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Response of Growth and Yield of Several Varieties of Lettuce Plants (Lactuca sativa L.) at Different Concentrations of Nutrients with Smart Aeroponic System

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***Abstract*— Lettuce cultivation is usually done conventionally and then transferred into a more controlled and efficient cultivation environment, one of which is using an aeroponic system. This study aimed to determine the Effect of different nutrient concentrations on the growth and yield of lettuce and the Effect of different varieties nested in nutrient concentrations on the growth and yield of lettuce with aeroponic systems. This research was conducted in March-July 2024 at Gunadarma University Technopark (UG-Technopark). The design used is RCBD Nested Design consisting of 2 factors (2x4), factor I AB Mix nutrient concentration (K), consisting of 2 levels of 1200 ppm (K1) and 1800 ppm (K2). Factor II, which is nested in factor I, is lettuce variety (V) consisting of 4 levels, namely Kriebo (V1), Karina (V2), Bisi SL 02 (V3), and Grand Rapids (V4). Each was repeated 4 times, so there were 32 experimental units. The results showed that differences in nutrient concentrations had a significant effect on the parameters of plant height, number of leaves, leaf length, root length, header dry weight, root wet weight and root header ratio. The best nutrient concentration was obtained at 1800 ppm AB Mix concentration. The difference in varieties nested in nutrient concentrations has a significant effect on the growth and yield of lettuce, the parameters of plant height of the Grand Rapids variety, number of leaves of Karina variety, leaf length of Bisi SL 02 variety, root length of Karina variety, header wet weight of Kriebo variety, root dry weight of Karina variety and root header ratio of Kriebo variety nested in 1800 ppm nutrient concentration.**

***Keywords*— AB Mix nutrition, Aeroponics, cultivation, lettuce, and varieties**

I. Introduction

Lettuce (Lactuca sativa L.) is one of the horticultural plants that is utilized by its leaves. Lettuce has nutritional content that is good for the body; lettuce also has anthocyanin pigments that are useful as antidotes to free radicals that damage body cells [1]. Lettuce has a relatively high nutritional content; the composition contained in 100 g wet weight of lettuce is calories 17.00 calories, protein 1.70 g, fat 0.30 g, carbohydrates 3.00 g, calcium 182.00 mg, phosphorus 27.00 mg, iron 2.50 mg, vitamin A 2.42 SI, vitamin B1 0.08 mg vitamin C 50.00 mg, and water 94.80 g [2]. Lettuce is one of the vegetable crops that have high economic value; its attractive shape and nutritional content give this plant the potential to continue to be cultivated. The production of lettuce vegetables in Indonesia in 2017 showed a production of 627,611 tons. In 2018, it was 625,132 tons; in 2019, production was 638,731 tons; and in 2020, it increased to 663,832 tons [3].

Lettuce is generally cultivated conventionally. In the development of lettuce cultivation, the decreasing agricultural land and the low quality of lettuce produced by farmers are some of the problems faced in the production of lettuce amid current land limitations [4]. Efforts that can be made to obtain quality vegetables in current land limitations are to improve crop cultivation methods, one of which is through an aeroponic system [5]. Aeroponics is a cultivation method that empowers air to increase agricultural land productivity. In the aeroponic system, nutrients are sprayed directly on the plant roots as a fine mist. Some of the advantages of this method include that in addition to being more efficient in land use, aeroponics can also streamline the use of nutrients, production yields are quite high, clean, and uniform in terms of quality and quantity guaranteed because planting can be done throughout the year. One of the key advantages of aeroponics is the oxygenation of each fine mist of nutrient solution so that root respiration is smooth and produces much energy [6].

Based on the description of the problems that have been described, and according to [7], differences in nutrient concentrations have a significant effect on the growth and yield of mustard plants on the parameters of the number of leaves, root length, header wet weight, root wet weight, header dry weight and root dry weight obtained at the AB Mix nutrient concentration of 1500 ppm. Thus, research was conducted on the growth response of several lettuce plants (Lactuca sativa L.) to different concentrations of nutrients with an intelligent aeroponic system. This study aimed to determine the Effect of different varieties and nutrient concentrations on the growth and yield of lettuce plants with an intelligent aeroponic system.

