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The Effect of Nutritioning Interval on Automatic Drip Hydroponic System on Growth and Production of Three Varieties of Lettuce (*Lactuca sativa* L.)

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ABSTRACT

Lettuce (Lactuca sativa L.) is a leaf vegetable that has a high level of consumer demand and commercial value and can be cultivated using a combination of hydroponic substrate and drip irrigation methods. This research aims to determine the effect of the time interval for providing nutrients on the growth and harvest results of three lettuce plant varieties. Plants were cultivated on cocopeat and husk charcoal media (ratio 1:3) and arranged using a Randomized Block Design (RAK) consisting of two treatments. The first treatment is the nutritional interval which consists of an interval of 2 hours with a discharge of 17 ml (I1), 3 hours with a discharge of 25 ml (I2), and 4 hours using a discharge of 34 ml (I3). The second treatment is the plant variety which consists of the Grand Rapids variety (V1), the Green Coral variety (V2), and the Red Coral variety (V3). The data is analyzed using analysis of variance and if the results obtained are significantly different then a DMRT test will be carried out. The research results showed that the Green Coral lettuce variety was better than the Grand Rapids and Red Coral varieties. This is shown by the results with the highest and best values for the observation variables of number of leaves, plant fresh weight, and chlorophyll content. The nutritional interval which consists of an interval of 2, 4, and 6 hours gave results that were inversely proportional to the variety treatment, that is, they were not significantly different in all observed variables.

1. INTRODUCTION

Lettuce (*Lactuca sativa* L.) is one of the leafy vegetable plants that is popular among the community because it contains quite high nutritional value such as pro-vitamin A, vitamin C, fiber, and mineral sources. In addition, lettuce contains 1.2 g of protein, 0.2 g of fat, 22 mg of Ca, 25 mg of Fe, 162 mg of vitamin A, 0.04 mg of vitamin B, and 8.0 mg of vitamin C (Panjaitan *et al.*, 2019). Lettuce has a high potential for cultivation in terms of climatology, technical aspects, economy, and also business (Islam *et al.*, 2021). There are several varieties of lettuce that have high demand and commercial value, making them widely cultivated by the Indonesian community and subjects of research related to lettuce, such as the Grand Rapids variety, Green Coral variety, and Red Coral variety (Ramadhan *et al.*, 2021; Kusmutafmi *et al.*, 2023; Lutfiana *et al.*, 2023; Fariroh & Priyantono, 2024). One of the technologies in agriculture that can be used for cultivating plants is the substrate hydroponic method, which is a hydroponic method using various substrate media as planting media for plants such as cocopeat, sawdust, vermiculite, rice husk, hydroton, pumice stone, sand, and so on (Patil *et al.*, 2021). This method has proven successful in cultivating large red chili peppers (*Capsicum annuum* L.) (Lutfi *et al.*, 2021), supplementary feed plants for livestock (Aniskina *et al.*, 2022), and cucumber cultivation using sheep wool substrate (Komorowska *et al.*, 2022).

Substrate hydroponic methods are usually combined with micro-irrigation systems in the form of drip irrigation. (Abedin *et al.*, 2021; Olubanjo *et al.*, 2021). Drip irrigation with nutrient provision for plants is very important because it has significant implications for increasing efficiency, reducing water usage, and enhancing crop production (Mustawa *et al.*, 2017). Irrigation technology will be appropriate if based on soil conditions, plant needs, and the climate in the area (Adhiguna & Rejo, 2018). The application of drip irrigation has a working principle, which is the direct delivery of water to the plant's root zone or soil surface slowly and in the form of droplets (Ravikumar, 2022). The advantages of using this drip irrigation system are increasing irrigation efficiency by 80% compared to conventional methods, boosting agricultural production, saving labor or wages, reducing fuel costs for water distribution, and lowering maintenance costs for irrigation system components (Chaer *et al.*, 2016; Anika *et al.*, 2024). Several studies have shown the positive impact of this combination of methods, such as the optimization of tomato cultivation (*Lycopersicon esculentum*) with the addition of potassium (Hidayat *et al.*, 2021), the development of paprika cultivation during the winter (Yeo *et al.*, 2021), and the increase in melon cultivation yields (*Cucumis melo* L.) with the addition of liquid organic fertilizer (Susanti *et al.*, 2024).

