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Analysis of Differences in Color and Irradiation Length of the LED Strip Lights in Lettuce (*Lactuca sativa L.* var. *Grand Rapids*) Cultivation with Wick Hydroponic System

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Abstract Lettuce (*Lactuca sativa* L.) is a plant that really needs water to support its growth. In addition, in order to get the maximum growth, lettuce requires irradiation for 14-16 hours daily. Sufficient irradiation can help lettuce to support the process of photosynthesis and plant growth. Engineering that can be done to optimize plant growth includes the use of hydroponic systems and the addition of artificial light (LED). The purpose of this study was to determine the effect of the difference in the color of LED lamp light and the duration of irradiation on the growth and production results of the lettuce. The method used in this study was a 2-factorial Group Randomized Design, namely the color of the LED lights (red 100%, blue 100%, white 100% and a combination (red 75%, blue 10% and white 15%)) and the duration of irradiation (3 hours and 12 hours) then continued with the LSD (Least Significance Different) and Duncan Multiple Range Test (DMRT) tests at a confidence level of 5%. The results showed that the lamp addition treatment using red color and the duration of additional irradiation for 3 hours had the best results.

Keywords Color, Hydroponic, Irradiation Length, LED Strip Lights, Lettuce

1. Introduction

Hydroponics is a method of cultivation that can be done when there is less agricultural land. Hydroponics is a planting technique without using soil but using rockwool, sawdust, coconut fiber or coconut fiber with the addition of a nutrient solution. The simplest hydroponic system is the wick system, which does not require electricity, pumps or aerators [18]. The working principle of the wick hydroponic system is to utilize the capillary power of water through a wick intermediary which will connect nutrients to the planting medium [13]. The wick commonly used is flannel. Flannel has good capillarity, so it can guarantee that plants do not lack the nutrients they need. Flannel can also be used as a place for plant roots to grow [11]. The wick hydroponic system has the advantage of a high

success rate of plant growth and a faster harvest time and can reduce pest attacks due to more controlled treatments. However, this wick system has the disadvantage that the nutrient solution settles easily and does not circulate properly. This problem can trigger moss growth so that plant growth is a little late [6]. This system is more suitable for small plants such as lettuce and other herbs [3].

Lettuce (*Lactuca sativa* L.) is a plant that is suitable to be cultivated with a wick hydroponic system. Lettuce grows well at temperatures between 15-20℃ with rainfall between 1000-1500 mm/year and humidity around 60-100% [1]. Lettuce is also a long-day plant that requires 14-16 hours of light a day to optimize the photosynthesis process [8]. Fulfilling the need for light in lettuce can be done by adding light using Light Emitting Diode (LED). LEDs have the advantage that the heat generated does not damage plants, saves energy, is brighter, and lasts longer. LEDs can emit a spectrum of colors that plants need in photosynthesis. The right color of light can help optimize plant growth, because not all colors of light can be absorbed properly by chlorophyll. Red and blue are colors that are easily absorbed by chlorophyll so that they can optimize plant growth. This study aims to determine the interaction between LED light color and irradiation time on plant growth and production.

2. Materials and Methods

2.1. Preparation

This research was conducted in Malang city, East Java. The tools used are seedling holder, impraboard, netpot, red LED, blue LED, white LED, power supply, plywood, black plastic, galvalume 2×4 cm, ruler, digital scale, lux meter, chlorophyllmeter/SPAD, TDS meter, pH meter, and EC meter. While the materials used are lettuce seeds, rockwool, AB mix nutrient solution, flannel / wick, and water. The process of growing lettuce plants.

2.1.1. Lighting Box Manufacturing and LED Mounting

The lighting box frame is made of galvalume iron with a roof and bulkhead of plywood and is covered in plastic to cover the surroundings. The height of the lighting box is 80 cm. The length of the lighting box is 200 cm and the width is 120 cm. In the lighting box, there are 8 bulkheads so the dimensions of the lighting box on each bulkhead are 50 cm long and 60 cm wide. LED are mounted on the roof of the plywood lighting box. The LED installed there are 87 pieces on each treatment with a power of 5 Watts. The distance between the installation of LED and the surface of the planting media is 60 cm. In the combined treatment using red (75%), blue (10%) and white (15%) LED, the number of lamps each was 66 Red LED, 9 blue LED and 15 white LED.