II. Research Methods

A. Object of Research

The research was conducted from March to July 2024 at the Smart Farming Greenhouse of Gunadarma Technopark University (UG-Technopark), Jamali-Mulyasari Village, Mande District, Cianjur Regency, West Java, which is located at an altitude of 392 meters above sea level. The tools used in this research are. Intelligent aeroponic system (pump, rack, box, lamp, nutrient tub, monitoring system, piping network, hose, sensor, automatic switch, nozzle set, and filter), TDS EC meter, pH meter, tray, hand sprayer, plastic bottle, pesticide sprayer, net pot, hygrometer, oven, envelope, stationery, camera, ruler, analytical balance, SAS 9 software. 4, Minitab 18 software and the materials used consist of lettuce seeds of Kriebo variety, Karina variety, Bisi SL 02 variety, Grand Rapids variety, Rockwool, AB Mix vegetable fertilizer, neem oil pesticide, disinfectant, label paper, and water.

B. Research Paradigm Approach

This research used the Randomized Complete Group Design (RKLT) Nested Design method consisting of 2 factors (2x4). Factor I (main plot) is nutrient concentration (K) consisting of 2 levels, namely 1200 ppm (K1) and 1800 ppm (K2). Factor II (subplots) nested in the nutrient concentration is lettuce variety (V) consisting of 4 levels, namely lettuce variety Kriebo (V1), lettuce variety Karina (V2), lettuce variety Bisi SL 02 (V3) and lettuce variety Grand Rapids (V4). Each treatment was repeated 4 times, so there were 32 experimental units. Each experimental unit consists of 3 plant samples, totaling 96 experimental units.

The following are the treatments used in the study, where varieties are nested in nutrient concentrations:

- K1V1: 1200 ppm AB Mix nutrient concentration and Kriebo lettuce variety.
- K1V2: AB Mix nutrient concentration of 1200 ppm and Karina lettuce variety
- K1V3: AB Mix nutrient concentration of 1200 ppm and lettuce variety Bisi SL 02
- K1V4: Konsentrasi nutrisi AB Mix 1200 ppm dan selada varietas Grand Rapids
- K2V1: AB Mix nutrient concentration of 1200 ppm and Grand Rapids lettuce variety
- K2V2: AB Mix nutrient concentration 1800 ppm and Karina lettuce variety
- K2V3: Nutrient concentration AB Mix 1800 ppm and lettuce variety Bisi SL 02
- K2V4: AB Mix nutrient concentration 1800 ppm and Grand Rapids lettuce variety

The statistical model used for the Randomized Complete Group Design (RKLT) Nested Pattern is as follows [8].

$$Yijk = \mu + \alpha i + \beta j(i) + \varepsilon ijk \quad \text{..(1)}$$

Description :

- Yijk = Observation value at the i-th level of factor A, the j-th level of factor B, and the k-th replication.
- μ = Generalized mean
- αi = Main Effect of factor I at level i
- $\beta j(i)$ = Main Effect of factor II at the j-th level nested in factor I at the i-th level
- εijk = Effect of error on factor I level I, factor II level j, and k-th replication

C. Data Measurement Method

The data collection method is done by directly observing the parameters. The parameters observed in this study consisted of growth and yield parameters. Growth parameters include plant height, number of leaves, leaf width, leaf length, and root length. Yield parameters are header wet weight, root wet weight, header dry weight, root dry weight, and root header ratio.

D. Data Analysis Method

The data that has been obtained is tested for normality and homogeneity and then analyzed using the Analysis of Variance (ANOVA). If the result of analysis shows that the perlakuan has a significant effect, then a further test with DMRT (Duncan's Multiple Range Test) with taraf α = 5% will be conducted. Correlation analysis performed using the statistical analysis system (SAS) version 9.4.

III. Results And Discussion

The research was conducted from March to July 2024 at the Smart Farming Greenhouse of Gunadarma Technopark University (UG-TechnoPark), located at an altitude of 392 meters above sea level with coordinates (6°45'43.1 "S 107°12'35.4 "E). The intelligent aeroponic system in this study consists of four levels with a length of 4 m and a width of 1.6 m. Each level of the aeroponic rack has a height of 60 cm and consists of 8 boxes. Each box has purple and white grow lights on it. One box has 18 holes with a distance of 10 x 15 cm. The intelligent aeroponic system has two nutrient basins; the front basin is connected to the first-level rack, and the back basin is connected to the second-level rack. The control system consists of Arduino uno, ESP 32, DHT22 sensor, pH sensor, TDS sensor, ultrasonic sensor, CO2 sensor, humidity sensor, automatic switch, wifi, and filter.

