Fresh weight plant, Fresh weight of crown, Dry weight plant

Table 5. Effect of different hydroponic systems and nutrient concentrations on fresh weight, of curly lettuce plants at 5 WAT.

Nutrient Concentration	Fresh weight (g)	
	NFT(H1)	DFT(H2)
AB Mix 0 ml + LOF 10 ml (P1)	0.53d	4.482c
AB Mix 5 ml + LOF 15 ml (P2)	95.26a	79.78b
AB Mix 10 ml + LOF 20 ml (P3)	58.97b	135.01a
AB Mix 20 ml + LOF 25 ml (P4)	36.12c	132.22a
Average	47.59^{B}	87.87^{A}

Note: Numbers followed by different uppercase letters in the same row indicate significantly different effects at the 5% DMRT level, while numbers followed by different lowercase letters in the same column indicate significantly different effects at the 5% DMRT level.

Based on the results of the Duncan Multiple Range Test (DMRT) analized at the 5% level, it shows that the DFT hydroponic system treatment significantly affects the parameters of plant fresh weight, crown fresh weight, and dry weight of curly lettuce plants. The treatment of nutrient concentration shows results that have a significant effect on the parameters of plant fresh weight, harvest weight, and dry weight of curly lettuce plants. AB Mix 10 ml + POC 20 ml (H2P3) treatment has the highest average fresh weight of 135.01 g and AB Mix 20 ml + POC 25 ml (H2P4) treatment has the highest average crown fresh weight and dry weight of 105.80 g and 9.93 g (Table 3).

The results of data analysis showed that the hydroponic system significantly affected the vegetative and generative variables of lettuce plants, such as plant height, number of leaves, leaf length and width, root length, stem diameter, plant fresh weight, crown fresh weight, and plant dry weight. After a system comparison study, it was found that the DFT hydroponic system proved superior to NFT. This system submerges the plant roots in a nutrient-rich solution. It has been shown to increase photosynthetic parameters and yield, and offers a shorter growing period compared to soil-based systems. Deep-water cultivation and nutrient layer techniques are effective alternatives to soil-based lettuce cultivation in the temperate region of northern India, as deep-water cultivation can reduce plant growth period by up to 15 days and improve harvest quality (Majid et al., 2020). Research of Nurza (2022) showed that the DFT system increased the height of kale plants at 13 and 21 WAT because nutrients are always available, even when the power is off, so that plant growth is more optimal (Wibowo, 2020). The roots of lettuce plants that are submerged in the DFT system nutrient solution cause the availability of nutrients and oxygen at the roots to always be abundant, so that plant growth becomes good, because if the lack of oxygen for plants is very dangerous, because oxygen in the water is used for respiration (breathing) roots (Fauzi, 2013). Insufficient oxygen around plant roots can cause inhibition of growth or can cause death (Resh, 2013) . DFT hydroponic models, such as the rung model, have advantages in water use efficiency and construction costs (Wibowo, 2020). This system produces faster harvests and higher income potential (Anika and Putra, 2020).

Nutrient concentration treatment also significantly affected the vegetative variables of lettuce plants. The nutrient concentration of AB Mix 20 ml + LOF 25 ml (P4) gave the best results for plant height (Figure 1), number of leaves (Figure 2), and root length (24.80 cm). AB Mix concentration of 10 ml + LOF 20 ml (P3) produced the best leaf length (17.01 cm) (Table 1), leaf width (18.68 cm) (Table 2), and stem diameter (11.10 cm) (Table 3). Sitepu et al. (2022), supports these results, with similar nutrient concentrations increasing plant growth. In the vegetative growth phase, nitrogen can spur plant growth, especially in the stem (Rizal., 2017). Nitrogen elements can increase the number of leaves, leaf area, larger stem diameter, longer internode length, resulting in higher plant weight (Puspadewi et al., 2016). Nitrogen increases leaf formation, thereby increasing plant absorption of nutrients (Nasution et al., 2014; Sepriani et al., 2016). In contrast, the AB Mix 0 ml + LOF 10 ml (P1) (Table 1 – Table 7) treatment showed the lowest results because the

Table 6. Effect of different hydroponic systems and nutrient concentrations on leaf width of curly lettuce plants at 5 WAT.