2.1.2. Preparation of Cultivation Place Media

Hydroponic wick system prepared as many as 27 pieces with 9 holes on the impraboard. This hole is useful for placing netpot filled with lettuce seeds ready for planting. The diameter of the netpot is 5 cm with a distance of 9 cm between plants. The netpot has been provided with a flannel wick to distribute nutrient water to the roots of the lettuce plants.

2.1.3. Seeding

The lettuce seeding process begins with selecting good-quality seeds. The rockwool planting media was cut using a cutter with a size of 2.5 cm ×2.5 cm ×2.5 cm. Then the rockwool is soaked in water until wet and a hole is made in the middle using a stick. Seeds that have been sorted are put into the rockwool holes and then placed on the seedling tray. Lettuce seeds can be transplanted after 14 days of seedling and have 2-3 leaves [15].

2.1.4. Transplanting

Lettuce seedlings that were 14 days old were then transferred to the wick system hydroponic installation. The netpot has a flannel attached as a wick to absorb nutrients. In this hydroponics, the wick must hit the nutrient solution in order to distribute the nutrients to the plant roots.

2.1.5. Maintenance

Maintenance of lettuce plants is carried out continuously by checking water nutrition and sanitation of containers to prevent moss growth which can interfere with the growth of lettuce plants.

2.1.6. Harvesting

Lettuce harvesting is done at 30 DAP or the Day after Planting. Lettuce harvest is done quickly to maintain the quality of the leaves so they don't wither. Harvesting can be done in the morning or at night [15]. Lettuce can be taken from all parts of the plant to the roots [2].

2.2. Data Retrieval

This study uses 2 factors. The first factor is the color of the LED which consists of red LED (100%), blue LED (100%), white LED (100%) and a combination of red LED (75%), blue (10%) and white (15%) as well as the control without the addition of LED. While the second factor is the duration of irradiation using LED, namely 3 hours and 12 hours and the control treatment. The LED circuit will be lit for 3 hours and 12 hours. Before the plants are treated with LED lights, the plants will get 12 hours of sunlight from 06.00-18.00 WIB then the plants are given additional radiation for 3 hours and 12 hours. The lights were turned on at 18.00 - 21.00 for 3 hours of light and at 18.00 - 06.00 WIB for 12 hours of light, while the control plants did not get additional light and only used 12 hours of sunlight. The number of plants to be planted is 243. There are a total of 24 treatments and 3 controls which can be seen in Table 1.

Table 1. Research Treatment

Treatment		Repetition		
Color (C)	**Length of Irradiation (T)**	**1**	**2**	**3**
C1 (Red)	3 hr (T1)	C1T1 (1)	C1T1 (2)	C1T1 (3)
	12 hr (T2)	C1T2 (1)	C1T2 (2)	C1T2 (3)
C2 (Blue)	3 hr (T1)	C2T1 (1)	C2T1 (2)	C2T1 (3)
	12 hr (T2)	C2T2 (1)	C2T2 (2)	C2T2 (3)
C3 (White)	3 hr (T1)	C3T1 (1)	C3T1 (2)	C3T1 (3)
	12 hr (T2)	C3T2 (1)	C3T2 (2)	C3T2 (3)
C4 (Combined)	3 hr (T1)	C4T1 (1)	C4T1 (2)	C4T1 (3)
	12 hr (T2)	C4T2 (1)	C4T2 (2)	C4T2 (3)

Description:
C = Color of LED
T = Length of Irradiation (hour)

Each plant will be put into the lighting box according to the treatment given. 3 lighting boxes will be used, with each lighting box being partitioned to prevent light from penetrating the other treatments. In each lighting box there will be 8 partitions used to place each treatment given, while the control plants will not enter the lighting box.

Data collection was carried out starting from the beginning of transferring the lettuce plants to the hydroponic wick system with the addition of LED lights as a light source. The parameters observed in this study were evapotranspiration, leaf greenness index, plant height (cm), leaf width (cm), leaf area (cm^2), number of leaves per plant (strands), fresh weight of plant (g), and root length (cm).

2.3. Data Analysis

The data that has been obtained is then analyzed using ANOVA (Analysis of Variance). After that, it was continued with the LSD (Least Significant Different) test and Duncan's Multiple Range Test (DMRT) with a level of 5%. This advanced test is used to determine whether there are differences in the results of the research that has been done.