A. Plant Height (cm)

Plant height is one of the important components in growth because it determines the plant’s response to the influence of the treatment given [9]. The average results of lettuce plant height every week can be seen in Table I.

TABLE I. EFFECT OF DIFFERENT NUTRIENT CONCENTRATIONS IN LETTUCE VARIETIES ON PLANT HEIGHT

Varieties	Plant Age (MSPT)							
	1		2		3		4	
	1200 ppm	1800 ppm	1200 ppm	1800 ppm	1200 ppm	1800 ppm	1200 ppm	1800 ppm
Kriebo	9,08^{BC}	9,82^{A}	15,82^{A}	18,28^{B}	22,58^{A}	22,36^{B}	31,69^{B}	36,38^{A}
Karina	8,63^{C}	8,75^{B}	13,55^{B}	15,94^{C}	18,24^{B}	20,12^{C}	29,33^{C}	31,04^{B}
Bisi Sl 02	9,99^{A}	9,67^{A}	16,54^{A}	18,36^{B}	21,53^{AB}	23,08^{B}	33,85^{B}	37,16^{A}
Grand Rapids	9,28^{B}	10,29^{A}	17,23^{A}	19,74^{A}	22,40^{A}	24,87^{A}	34,12^{A}	38,63^{A}
Average	9,25^{b}	9,63^{a}	15,78^{b}	18,08^{a}	21,19^{a}	22,61^{a}	32,31^{b}	35,85^{a}

NOTE: Numbers followed by different capital letters in the same column indicate significantly different effects, while numbers followed by different lowercase letters in the same row indicate significantly different effects in the 5% DMRT follow-up test

The treatment of different concentrations of nutrients has a significant effect on the height of lettuce plants. The parameter of plant height at a concentration of 1800 ppm (K2) has a higher average value of 38.63 cm compared to a concentration of 1200 ppm (K1), which has an average value of 32.31 cm. Then, the difference in lettuce varieties has a real influence on plant height; lettuce variety Grand Rapids (V4) has the highest average value of plant height of 38.63 cm, which is nested at a concentration of 1800 ppm (K2). Optimal plant height growth is influenced by the optimal absorption of nutritional factors, especially the absorption of nutrients nitrogen, phosphate, and potassium which are beneficial for plant growth [10]. Plant height is influenced by the nutrient N or nitrogen. The nutrient N in the AB Mix used has a high content of 353.51 mg/l. [11] Nutrient N plays a vital role in accelerating plant vegetative growth. In addition to nitrogen, plant height is also influenced by the P nutrient factor, where the P nutrient contained in AB Mix has a relatively high content of 13.38 mg/l. Plants need phosphate (P) to form new cells in growing tissues and strengthen the stem [12].

Different varieties of lettuce nested in nutrient concentrations gave significantly different results on plant height parameters (Table I). Lettuce variety Grand Rapids (V4) produces the highest average plant height of 38.63 cm, which is nested at a concentration of 1800 ppm (K2), while lettuce variety Karina (V2) produces the lowest average plant height of 29.33 cm, which is nested at a nutrient concentration of 1200 ppm (K1). The difference in plant height is because each variety responds differently in absorbing nutrients.

Each variety has a different growth response from other varieties. [13] Hereditary or genetic factors and the influence of the environment on plants can cause variations in a plant. In addition to internal factors such as genetics, external factors such as climate can also affect plant height. This is appropriate where the cultivation environment has environmental conditions with an average daily light intensity of 2,447.66 lux, temperature of 32.6 ℃, and humidity of 62.66%. This is because plant height is more influenced by environmental factors such as light, temperature, and humidity [14].

B. Number of Leaves

Leaves are one of the organs in plants that have a vital role in the survival of these plants. This is because plants are obligate autotroph organisms, where plants must produce their food to meet their energy needs. Leaves are the main organ of the photosynthesis process because adult leaves contain hundreds of chloroplasts that play a role in the photosynthesis process [15]. The average number of lettuce leaves each week can be seen in (Table II). The difference in nutrient concentration significantly affects the number of lettuce leaves at 2-4 MSPT. The number of leaves of lettuce plants at 1800 ppm nutrient concentration (K2) has a higher average value of 8.93 leaves compared to 1200 ppm nutrient concentration (K1), which has an average number of leaves of 8.37. The treatment of different varieties of lettuce showed significantly different results on the number of lettuce leaves; it was shown at 2-4 MSPT.