Efforts to combine substrate hydroponics and drip irrigation are related to irrigation management for agriculture, particularly in the precise and appropriate regulation of water needs for plants (Incrocci *et al.*, 2020). If the plants experience a lack of water, they will become stunted and their growth will be poor (Bhattacharya, 2021), whereas if the plants experience excess water, it will cause the soil to become saturated, leading to the emergence of pests and diseases, susceptibility to root rot, and water wastage (Mall *et al.*, 2021). One of the plants whose water needs must be monitored intensively is horticultural plants because the level of water availability will greatly affect the production yield of these plants (Suhaeni, 2024). The previous background description formulated a problem, namely the unknown frequency of watering and the recommended varieties in the effort to cultivate lettuce plants. This problem formulation is interpreted in the research objective, which is to determine the effect of drip irrigation intervals and the cultivated varieties on the development and growth of the lettuce plants. This research will provide benefits in developing a guideline for the community, farmers, practitioners, and academics regarding the cultivation of lettuce using substrate hydroponics integrated with irrigation automation. The design being built will also add benefits in the preparation of a prototype for the development of a microirrigation network in future research.

2. RESEARCH METHODS

2.1. Tools and Materials

The tools and materials used in this research included an automatic drip irrigation system on substrate hydroponics (Figure 1) consisting of 27 polybags. The drip irrigation installation uses ¾ inch-diameter PVC pipes to distribute nutrients from the reservoir, supplemented with 0.5 cm diameter PE hoses as conduits from the pipes to each polybag. Each row contains nine polybags, each 320 cm long with a 40 cm gap between each polybag. The automation of watering according to the research treatment uses a digital timer for the automatic garden tap.

Figure 1. Integrated substrate hydroponic installation with automatic drip irrigation

The main materials in this study are the seeds of Grand Rapids, Green Coral, and Red Coral lettuce varieties cultivated in a substrate planting medium with an AB mix nutrient concentration of 1400 ppm. Each polybag contains a mixture of cocopeat and rice husk charcoal in a 1:3 ratio, weighing 5 kg. The measuring instruments used are a ruler, digital scale, SPAD 502 chlorophyll meter, 500 ml measuring cup, assisted by an oven, camera, and ImageJ software.

2.2. Experimental Design

This study uses two treatments, namely: The first treatment is the interval of nutrient application, which consists of: I1: 2-hour interval (6 times/day) with a nutrient volume of 17 ml per watering; I2: 3-hour interval (4 times/day) with a nutrient volume of 25 ml per watering; and I3: 4-hour interval (3 times/day) with a nutrient volume of 34 ml per watering. The second treatment is the lettuce plant varieties, namely: V1: Grand Rapids lettuce variety; V2: Green Coral lettuce variety; and V3: Red Coral lettuce variety. The two treatment factors were arranged using a Randomized Block Design (RBD) with the research layout as shown in Figure 3.