3. Result and Discussion

3.1. Greenhouse

Monitoring of the greenhouse environment is carried out by checking the temperature and humidity periodically. Temperature and humidity were measured daily for 30 days at 07.00, 12.00 and 16.00 WIB. Temperature and humidity were measured using a thermo hygrometer. The results of greenhouse temperature measurements can be seen in Table 2. Temperature is an important factor in supporting plant growth. A good temperature for optimal growth of lettuce is in the range of 25-28 ℃ [17]. The results of the observations showed that in the morning and evening the environmental temperature of the green house could still be said to be ideal for lettuce plants. It was different during the day, the temperature around the greenhouse environment was too high for lettuce plants. Temperatures that are too high can cause plants to wilt because there is an imbalance in the amount of water in the plants, namely the amount of water that comes out of the plants is not balanced with the amount of water absorbed by the plants [5].

Lettuce plants can grow optimally if the air humidity is 65-78% [17]. The average air humidity in the morning and evening is enough to meet the needs of lettuce plants in their growth process. However, during the day the average air humidity both inside and outside the green house is less than optimal for the growth of lettuce plants. Low humidity can be caused by the intensity of sunlight and high air temperatures. Relatively low air humidity will be able to increase the transpiration process of plants. However, humidity that is too high can also cause plants to develop diseases and pests to reproduce [9]. The results of greenhouse humidity measurements can be seen in Table 3.

Table 2. Results of Inside and Outside Temperature of the Green House

Place	Time		
	7:00	**12:00**	**16:00**
Inside Green House	27.15 ±2.39	37.92 ±8.18	27.68 ±2.51
Outside Green House	26.09 ±1.84	32.00 ±2.27	27.23 ±2.96

Table 3. Results of Moisture Measurement Inside and Outside the Green House

Place	Time		
	7:00	**12:00**	**16:00**
Inside Green House	73% ±0.08	49% ±0.13	71% ±0.09
Outside Green House	73% ±0.07	50% ±0.13	74% ±0.10

3.2. Lighting Box

Environmental observations inside the lighting box are carried out by measuring the level of light intensity, the amount of energy expended by each treatment, and the

temperature in it.

3.2.1. Light Intensity

The level of light intensity was measured during the study on a 5 Watt LED light source using a lux meter and the results obtained were a red LED of 21.2 lux, a blue LED of 8.5 lux, a white LED of 25.7 lux, and a combined LED (red 75 %, blue by 10% and white by 15%) the light intensity was 17.8 lux. Based on light intensity measurements, white LEDs produce the greatest light intensity compared to red LEDs, blue LEDs, or combined LEDs (red 75%, blue 10% and white 10%).

3.2.2. Electrical Energy

Electrical energy is the ability to do or generate electricity. The electrical tool uses electrical energy can be defined as the rate of power use (power) multiplied by the length of time the tool is used (time) [23]. The power used in the treatment is 5 watts which will be turned on for 3 hours and 12 hours. Calculation of the energy of the lamp using the formula:

$$W = P \times t$$

Description:
P = Power (watt)
t = Time (hour)
W = Energy (watthours)

The calculation results were obtained at 3-hour irradiation of 0.015 kWh or 54 KJ with total energy used for 30 days of 5.4 kWh or 19440 KJ. Then the calculation of energy on lamps with an irradiation duration of 12 hours is 0.036 kWh or 129.6 KJ with total energy used for 30 days, namely 21.6 kWh or 77760 KJ.

3.2.3. Lighting Box Temperature

Table 4. The Results of Temperature Measurement Inside the Lighting box

Color	Treatment	Temperature (˚C)
Red	C1	25.4 ±0.6
Blue	C2	25.65 ±0.85
White	C3	25.85 ±1.15
Combined (red 75%, blu 10% and white 15%)	C4	24.8 ±0.00

The lighting box temperature measurement using a room thermometer, the temperature measurement results can be seen in Table 4. The average temperature measurement in a lighting box with a series of LED lights is 24.8-25.85 ℃, while the temperature in the control treatment or without a lighting box and the addition of LED lights have an average temperature of 24.2 ℃. When compared between the temperature in the lighting box which has additional LED lights with the treatment without the lighting box and the LED, the temperature value in the lighting box with the treatment of LED lights has a greater value. This is because the LED emits light so that there will be a rise in temperature in the lighting box. However, the temperature generated from the LED light is not too hot [7]. Thus, the addition of LED lights will produce heat so that it can increase the temperature even though the temperature increase given is not much.