TABLE II. EFFECT OF DIFFERENT NUTRIENT CONCENTRATIONS IN LETTUCE VARIETIES ON NUMBER OF LEAVES.

Varieties	Plant Age (MSPT)							
	1		2		3		4	
	1200 ppm	1800 ppm	1200 ppm	1800 ppm	1200 ppm	1800 ppm	1200 ppm	1800 ppm
Kriebo	4,25	4,25	4,50	5,00^{B}	5,25	5,25^{B}	7,75	8,00^{B}
Karina	4,25	5,00	4,75	5,75^{A}	5,50	6,00^{A}	8,75	11,00^{A}
Bisi Sl 02	4,50	4,50	4,50	5,25^{AB}	5,25	6,00^{A}	8,00	8,50^{B}
Grand Rapids	4,75	4,50	5,00	5,00^{B}	5,25	5,50^{AB}	9,00	8,25^{B}
Average	4,43	4,56	4,68^{b}	5,25^{a}	5,31^{b}	5,68^{a}	8,37^{a}	8,93^{a}

NOTE: Numbers followed by different capital letters in the same column indicate significantly different effects, while numbers followed by different lowercase letters in the same row indicate significantly different effects in the 5% DMRT follow-up test.

The nutrient N in AB Mix used has a high content of 353.51 mg/l; this is in line with [16], which says that the nutrient N plays a vital role in accelerating the growth of plant organs. Nitrogen is one of the macronutrients needed by plants in large quantities; nitrogen plays an important role in the formation of chlorophyll and the process of photosynthesis; lettuce plants will grow well if supporting factors such as sufficient light intensity. The light intensity obtained every day averages 2,447.66 lux, affecting one of the energy sources: light, which is one of the supporting factors in photosynthesis [17].

Differences in lettuce varieties nested in nutrient concentrations show significantly different weekly results. Lettuce variety Karina (V2), which is nested at a concentration of 1800 ppm (K2), has an average value of 11.00 leaves; this average is the highest value among other lettuce varieties, while lettuce variety Kriebo (V1), which is nested at a concentration of 1200 ppm (K1) has the lowest average number of leaves which is 7.75 leaves. This can be caused by the morphology of varieties and environmental conditions that can affect differences in yield between lettuce varieties. In addition, the yield of each plant variety is influenced by the genetics of the plant itself. Each variety has genetic properties that are not the same; the occurrence of variations in a plant can be caused by environmental influences and hereditary or genetic factors [18]. This can be seen from the character of each variety. Differences in genetic traits can show different responses to the environment and production factors. Thus, growth and production are influenced by varieties and other environmental conditions [19].

C. *Leaf Length, Leaf Width, and Root Length*

Leaves are the most important plant organ in photosynthesis, affecting crop yield growth and productivity [14]. Meanwhile, the root is one of the main plant organs generally found at the bottom of the plant, and the root transports water and other nutrients from the soil to the stem [20]. The average leaf width, leaf length, and root length of lettuce can be seen in Table III.

TABLE III. EFFECT OF DIFFERENT NUTRIENT CONCENTRATIONS IN LETTUCE VARIETIES ON LEAF WIDTH, LEAF LENGTH AND ROOT LENGTH OF LETTUCE.

Varieties	**Leaf Width**		**Leaf Length**		**Root Length**	
	1200 ppm	**1800 ppm**	**1200 ppm**	**1800 ppm**	**1200 ppm**	**1800 ppm**
Kriebo	$14{,}12^{B}$	$17{,}20^{A}$	23,16	$24{,}12^{AB}$	22,48	$22{,}30^{B}$
Karina	$16{,}66^{A}$	$17{,}12^{A}$	21,87	$23{,}16^{B}$	22,48	$23{,}66^{A}$
Bisi Sl 02	$14{,}62^{B}$	$14{,}91^{B}$	24,16	$24{,}99^{A}$	22,39	$23{,}29^{AB}$
Grand Rapids	$14{,}03^{B}$	$15{,}62^{BA}$	22,85	$23{,}91^{AB}$	21,34	$22{,}35^{B}$
Average	$14{,}86^{b}$	$16{,}21^{a}$	$23{,}01^{b}$	$24{,}04^{a}$	22,17	22,90

NOTE: Numbers followed by different capital letters in the same column indicate significantly different effects, while numbers followed by different lowercase letters in the same row indicate significantly different effects in the 5% DMRT follow-up test.