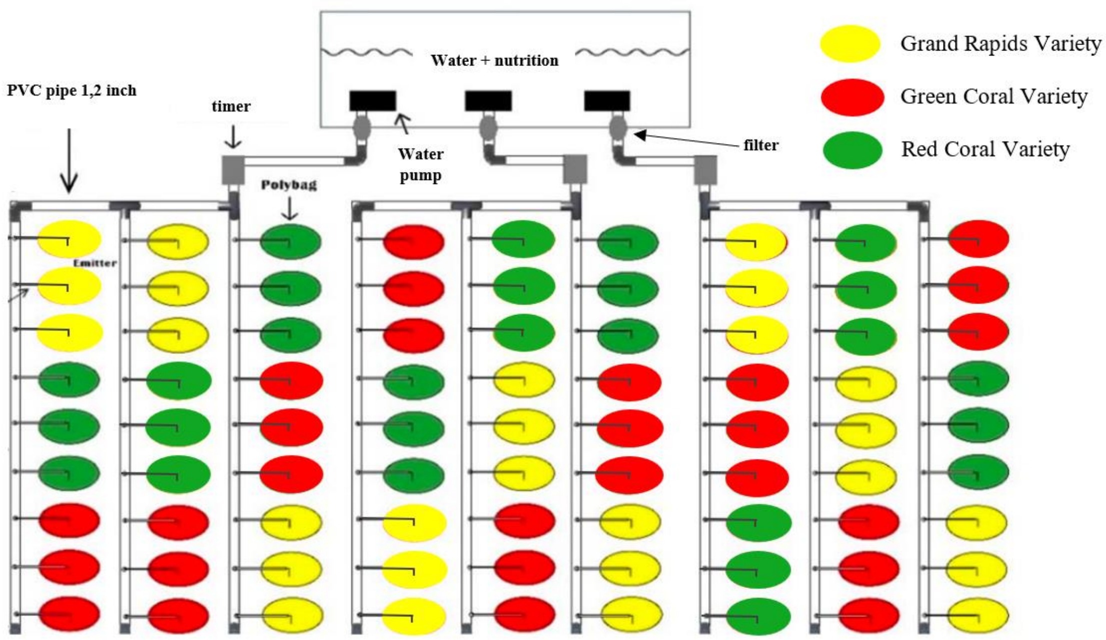

Figure 3. Experimental layout to evaluate the effect of nutritioning interval on lettuces.

2.3. Observation Variables

The research data is the result of measuring the observed variables at harvest or 35 DAP (days after planting) with the following details:

a. Plant height (cm)
   Plant height is measured using a ruler from the base of the stem to the tip of the uppermost leaf, with measurements taken once a week.
b. Number of leaves (leaves)
   The leaves counted on a single plant are those that are fully opened and observed once a week.
c. Leaf area (cm²)
   Leaf area measurement is conducted at harvest using ImageJ software through photos of the leaves with a black background and a ruler as a measurement scale. The leaf area analyzed is the average area per leaf using Equation 1.

$$\text{Average leaf area} = \frac{\text{total surface area of all the leaves in one plant}}{\text{number of leaves}} \tag{1}$$

d. Fresh weight of the plant (g)
The fresh weight of the plant is measured at harvest using a digital scale on the shoot and root parts of the plant. Before weighing, the roots are cleaned of any remaining planting medium.
e. The root-to-shoot ratio of plants.
The ratio is obtained by dividing the dry weight of the canopy by the dry weight of the roots as shown in Equation 2. The dry weight is obtained by oven-drying at a temperature of 130-133 °C for about 1 hour until a constant moisture content is reached.

$$\text{Rasio} = \frac{\text{weight of the plant title}}{\text{weight of plant roots}} \tag{2}$$

f. Leaf Chlorophyll Content
The leaf chlorophyll content is measured at harvest using the SPAD 502 Chlorophyllmeter by clamping the SPAD device onto the plant leaf. Each sample will have 3 leaves taken from the bottom, middle, and top parts, and then the average value will be calculated.

2.4. Data Analysis

The obtained data is then analyzed using Analysis Of Variance (ANOVA) to determine the effect of treatment variations. If the ANOVA results show an F-calculated value exceeding the F-table value at the 5% and 1% probability levels, a further test is conducted using the Duncan's Multiple Range Test (DMRT) at the 95% confidence level to determine the differences between treatments.

3. RESULTS AND DISCUSSION

The results of data collection on each observation variable have been analyzed using statistical tests, and the results are displayed in Table 1. The F-value as a result of ANOVA is shown for each observation variable and research treatment. Sections that differ significantly are indicated by the symbols * and **, which means they qualify for further testing using DMRT.