Nutrient Concentration	Fresh weight of crown (g)	
	NFT(H1)	DFT(H2)
AB Mix 0 ml + LOF 10 ml (P1)	0.16d	0.51c
AB Mix 5 ml + LOF 15 ml (P2)	69.22a	54.96b
AB Mix 10 ml + LOF 20 ml (P3)	35.23b	99.05ab
AB Mix 20 ml + LOF 25 ml (P4)	23.06c	105.80a
Average	31.92^{B}	65.08^{A}

Note: Numbers followed by different uppercase letters in the same row indicate significantly different effects at the 5% DMRT level, while numbers followed by different lowercase letters in the same column indicate significantly different effects at the 5% DMRT level.

Table 7. Effect of different hydroponic systems and nutrient concentrations on dry weigth of curly lettuce plants at 5 WAT.

Nutrient Concentration	Dry weight (g)	
	NFT(H1)	DFT(H2)
AB Mix 0 ml + LOF 10 ml (P1)	0.00c	0.26c
AB Mix 5 ml + LOF 15 ml (P2)	7.32a	5.71b
AB Mix 10 ml + LOF 20 ml (P3)	3.98b	8.78ab
AB Mix 20 ml + LOF 25 ml (P4)	4.28b	9.93a
Average	3.89^{B}	6.17^{A}

Note: Numbers followed by different uppercase letters in the same row indicate significantly different effects at the 5% DMRT level, while numbers followed by different lowercase letters in the same column indicate significantly different effects at the 5% DMRT level.

dose did not meet the nutrient needs of plants. Rohmaniyah and dan E. T. S. Putra (2015) mentioned that inadequate doses of nutrients cause stunted plants. LOF alone cannot be used as the main fertilizer because it produces low lettuce growth and production (Muhadiansyah et al., 2016). This is also reinforced by research conducted by Djidonou and Leskovar (2019), which states that higher nutrient concentrations generally increase growth and yield, a study found that increasing nitrogen concentration from 100 to 400 mg-L^{-1} increased yields in various seasons, with the highest yields observed in spring. Similarly, a nutrient concentration of 1200 ppm was found to significantly increase lettuce fresh weight compared to lower concentrations (Hidayat et al., 2016).

AB Mix 10 ml + LOF 20 ml (P3) (Table 5) treatment gave the best plant fresh weight, while AB Mix 20 ml + LOF 25 ml (P4) (Table 6 and Table 7) treatment produced the highest crown fresh weight and dry weight. Sitepu et al. (2022) showed that increasing the dose of LOF kepok banana peel affects the wet weight of lettuce plants, namely the combination of 20 ml AB Mix and 25 ml LOF gives the best results until 4 WAT, which indicates that this combination provides balanced nutrients and shows the opposite results in the combination of LOF which exceeds 50 ml with AB Mix will reduce the wet weight of plants due to low nitrogen content. According to Putri et al. (2017), balanced nutrients increase photosynthesis, leaf area, and plant dry matter. Agustin and Wahyuningrum (2019) mentioned that nitrogen supports the formation of proteins, carbohydrates, and starch, thus increasing the wet and dry weight of lettuce plants. Proper use of nutrients is the key to optimal growth. In addition to the use of proper nutrition, environmental factors can also affect the growth and production of lettuce.

AB Mix is effective but expensive and has the potential to negatively impact the environment if used continuously (Ilhamdi et al., 2020). Environmentally friendly alternatives such as Liquid Organic Fertilizer (LOF) can be a more economical and sustainable solution (Astuti et al., 2021).