Differences in nutrient concentrations significantly affect the leaf length and width of lettuce leaves but do not significantly affect the root length of lettuce plants. The parameter of leaf length at a concentration of 1800 ppm (K2) has a higher average value of 24.04 cm compared to the concentration of 1200 ppm (K1), which has an average value of 20.01 cm. The leaf width parameter at a concentration of 1800 ppm (K2) has a higher average value of 16.21 cm compared to a concentration of 1200 ppm (K1), which has an average value of 14.86 cm. The treatment of different varieties has a significant effect on leaf width, leaf length, and root length; lettuce variety Kriebo (V1), which is nested at 1800 ppm nutrient concentration (K2), has the highest leaf width value among other lettuce varieties, which is 17.20 cm. Lettuce variety Bisi Sl 02 (V3), which is nested at 1800 ppm nutrient concentration (K2), has the highest leaf length value among other lettuce varieties, which is 24.99 cm, and lettuce variety Karina (V2), which is nested at 1800 ppm nutrient concentration (K2) has the highest root length value among other varieties which is 23.66 cm.

The treatment of different concentrations of AB Mix is significantly different on the width of lettuce leaves; leaf width at a concentration of 1800 ppm (K2) has a higher average value of 16.21 cm compared to a concentration of 1200 ppm (K1), which has an average value of 14.86 cm. This is influenced by the availability of nutrients and genetic differences from each plant. The nutrient N in AB Mix used has a high content of 353.51 mg/l; this is in line with [21]; the availability of nutrients is essential for plant growth and development, just like the number of leaves; the content of nutrient N influences leaf width by research [22], which states that the number of leaves and leaf width is influenced by the availability of nitrogen in the nutrients given.

In the variety factor, lettuce variety Karina (V2), which is nested at a concentration of 1800 ppm (K2), produces the highest root length average value of 23.66 cm, while lettuce variety Grand Rapids (V4), which is nested at a nutrient concentration of 1200 ppm (K1) produces the lowest root length of 21.34 cm. This is in line with [23], which states that the shape or size of the root is more influenced by genetic factors than environmental factors. However, environmental factors also determine the formation of the roots. In addition, the development of the root system is also influenced by the substrate or growing media. In the aeroponic system, the oxygen needed by plants is obtained maximally, so the use of aeroponic systems can produce plants with better quality due to root respiration and produce much energy for the growth of lettuce plants [24]. Most oxygen the plant absorbs is obtained from the nutrient solution, and the roots hanging are not exposed to the nutrient mist spray. The aeroponic growing technique utilizes a misting nozzle or sprays nutrient solution in the form of a mist onto the roots of plants suspended in the air. With this technique, the shortcomings of previous hydroponics can be overcome so that the plant roots can absorb the nutrients provided to the maximum [25].

D. *Wet Weight and Dry Weight of Header*

Plant weight consists of wet weight, which is only called fresh weight, and dry weight. Wet weight is the total weight of plants that are still fresh and obtained by weighing the plants after harvest before the plant wilts due to water loss. Besides, the wet weight shows the results of the metabolic activity of the plant itself, which is influenced by the availability of nutrients [26]. The average results of header wet weight and header dry weight of lettuce can be seen in Table IV.

TABLE IV. EFFECT OF DIFFERENT NUTRIENT CONCENTRATIONS IN SOME LETTUCE VARIETIES ON THE WET WEIGHT AND DRY WEIGHT OF HEADER.

Varieties	**Weight of Header**			
	Header Wet Weight		**Header Dry Weight**	
	1200 ppm	**1800 ppm**	**1200 ppm**	**1800 ppm**
Kriebo	78,54^{A}	83,83^{A}	2,74	2,85
Karina	75,62^{B}	77,81^{C}	2,37	3,19
Bisi Sl 02	79,47^{B}	82,95^{AB}	2,47	3,20
Grand Rapids	80,90^{A}	81,45^{B}	2,91	2,76
Average	78,63	81,51	2,62^{b}	3,00^{a}

NOTE: Numbers followed by different capital letters in the same column indicate significantly different effects, while numbers followed by different lowercase letters in the same row indicate significantly different effects in the 5% DMRT follow-up test.