3.3. Hydroponic System

The hydroponic tub used is 36 ×30 ×12 cm in size and the axis for distributing nutrient water to the plants is 20 ×1.5 cm in size. There are 243 netpot used as a place to plant plants with a diameter of 5 cm. The impraboard used were 27 pieces with 9 planting holes where the distance between the planting holes was 9 ×5 cm. In this study, 4 liters of raw water or 4 cm of water were used. Then the nutrient content used is a 1:1 ratio for AB nutrient mixtures up to 800 ppm. Furthermore, observations of nutrient levels, temperature, pH, and EC were carried out for 3 days. Checks are carried out regularly so that the plants can grow optimally. Measurement of temperature in each treatment obtained an average value of 25.34-28.40 ℃ for an average pH of 7.20-7.39 and an average EC value of 1.47-1.60 mS/cm for each treatment.

3.4. Plant Growth Yield

Observations made on lettuce plant growth include evapotranspiration, leaf greenish index, plant height, leaf width, leaf area, number of leaves, fresh weight and root length. Evapotranspiration is observed once every 3 days, for plant height and the number of leaves once every 5 days while leaf greenish index, leaf width, leaf area, fresh weight of harvest, and root length are observed by the time the plant is ready for harvest or age 30 DAP. The results of observations of the growth of lettuce plants can be seen in Table 5.

Based on the results of the study, that in control plants (C0T0) or without the addition of LED light gave better results on plant height, leaf area and root length compared to other treatments with an average plant height of 10.73 ±7.55 cm, an average leaf area of 142.51 ±23.13 cm^2 and an average root length of 25.99 ±2.48 cm. Then the parameters of the greenish index of the leaves of the C3T1 treatment or white color irradiation for 3 hours with an average of 22.77 ±3.23 units gave greater results compared to other treatments. At leaf width, C2T2 treatment or blue color irradiation for 12 hours gave a good result of 11.48 ±1.33 cm. for the parameters of the number of leaves, the treatment of C1T1 or red color for 3 hours gave the highest average of 6.67 ±2.03 strands. Furthermore, the treatment of C4T1 or combined colors (red 75%, blue 10% and white 15%) for 3 hours gave good results against evapotranspiration with an average of 6.84 ±4.28 mm / 3 days and fresh weight of the harvest with an average of 28.07 ±1.39 grams.

Table 5. Lettuce Growth Average Yield

Treatment	Parameter							
	Evapotranspiration (mm/3 days)	**Leaf Greenish Index (unit)**	**Plant Height (cm)**	**Leaf Width (cm)**	**Leaf Area (cm2)**	**Number of Leaves (Sheet)**	**Fresh Weight (gram)**	**Long of Root (cm)**
C0T0	5.28±2.61	20.81±4.73	10.73±7.55	11.37±0.44	142.51±23.13	6.32±1.65	26.07±2.93	25.99±2.48
C1T1	6.47±3.82	18.33±1.46	8.01±5.10	10.77±0.82	115.90±19.71	6.67±2.03	26.73±4.09	24.28±1.35
C1T2	5.67±4.14	19.36±2.65	8.41±5.67	10.47±0.62	109.61±29.23	6.33±1.70	23.06±4.15	25.03±2.02
C2T1	5.66±3.81	19.26±1.27	7.89±5.23	10.47±0.59	109.97±16.56	6.26±1.60	23.06±2.47	24.04±2.57
C2T2	6.12±4.53	17.37±2.25	8.78±5.53	11.48±1.33	118.68±24.19	6.08±1.48	23.73±4.99	22.05±0.93
C3T1	5.65±3.43	22.77±3.23	7.34±4.87	10.39±0.73	92.10±14.17	6.30±1.78	21.97±1.30	22.49±2.16
C3T2	5.62±3.73	19.28±3.37	7.58±5.12	11.02±0.61	98.23±10.81	6.11±1.51	19.63±5.32	23.27±0.74
C4T1	6.84±4.28	21.00±2.57	8.07±5.22	11.39±0.70	114.45±12.67	6.47±1.88	28.07±1.39	24.42±1.05
C4T2	6.29±3.89	21.85±4.73	8.04±4.87	10.48±0.17	91.65±18.50	6.37±1.81	25.71±1.33	25.66±0.87