Table 1. Summary of F-ratio values for all observed variables

No	Observation Variable	F-Calculated Value	
		Interval (I)	**Variety (V)**
1.	Fresh weight of the plant (g)	0,11ns	47,36**
2.	Number of leaves (pieces)	1,76ns	92,39**
3.	Leaf area (cm^2)	0,73ns	23,34**
4.	Plant height (cm)	0,313ns	64,45**
5.	Plant shoot-root ratio	0,77ns	7,72**
6.	Leaf chlorophyll content (µg/mL)	1,15ns	38,05**

Note: ns = $F_{ratio} < F_{critical}$ 5%; * = value $F_{critical}$ 5%< $F_{ratio} < F_{critical}$ 1%; **= value $F_{ratio} > F_{critical}$ 1%

Table 1 shows the effect of variations in nutrient application intervals, which consist of nutrient application for 2 hours (6 times/day) with a nutrient volume of 17 ml per watering, nutrient application for 3 hours (4 times/day) with a nutrient volume of 25 ml per watering, and nutrient application for 4 hours (3 times/day) with a nutrient volume of 34 ml per watering, did not have a significant effect on the growth and yield of lettuce plants. All observation variables showed results that did not meet the requirements for further testing, so the best treatment variations could not be compared based on the analysis of each observation variable's values. For your information, Table 2 shows the average measurement results based on the interval of nutrition administration.

Table 2. Average value of all observation variables in the nutritional administration time interval treatment

No	Observation Variable	Treatment Variation		
		2 hours (I_1)	**3 hours (I_2)**	**4 hours (I_3)**
1.	Fresh weight of the plant (g)	62,25	61,7	63,64
2.	Number of leaves (pieces)	12	11	11
3.	Leaf area (cm^2)	116,05	105,89	128,58
4.	Plant height (cm)	19,16	19,17	19,58
5.	Plant shoot-root ratio	5,18	4,55	4,49
6.	Leaf chlorophyll content (µg/mL)	22,33	23,39	23,51

The results that did not differ significantly in the nutrient treatment also occurred in the cultivation of stevia plants (*Stevia rebaudiana* B.) with intervals adjusted to the Management Allowable Depletion (MAD). The MAD value for a 1-day interval is 96% with an irrigation volume of 170 ml, the MAD value for a 2-day interval is 93% with an irrigation volume of 300 ml, and the MAD value for a 3-day interval is 90% with an irrigation volume of 430 ml. (Pambudi *et al.*, 2024). Different results were shown in the use of drip irrigation on corn plants with intervals of every 3 days and every 6 days. There is a significant effect on the silage yield obtained with the highest weight at the 3-day interval (Tari, 2022). A significant effect is also observed at the irrigation intervals of 7, 9, and 11 days on the productivity of pumpkin plants cultivated in clay soil conditions (Okasha *et al.*, 2020). This treatment does not have a significant impact but can support the productivity of lettuce plants because the adjustment of the watering interval can automatically meet the water needs of the plants (Fajar *et al.*, 2018). For example, Table 2 shows a comparison of fresh weight, plant height, and leaf count values in several studies using the *Grand Rapids* variety.

Table 3. Comparison of the results of the Grand Rapids variety in various studies

No	Reference	Treatment Variation		
		Fresh weight of the plant (g)	Plant height (cm)	Number of leaves (pieces)
1	Tarihoran & Guritno, 2020	39,67	14,28	4,89
2	Anwary *et al.*, 2019	50,69	14,43	10,19
3	**This research**	**52,64**	**21,93**	**8,00**
4	Ivanka *et al.*, 2021	147,04	34,16	14,42