The nutrient concentration of 1800 ppm (K2) produces an average header wet weight of 81.51 g and header dry weight of lettuce plants of 3.00 g. This value is higher than the nutrient concentration of 1200 ppm (K1), with an average value of 78.63 g in header wet weight and 2.62 g in header dry weight. Varietal differences significantly affect the wet weight of the header but do not significantly affect the dry weight of the header of lettuce plants. Lettuce variety Kriebo (V1), which is nested at 1800 ppm nutrient concentration (K2), has the highest header wet weight compared to other lettuce varieties, which is 83.83 g, and lettuce variety Bisi Sl 01 (V3), which is nested at 1800 ppm concentration (K2) has the highest header dry weight which is 3.20 g. This value is the highest compared to other varieties.

The header's fresh weight is the plant's weight after harvesting before the plant wilts and loses water. Besides, the fresh weight of the header is the total weight of the plant without roots, which shows the results of the metabolic activity of the plant itself [27]. Different concentrations of AB Mix nutrients did not show significant differences in the wet weight of lettuce plant headers (Table IV). However, the nutrient concentration of 1800 ppm (K2) has a higher average value of header wet weight of 81.51 g compared to the average header wet weight at a concentration of 1200 ppm (K1), which is 78.63 g. The concentration of the AB Mix nutrient did not show a significant difference in the header wet weight of lettuce plants (Table IV).

The difference in nutrient concentration showed no significant difference in header wet weight. This result is thought to be because the water content in the plant tissue has reached the maximum level of water saturation, as said [28], that at specific AB Mix nutrient concentrations, plants can reach the optimal level of water saturation so that despite differences in nutrient concentrations the absorption of water by plants and the accumulation of water in the header tissue can be similar. Therefore, there was no significant difference in wet weight due to the presumed similar water content in both treatments.

Differences in lettuce varieties showed significantly different results on the wet weight of plant headers. The Kriebo variety (V1) has the highest average value of 83.83 g, which is nested at a concentration of 1800 ppm (K2), while the Karina lettuce variety (V2), which is nested at a nutrient concentration of 1200 ppm (K1), produces the lowest average header wet weight of 75.62 g. This is because each variety has a different ability to absorb and distribute nutrients. This is because each variety has a different ability to absorb and distribute nutrients to the header of the plant. According to [29], the fresh weight of plants is genetically influenced in each variety, and each variety of lettuce produces a different response to the growth and production components of lettuce plants.

This difference is due to the genetics of each variety of lettuce plants, which have characteristics of color, shape, physical, and size that are not the same. This is supported by [30], which states that each plant variety has different physiological characteristics and characteristics that are influenced by metabolic processes in certain lettuce varieties. In addition, this is due to the suitability of the cultivation environment for Kriebo varieties where this variety can be cultivated in the lowlands with an altitude of 100-300 masl; this is by the cultivation environment carried out in the lowlands with an altitude of 392 masl. The wet weight of the header is a combination of tissue growth and plant development, such as plant height, number of leaves, leaf length, and leaf width, which is influenced by the amount of water and nutrient content in plant cells and tissues. This result is thought to be due to environmental factors and the intensity of light absorbed; this is to the statement [31], which states that the length and width of the leaves will make the photosynthesis results higher and result in higher production, photosynthate can be formed in large quantities and flowed to all parts of the plant.

Header dry weight shows the amount of biomass that plants can absorb. Different concentrations of AB Mix nutrients showed significant differences in the dry weight of lettuce plant headers (Table IV). The header dry weight of lettuce plants at 1800 ppm AB Mix nutrient concentration (K1) has a higher average header dry weight value of 3.00 g compared to the average header dry weight of 2.62 g at 1200 ppm AB Mix nutrient concentration (K2). This is thought to be because the higher the concentration of AB Mix nutrients given, the availability of nutrients such as nitrogen (N), phosphorus (P), and potassium (K) also increases so that plant growth looks more and more [32]. The higher the concentration, the more nutrients are absorbed by plants; the result of header dry weight is the optimal result of nutrient absorption by plants in the form of total photosynthate produced [33].