4. CONCLUSION AND SUGGESTION

The conclusion obtained from this research is that the effect of different hydroponic systems on the growth and production of curly lettuce at several nutrient concentrations shows that the DFT hydroponic system has a significant effect compared to the NFT hydroponic system on the parameters of plant height, number of leaves, leaf length, leaf width, root length, stem diameter, plant fresh weight, crown fresh weight, and plant dry weight. The effect of nutrient concentration on the growth and production of curly lettuce plants in each type of hydroponic system shows significant

results. Nutrient concentration AB Mix 20 ml + LOF 25 ml (P4) showed the highest average results in the parameters of plant height, number of leaves, leaf length, leaf width, root length, stem diameter, crown fresh weight, and dry weight of lettuce plants. The nutrient concentration of AB Mix 10 ml + LOF 20 ml (P3) showed the highest average results in the parameters of plant fresh weight.

ACKNOWLEDGEMENT

The author is grateful to the supervisor who has provided guidance and direction so that the author can complete this writing well, as well as all the people who contributed to the preparation of this writing.

REFERENCES

Agustin, S. and M. Wahyuningrum (2019). Pengaruh Konsentrasi POC Limbah Kulit Jeruk Peras Terhadap Pertumbuhan dan Produksi Tanaman Sawi Hijau (*Brassica Juncia* L.). *Jurnal Ilmiah Respati*, **10**(2); 136–145. https://doi.org/10.52643/jir.v10i2.655

Anika, N. and E. P. D. Putra (2020). Analisis Pendapatan Usahatani Sayuran Hidroponik Dengan Sistem Deep Flow Technique (Dft). *Jurnal Teknik Pertanian Lampung (Journal of Agricultural Engineering)*, **9**(4); 367. https://doi.org/10.23960/jtep-l.v9i4.367-373

Astuti, Y., M. Setyaningsih, and S. Lestari (2021). Alternatif Pengganti Ab Mix Pada Perangkat Hidroponik. *Journal ABDI*, **7**(1); 6–11. https://journal.unesa.ac.id/index.php/abdi/article/view/4424

Badan Pusat Statistik (2020). Produksi Tanaman Selada di Indonesia Tahun 2017-2020

Djidonou, D. and D. Leskovar (2019). Seasonal Changes in Growth, Nitrogen Nutrition, and Yield of Hydroponic Lettuce. *HortScience*, **54**(1); 76–85. https://doi.org/10.21273/HORTSC113567-18

Fauzi, R. (2013). Pengayaan Oksigen di Zona Perakaran Untuk Meningkatkan Pertumbuhan dan Hasil Selada (Lactuca sativa L.) Secara Hidroponik. *J. Vegetalika*, **2**(4); 63–74

Hardaningsih, W., D. Budianta, A. Madjid, and A. Syazili (2024). Organic Farming for Healthy Food Production and Land Sustainability. *Journal of Smart Agriculture and Environmental Technology*, **2**(3); 107–114

Hidayat, R., M. P. P. Artiningrum, and P. Nugrahani (2016). Study of planting media and nutrition concentration on growth rate and yield of Lettuce (Lactuca sativa L.) in NFT hydroponic systems. In *IOP Conference Series: Earth and Environmental Science*, volume 637. page 012097. https://10.1088/1755-1315/637/1/012097

Ilhamdi, M. L., K. Khairuddin, and M. Zubair (2020). Pelatihan Penggunaan Pupuk Organik Cair (POC) Sebagai Alternatif Pengganti Larutan Nutrisi AB Mix pada Pertanian Sistem Hidroponik di BON Farm Narmada. *Jurnal Pengabdian Masyarakat Sains Indonesia*, **2**(1). https://doi.org/10.29303/jpmsi.v2i1.20

Lonardy, M. (2006). *Response of tomato plants (Lycopersicon esculentum mill.) to the supply of nitrogen compounds from different sources in a hydroponic system*. Ph.D. thesis, Tadulako University

Majid, M., J. N. Khan, Q. M. A. Shah, K. Z. Masoodi, B. Afroza, and S. Parvaze (2020). Evaluation of hydroponic systems for the cultivation of Lettuce (Lactuca sativa L., var. Longifolia) and comparison with protected soil-based cultivation. *Agricultural Water Management*, **245**; 106572. https://10.1016/j.agwat.2020.106572