Several studies show that the interval of nutrient application on plants will have a significant impact if it exceeds a range of 2 days or more. This is influenced by the ability of the growing medium to retain water well, especially cocopeat and rice husk charcoal substrates. (Shafira *et al.*, 2021; Ezperanza *et al.*, 2023). The recommendation for the interval of nutrient application is to consider the ease of nutrient application. An interval of nutrient application every 4 hours (3 times/day) with a nutrient volume of 34 ml per watering is the easiest application compared to other variations, especially if the nutrient application must be done conventionally under certain conditions. Each variety carries different genetic traits and growth results even when given the same treatment, including lettuce. (Wardani *et al.*, 2023). Table 1 shows the results of the variance analysis among the *Grand Rapids* lettuce variety, the *Green Coral* lettuce variety, and the *Red Coral* lettuce variety, indicating a significant effect on growth and yield. All observation variables showed results that met the criteria for further testing, allowing for the comparison of the best varieties based on the analysis of each observation variable's values. In Figure 4, the comparison of the average values of each lettuce variety is shown along with letter notations as a result of further testing, noting that differences in notation indicate significant differences. The superiority of each variety is based on the highest and best scores that differ in each observation variable. The *Grand Rapids* variety excels in the observation variable of plant height at 21.93 cm and leaf area at 189.43 cm², while the *Green Coral* variety excels in the observation variable of leaf count with 16 leaves, fresh plant weight at 86.77 g, and chlorophyll content at 27.28 mg/mL. The *Red Coral* variety only excels in the root-to-shoot ratio with a ratio of 6.01.