Differences in lettuce varieties showed results that were not significantly different from the dry weight of the header of lettuce plants (Table IV). The wet weight of the header influences the difference in the yield of header dry weight; this is in line with [34], which states that the results are not significantly different on the variety factor, indicating that each variety has almost the same ability genetically in showing results that are not significantly different on the parameter of header dry weight. This is supported by [35], which states that three varieties of Pak choy with various types of liquid organic fertilizers produce root-header ratio values that are not significantly different.

E. *Root Wet Weight and Root Dry Weight*

Root fresh weight is the wet weight after harvest without any drying process, while root dry weight is the weight obtained after the drying process. The average results of the wet and dry weight of lettuce roots can be seen in Table V.

TABLE V. EFFECT OF DIFFERENT NUTRIENT CONCENTRATIONS IN DIFFERENT LETTUCE VARIETIES ON ROOT WET WEIGHT AND DRY WEIGHT

Varieties	Root Weight			
	Root Wet Weight		Root Dry Weight	
	1200 ppm	1800 ppm	1200 ppm	1800 ppm
Kriebo	19,20	20,13	1,18	0,95^{B}
Karina	16,84	20,15	1,06	1,31^{A}
Bisi Sl 02	17,00	19,74	1,19	1,23^{A}
Grand Rapids	17,69	20,38	1,23	1,06^{AB}
Average	17,68^{b}	20,10^{a}	1,17	1,14

NOTE: Numbers followed by different capital letters in the same column indicate significantly different effects, while numbers followed by different lowercase letters in the same row indicate significantly different effects in the 5% DMRT follow-up test.

Differences in nutrient concentrations significantly affected root wet weight but did not significantly affect root dry weight. The nutrient concentration of 1800 ppm (K2) produced a higher average root wet weight of 20.10 g compared to the average root wet weight of 17.68 g at 1200 ppm nutrient concentration (K1). While differences in varieties did not significantly affect the wet weight of the roots, they significantly affected the dry weight of the roots. Lettuce variety Karina (V2), nested at a nutrient concentration of 1800 ppm (K2), has the highest root dry weight of 1.31 g. This value is the highest compared to other lettuce varieties.

Different concentrations of AB Mix nutrients showed significant differences in the wet weight of lettuce plant roots (Table V). The wet weight of lettuce plant roots at the AB Mix nutrient concentration of 1800 ppm has a higher average root wet weight value of 20.10 g compared to the average root wet weight of 17.68 g at the AB Mix nutrient concentration of 1200 ppm (K2). This is thought to be because the higher the concentration of AB Mix nutrients given, the availability of nutrients increases so that plant growth looks more; this is in line with the statement [36], which states that the wet weight of the roots with high results shows that the roots can absorb nutrients well. The faster absorption of nutrients will accelerate root growth.

Differences in lettuce varieties showed results that were not significantly different from the wet weight of the roots of lettuce plants; this was thought to be due to the ability of the roots of each variety to be almost genetically the same in absorbing nutrients. This is supported by research [37], which states that three varieties of mustard on the Effect of manure application show results that are not significantly different in the parameter of root wet weight. Roots are plant organs that function to store water. They are then distributed to plants and used to carry out metabolic processes. Root dry weight is very dependent on the volume of the roots and the number of roots of the plant itself, so the volume and number of roots significantly influence the dry weight of the affected roots. Different concentrations of AB Mix nutrients did not show significant differences in the dry weight of lettuce plant roots (Table V). This result is thought to be because the roots have reached the maximum capacity in absorbing nutrients at both concentrations; this is in line with [38], which states that the roots have reached the maximum capacity in absorbing nutrients even though the concentration of nutrients increases, the roots are not able to absorb additional nutrients significantly.

Different varieties of lettuce showed significantly different results on the dry weight of the roots of lettuce plants. Karina variety (V2) has the highest root dry weight average value of 1.31 g, which is nested at a concentration of 1800 ppm (K1), while the lettuce variety Kriebo (V1), which is nested at a nutrient concentration of 1800 ppm (K1) produces the lowest root dry weight average of 0.95 g (Table V). These results are due to varieties having differences in growth power caused by genetic factors. This is supported by [39], which states that each plant variety has differences in growth power caused by its genetic factors. One of the supporting factors in plant growth and development is the length and number of roots. This is in line with [40], which states that roots are plant organs that store water and then be distributed to plants, which will be used to carry out metabolic processes.