3.5. The Effect of LED on Evapotranspiration of Lettuce Plants

Lettuce evapotranspiration data was collected by measuring changes in the water level in the hydroponic tub. Evapotranspiration can be calculated based on the lowering of the water level. The greater the growth of lettuce increases its evapotranspiration value. This indicates that the need for water and nutrients in lettuce is increasing [16]. In addition, the increase in evapotranspiration value can also be affected by temperature, humidity, light intensity and plant conditions. The higher the ambient temperature, the evapotranspiration value will also increase because the plants will lose water either from the plants themselves or from the evaporation of nutrient water [10]. Water level measurements were carried out for 3 days with a controlled water level reference of 4 cm. If the water level decreases, water is added up to 4 cm and then the water level is measured again in the next 3 days. Based on the graph, the results of the largest decrease in water level were in the C2T2 treatment or the blue treatment for 12 hours on day 27 DAP with a height reduction of 16 mm/3 days while the lowest value was in the C1T2 treatment or the red color treatment 12 hours of irradiation of 0.00 mm/ 3 days. The results of measuring the evapotranspiration of lettuce plants can be seen in Figure 1.

3.6. The Effect of LED on the Greenish Index of Lettuce Plants

The measurement of the greenish index is carried out at the time of harvest, which is 30 days after planting. Sampling was carried out on each plant using chlorophyllmeter / SPAD (Soil Plant Analysis Development) type 502 Plus brand Konica Monita. Measurement of the greenish index is carried out by clamping the leaves on the measurement head. The measurement is carried out at 3 points at the top, middle, and lower base of the leaf and then averaged. The results of measuring the greenish index of lettuce plants can be seen in Table 6.