Muhadiansyah, T. O., Setyono, and S. A. Adimihardja (2016). EFEKTIVITAS PENCAMPURAN PUPUK ORGANIK CAIR DALAM NUTRISI HIDROPONIK PADA PERTUMBUHAN DAN PRODUKSI TANAMAN SELADA (Lactuca sativa L .) The Effectiveness of Mixing Liquid Organic Fertilizer in Hydroponics Nutrients on Growth and Yield (Lactuca sativa L .). *J. Agronida*, **2**; 37–46

Nasution, F. J. (2013). Aplikasi Pupuk Organik Padat dan Cair dari Kulit Pisang Kepok untuk Pertumbuhan dan Produksi Sawi (*Brassica Juncea* L.). Skripsi Program Sarjana. Universitas Sumatera Utara. Medan

Nasution, F. J., L. Mawarni, and M. Meiriani (2014). Aplikasi Pupuk Organik Padat Dan Cair Dari Kulit Pisang Kepok Untuk Pertumbuhan Dan Produksi Sawi (Brassica Juncea L.). *Agroekoteknologi*, **2**(3); 1029–1037

Nurza, I. S. A. (2022). Cultivation of Water Spinach (Ipomoea Reptans Poir) Production By Using Dft and Nft. *Journal of Social Research*, **1**(10); 1110–1115. https://doi.org/10.55324/josr.v1i10.241

Puspadewi, S., W. Sutari, and K. Kusumiyati (2016). Pengaruh konsentrasi pupuk organik cair (POC) dan dosis pupuk N, P, K terhadap pertumbuhan dan hasil tanaman jagung manis (Zea mays L. var Rugosa Bonaf) kultivar talenta. *Kultivasi*, **15**(3); 208–216. https://doi.org/10.24198/kultivasi.v15i3.11764

Putri, N. D., E. D. Hastuti, and R. Budihastuti (2017). Pengaruh pemberian limbah kopi terhadap pertumbuhan tanaman selada (Lactuca sativa L.). *J. Biologi*, **6**(4); 41–50

Resh, H. (2013). *Hydroponic Food Production*. CRC Press. New York

Rizal., S. (2017). pengaruh nutrisi terhadap perrumbuhan tanaman sawi pakcoy (Brasicca rapa L.) yang di tanam secara hidroponik. *Sainmatika*, **14**(1); 38–44

Rohmaniyah, L. K. and D. I. dan E. T. S. Putra (2015). Tanggapan tanaman kangkung *(Ipomea reptans* Poir.), bayam (*Amaranthus tricolor* L.), dan selada (*Lactuca sativa* L.) terhadap pengayaan kalsium secara hidroponik. *J. Vegetalika*, **4**(2); 63–78

Sepriani, Y., Jamaluddin, and S. P. Hernosa (2016). *Applied Microbiology and Biotechnology*, **85**(1); 6

Sesanti, R. N. and Sismanto (2016). Pertumbuhan dan Hasil Pakchoi (Brasicca rapa L.) pada Dua Sistem Hidroponik

dan Empat Jenis Nutrisi. *J Inovasi Dan Pembangunan*, **04**(01); 1–9

Sitepu, D. N., S. M. Sholihah, and M. A. Wahyuningrum (2022). Pengaruh Konsentrasi Nutrisi AB Mix dan Pupuk Organik Cair Kulit Pisang Kepok Terhadap Produksi Tanaman Selada (Lactuca sativa L.) Sistem Rakit Apung. *Jurnal Ilmiah Respati*, **13**(2); 174–188. https://doi.org/10.52643/jir.v13i2.2707

Wibowo, S. (2020). Pengaruh Aplikasi Tiga Model Hidroponik DFT Terhadap Tanaman Pakcoy (Brassica rapa L.). *Jurnal Keteknikan Pertanian Tropis Dan Biosistem*, **8**(3); 245–252. https://doi.org/10.21776/ub.jkptb.2020.008.03.06