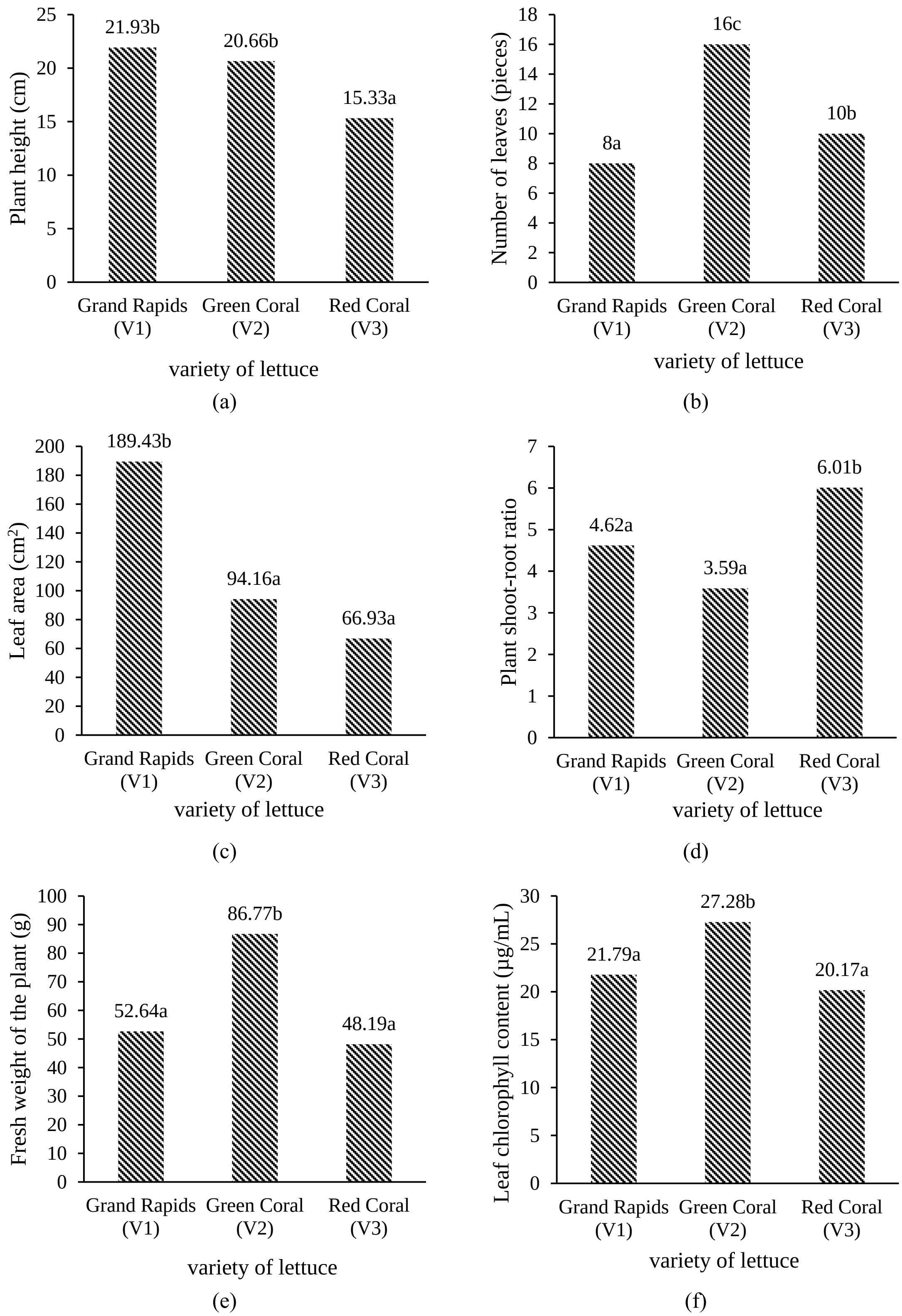

Figure 4. Comparison of each observation variable based on lettuce variety treatment: (a) plant height (cm); (b) number of leaves (leaflets); (c) leaf area (cm^2); (d) plant root shoot ratio; (e) fresh plant weight (g); (f) chlorophyll content (µg/mL).

The Grand Rapids and Green Coral varieties belong to the green lettuce or curly lettuce type, which has better growth results compared to red lettuce, especially in terms of fresh plant weight (Soleha *et al.*, 2020). The superiority of these two varieties is also supported by the average height of the green lettuce plants (*Lactuca sativa* L. var. Grand Rapids), which is higher compared to the red lettuce plants (*Lactuca sativa* L. var. Red Rapids) using the floating raft hydroponic method (Anwary *et al.*, 2019). In another study, the Grand Rapids variety also excelled in the plant height parameter compared to the Green Coral variety, but this was inversely related to the leaf count parameter (Nefa & Sutoyo, 2022). Based on all observation variables, the Green Coral variety was superior compared to both the Grand Rapids and Red Coral varieties, especially in the main observation variable, which is the fresh weight of the plant. This is based on the agricultural aspect that measures income from the weight of the harvest and plants, with higher fresh weight also yielding higher profits in the same area (Anika & Putra, 2020). The productivity of the Green Coral variety in this study is around 5.4 ton/ha, obtained from a lettuce population of 62,500/ha multiplied by 86.77 g/plant.

4. CONCLUSION

The research results show that the Green Coral lettuce variety is better compared to the Grand Rapids and Red Coral varieties. The Green Coral variety achieved the highest and best results in the observation variables of the number of leaves with 16 leaves, fresh plant weight of 86.77 g, and chlorophyll content of 27.28 mg/mL. These three observation variables serve as benchmarks in determining the best variation for lettuce varieties, although the Grand Rapids and Red Coral varieties proved superior in other observation variables. The treatment of nutrient application intervals of 2, 4, and 6 hours yielded results that were inversely proportional to the variety of treatments, meaning there were no significant differences in all observed variables. The best treatment cannot be seen from the results of the analysis of each observation variable, but rather from the ease of its application. This is demonstrated by an administration interval of 4 hours (3 times/day) with a nutrient volume of 34 ml per watering. Based on the analysis of plant variety treatments and nutrient application intervals in hydroponic substrate lettuce (Lactuca sativa L.) cultivation with automatic drip irrigation, it can be recommended that the best treatment for cultivation is using the Green Coral variety with nutrient application intervals of three times a day.

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