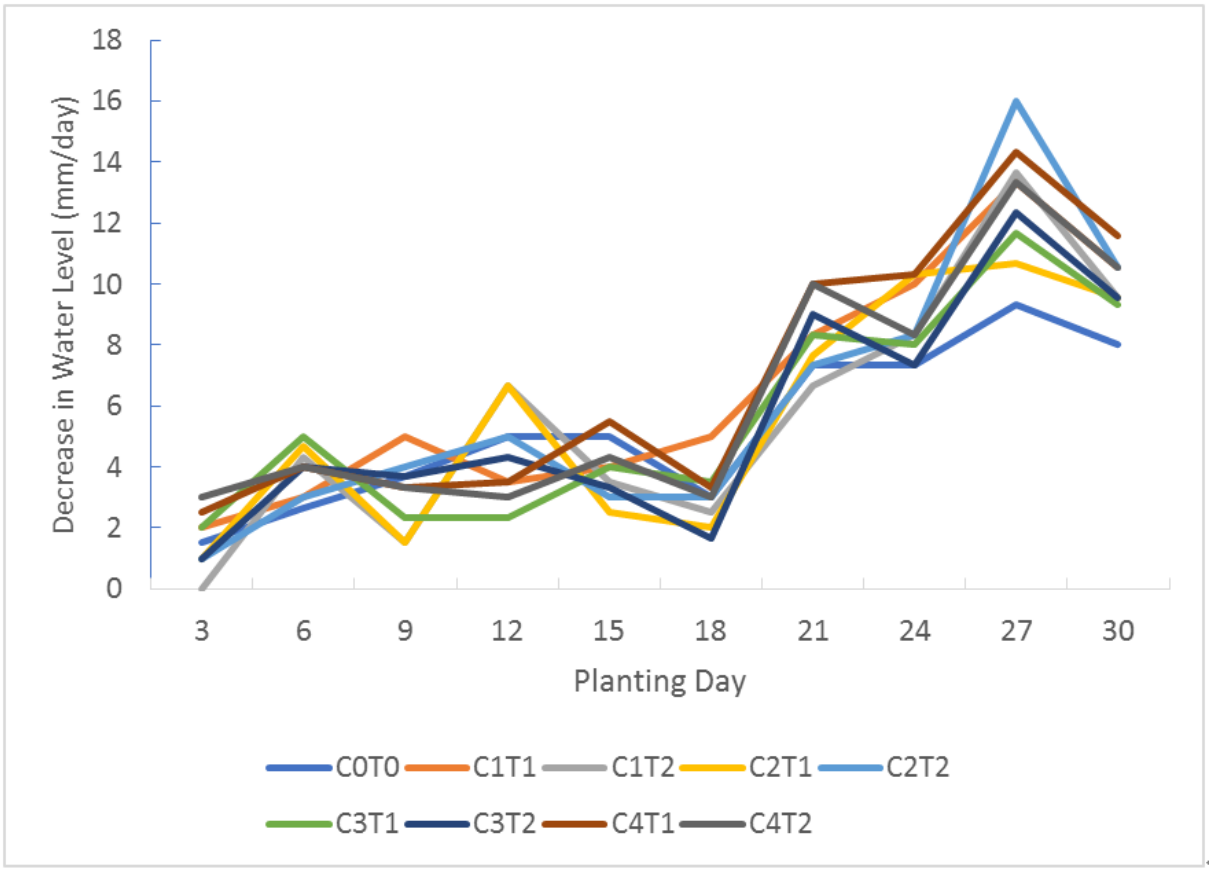

Figure 1. Evapotranspiration measurement results

Table 6. Results of Varian Analysis from Greenish Indeks

Analysis of Variance				
SV	F Count	F Table		Notation
		F Table 5%	F Table 1%	
C	1.8084	3.34	5.56	ns
T	0.5740	4.6	8.86	ns
C x T	0.9061	3.34	5.56	ns

Based on the results of the analysis, the addition of LED color, duration of irradiation and the interaction between the two did not significantly affect the greenness index of the leaves. This is because the light intensity used is not suitable for adding light to the greenness index of the leaves. The right light intensity can help plants to carry out the process of photosynthesis optimally because the chlorophyll content in the leaves is related to the amount of energy received. The optimal addition of light to optimize the plant growth process is 3-4 hours with a light intensity of 32-108 lux [24]. The LED lamp used in the study had the greatest light intensity of 25.7 lux, so it was not able to meet the need for an additional light for lettuce plants.

3.7. The Effect of LED on Lettuce Plant Height

Lettuce plant height was measured 6 times during the planting period, which is 30 DAP. Data collection is carried out every 5 days, namely at 5 DAP, 10 DAP, 15 DAP, 20 DAP, 25 DAP and 30 DAP. Measurement of plant height is carried out using a ruler in centimeters (cm) units. Plant height is measured based on the highest lettuce leaves. Measurements start from the base of the stem of the lettuce plant to the top of the highest lettuce leaf. The results of measuring the height of lettuce plants can be seen in Table 7.

Based on the results of the analysis of variance, it can be seen that the color treatment (C) gives significantly different results. Meanwhile, the duration of irradiation (T) and the interaction between color and duration of irradiation (C×T) did not give significantly different results. Then the treatment of the color of the LED lights is continued with the 5% LSD test. Table 8 shows the results of the 5% plant height LSD analysis test for color.

Table 7. Results of Varians Analysis of Lettuce Plants

Analysis of Variance				
SV	F Count	F Table		Notation
		F Table 5%	F Table 1%	
C	4.6848	3.34	5.56	*
T	4.3279	4.6	8.86	ns
C x T	1.1524	3.34	5.56	ns

Table 8. The Results of LSD 5% for Lettuce Plant Height

Treatment	Average	Notation with LSD 5%	Notation with LSD 1%
C1	8.21	a	a
C2	8.34	b	a
C3	7.46	a	a
C4	8.06	a	a
LSD Value		0.77159	1.07087

Based on the 5% LSD test, it can be concluded that blue LED (C2) has the best effect on the height growth of lettuce plants compared to other LED colors. This is in accordance with research conducted on chrysanthemum plants where the use of additional lighting lamps wrapped in the white, red and blue paper can increase the height of chrysanthemum plants [4]. The best value for chrysanthemum plants was obtained by adding red and blue LED lights. The light that has the longest and shortest wavelengths will affect plant growth [24].

3.8. The Effect of LED on the Width of Lettuce Leaves

The width of lettuce leaves is measured when the plant is 30 days old. The measured lettuce leaves are the widest. Measurements are made at the distance between the right edge to the left edge of the leaf or vice versa with a ruler. The results of the leaf width measurement were then analyzed using ANOVA. The results of the ANOVA analysis can be seen in Table 9.

Table 9. Results of Analysis Varians of Lettuce Leaf Width

Analysis of Variance				
SV	F Count	F Table		Notation
		F Table 5%	F Table 1%	
C	0.4285	3.34	5.56	ns
T	0.1686	4.6	8.86	ns
C x T	2.7444	3.34	5.56	ns

Based on the results of the analysis, it can be seen that the addition of LEDs, both color (C), irradiation time (T) and the interaction between color and irradiation time (CxT)

did not have a significant effect on the width of lettuce leaves. The use of red and blue LEDs has results that are not much different from leaf width [21]. This is due to the intensity of the additional light received by the plants is not in accordance with the needs. Appropriate light can be absorbed by plants to carry out photosynthesis. Lettuce that gets optimal irradiation can grow well-marked with wider leaves than those that do not get optimal irradiation [14].