F. *Root Header Ratio*

The ratio of header roots is a comparison of the dry weight of the header and roots; if the dry weight of the header is not greater than the dry weight of the roots, then the results of the analysis of the header root ratio will not show a real effect [41]. The average results of the root header ratio of lettuce plants can be seen in Table VI.

The difference in nutrient concentration was significantly different to the root header ratio. A nutrient concentration of 1800 ppm (K2) resulted in a higher root header ratio of lettuce plants at 2.69 g compared to 2.25 g at 1200 ppm nutrient concentration (K1). Variety differences significantly affect the root header ratio; lettuce variety Kriebo (V1), which is nested at 1800 ppm nutrient concentration (K2), has the highest root header ratio of 3.09 g; this value is the highest compared to other lettuce varieties. Lettuce yield is also called lettuce biomass. Biomass is usually used as an indicator that shows the characteristics of growth. Biomass is the accumulation of photosynthate products in the form of lipids (fats), carbohydrates, and proteins. The higher the biomass of a plant, the higher the nutrient content of the soil absorbed by the plant. Header or upper biomass accumulates photosynthate in leaves and stems [42].

The difference in AB Mix nutrient concentration showed significantly different results on the root header ratio of lettuce plants. The root header ratio at the concentration of AB Mix 1800 ppm (K2) has a higher value of 2.69 g compared to the concentration of AB Mix 1200 ppm (K1), which has an average root header ratio of 2.25 g (Table VI). This can occur because nutrients N, P, K, Ca, and Mg can be absorbed well by plant roots; this is by [43], stating that the root is the main vegetative organ that supplies mineral water and materials important to support the growth process. By [44], which states that dry plant weight reflects nutritional status because dry plant weight depends on the results of photosynthesis and transpiration. Root header ratio is influenced by header dry weight and root dry weight. Differences in lettuce varieties significantly affect the root header ratio. Kriebo variety (V1) has the highest root header ratio average value of 3.09 g, which is nested at 1800 ppm concentration (K2), while lettuce variety Bisi Sl 02 (V3), which is nested at 1200 ppm nutrient concentration (K1) produces the lowest root dry weight average of 2.11 g (Table VI).

TABLE VI. EFFECT OF DIFFERENT NUTRIENT CONCENTRATIONS IN LETTUCE VARIETIES ON ROOT-HEADER RATIO.

Varieties	Root-Header Ratio	
	1200 ppm	1800 ppm
Kriebo	2,32	3,09[A]
Karina	2,21	2,45[B]
Bisi Sl 02	2,11	2,64[AB]
Grand Rapids	2,36	2,59[AB]
Average	2,25[b]	2,69[a]

These results indicate that each variety shows different responses to nutrient absorption. This is in line with [45], which states that each variety will require different nutrients to support growth and produce better production. Each variety will provide different growth responses and production levels. The greater the header dry weight compared to the root dry weight, the greater the root-header ratio value; the root-header ratio is influenced by the level of photosynthate distribution to the header, automatically affecting the header dry weight [46].

IV. CONCLUSION

The result of giving differences in nutrient concentrations significantly affect growth parameters in plant height, number of leaves, leaf length, root length, and production parameters in header dry weight, root wet weight and root header ratio. The best nutrient concentration was obtained at 1800 ppm AB Mix nutrient concentration (K2).

Differences in lettuce varieties nested at nutrient concentrations had a significant effect on growth parameters, namely plant height in the Grand Rapids variety (V4), number of leaves in the Karina variety (V2), leaf length in the Bisi SL 02 variety (V3) and root length in the Karina variety (V2), as well as production parameters, namely header wet weight in the Kriebo variety (V1), root dry weight in the Karina variety (V2) and root header ratio in the Kriebo variety (V1) nested at 1800 ppm nutrient concentration (K2).

Differences in nutrient concentrations have been shown to have a significant effect on the yield and growth of lettuce crops, but further research on the influence of color differences in grow light lamps and differences in watering frequency on intelligent aeroponic systems can then also be carried out next research on the comparison between hydroponic systems and aeroponic systems.

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