3.9. The Effect of LED on the Lettuce Leaf Area

Measurement of lettuce leaf area is carried out during the harvest period, which is when the plant is 30 DAP. Measurement of lettuce leaf area is carried out using the application of imageJ in units of squared centimeters (cm^2). The leaves taken for the measurement of leaf area are the largest leaves. The data that has been obtained is then carried out by fingerprint analysis as can be seen in Table 10.

Based on the analysis of variance, it can be seen that the LED color treatment (C) and the interaction between LED color and irradiation time (C×T) give significantly different results. Whereas the long irradiation treatment (T) did not give significantly different results. Then the color treatment (C) is continued with the 5% LSD test and the interaction between LED color and irradiation time (CxT) is continued with the 5% DMRT test. Table 11 shows the results of the 5% LSD analysis test on the area of lettuce leaves for color.

Table 10. Results of Varians Analysis of Lettuce Leaf Area

Analysis of Variance				
SV	F Count	F Table		Notation
		F Table 5%	F Table 1%	
C	5.3561	3.34	5.56	*
T	0.8469	4.6	8.86	ns
C x T	3.4618	3.34	5.56	*

Table 11. The result of LSD 5% for Lettuce Leaf Area

Treatment	Average	Notation with LSD 5%	Notation with LSD 1%
C1	112.75	b	a
C2	114.33	b	a
C3	95.16	a	a
C4	103.05	a	a
LSD Value		16.60317	23.04319

Based on the 5% LSD test, it can be concluded that red (C1) and blue (C2) have the same and different effects as white (C3) and combined (75% red, 10% blue and 15% white or C4). So, the blue color (C2) gives the best leaf area results in lettuce plants, but the effect is not different from the red color (C1). Red and blue light is very good for plant growth because the light color can be absorbed properly by chlorophyll for photosynthesis [22]. Red light color is good for the vegetative phase of plants and red color is used for the generative phase [19]. The vegetative phase in plants includes the development of roots, stems, branches and leaves.

Table 12. The result of DMRT 5% for Lettuce Leaf Area

Treatment	Average	Average + DMRT	Notation
C1T1	115.90	134.56	bc
C1T2	109.61	127.84	bc
C2T1	109.97	128.42	bc
C2T2	118.68		c
C3T1	92.10	109.50	a
C3T2	98.23	116.13	ab
C4T1	114.45	133.01	bc
C4T2	91.65	108.24	a

Table 12 shows the results of the 5% DMRT analysis test on the area of lettuce leaves. Based on the 5% DMRT test, it can be concluded that the blue color with an irradiation duration of 12 hours (C2T2) has the highest influence. So, the treatment of C2T2 gives the best increase in the leaf area in lettuce plants. Lettuce plants are long-day plants that require longer lighting to help the photosynthesis process run optimally. In the process of photosynthesis, chlorophyll can absorb as much as 90% of the light in red and blue colors [21]. In addition, irradiation using LED lights at night for 3 hours or more can help lettuce grow better [20]. Thus, irradiation for 12 hours causes the area of the resulting lettuce leaves to be larger compared to 3 hours.

3.10. The Effect of LED on the Number of Leaves Per Plant

Measurement of the number of lettuce leaves is carried out 6 times, namely once every 5 days at 5 DAP, 10 DAP, 15 DAP, 20 DAP, 25 DAP and 30 DAP. Measurements are made on leaves that have been fully opened. Then the data that has been obtained is analyzed using variance as shown in Table 13.

Table 13. Results of Analysis of the Variance of Lettuce Leaves

Analysis of Variance				
SV	F Count	F Table		Notation
		F Table 5%	F Table 1%	
C	6.3185	3.34	5.56	**
T	9.6794	4.6	8.86	**
C x T	0.5726	3.34	5.56	ns

Based on the results of the analysis of variance, it can be

seen that the LED color treatment (C) and the duration of irradiation (T) gave significantly different results. Meanwhile, the interaction between color and duration of irradiation (C × T) did not give significantly different results. Then the LED color treatment (C) and duration of irradiation (T) were continued with the 5% LSD test. The results of the 5% LSD test on the number of lettuce leaves on the color of the LED lights can be seen in Table 14.

Table 14. The Results of LSD 5% Amount of Lettuce Against LED Light Color

Treatment	Average	Notation with LSD 5%	Notation with LSD 1%
C1	6.50	b	a
C2	6.17	a	a
C3	6.21	a	a
C4	6.42	a	a
LSD Value		0.27578	0.38275

Based on the 5% LSD test, it can be concluded that the red LED (C1) has a large and different effect from the blue (C2), white (C3) and combined color LEDs (75% red, 10% blue and 15% white or C4). So that giving red color (C1) gives the best number of leaves on lettuce plants compared to other color treatments. The addition of LED to lettuce plants makes growth faster and produces more leaves. This can make plants grow optimally and avoid etiolation. Good lettuce is shown by short leaf stems and very tight spacing between leaf nodes and wider leaf width compared to others [14]. Leaves have an important role in the process of photosynthesis, so that the more light is absorbed, the number of leaves will also increase [12].

Table 15. Results of Advanced Test of LSD 5% Number of Lettuce Leaves on Exposure Time

Treatment	Average	Notation with LSD 5%	Notation with LSD 1%
T1	6.42	a	a
T2	6.22	a	a
LSD Value		0.27578	0.38275

The results of the 5% LSD test for the duration of irradiation on the number of lettuce leaves can be seen in Table 15. Based on the 5% LSD test, it can be concluded that the 3-hour treatment duration (T1) had the best effect but was not significantly different from the 12-hour treatment duration. The duration of LED irradiation on plants for 3 hours has a better effect than without irradiation [20]. This shows that the addition of an LED lamp with a time of 3 hours can help lettuce carry out photosynthesis better so that it will be more optimal. However, the effect is not significantly different from the addition of the LED for 12 hours which is just as good.

3.11. Effect of LED on Lettuce Plant Fresh Weight

Measurement of the fresh weight of harvested lettuce was carried out at the age of 30 DAP. Measurement of the fresh weight of the harvest is done using a digital scale in units of grams (gr). Measurements were made by weighing all parts of the lettuce plant which includes the leaves, stems and roots of the plant. Then the data that has been obtained is analyzed using variance as shown in Table 16.

Table 16. The Result Analysis of Variance Harvest Fresh Weight

Analysis of Variance				
SV	F Count	F Table		Notation
		F Table 5%	F Table 1%	
C	3.6063	3.34	5.56	*
T	2.0278	4.6	8.86	ns
C x T	0.4614	3.34	5.56	ns

Based on the results of the analysis of variance, it can be seen that the LED color treatment (C) gave significantly different results. Meanwhile, the treatment duration of irradiation (T) and the interaction between color and duration of irradiation (C × T) did not give significantly different results. Then the color treatment was continued with the test LSD 5%. The results of the test LSD 5% on harvested fresh weight can be seen in Table 17.

Table 17. The Results of Test LSD 5% Fresh Weight Lettuce Harvest

Treatment	Average	Notation with LSD 5%	Notation With LSD 1%
C1	24.90	a	a
C2	23.39	a	a
C3	20.80	a	a
C4	26.89	b	a
Nilai LSD		5.80431	8.05568

Based on the test LSD 5%, it can be concluded that the combined colors (75% red, 10% blue and 15% white or C4) have a good effect, different from red (C1), blue (C2) and white (C3) colors. So that the combined color (75% red, 10% blue and 15% white or C4) gave the best fresh weight gain for lettuce compared to other color treatments. The addition of LED lights can help plants to carry out the photosynthesis process longer so that the yield of harvest weight will also increase compared to without treatment. The addition of red and blue light has a good effect on the photosynthesis process. The color can be absorbed by chlorophyll. If the light needs are met and the photosynthesis process runs optimally, it can affect the leaf area and width of the plant so that the fresh weight of the harvest will also increase [14].

3.12. The effect of LED on Lettuce Root Length

Data collection on the length of the roots of lettuce plants is carried out at the time of age 30 days after planting or at the time of harvest. Measurement of the length of lettuce roots is carried out using a ruler in centimeters (cm). The length of the roots is measured from the base of the roots to the tips of the roots of the lettuce plant. The results of the root length measurement data that have been obtained are then analyzed using ANOVA. The results of the ANOVA analysis can be seen in **Table 18.**

Table 18. Lettuce Root Length Variation Analysis Results

Analysis of Variance				
SV	**F Count**	**F Table**		**Notation**
		F Table 5%	F Table 1%	
C	4.3751	3.34	5.56	*
T	0.1770	4.6	8.86	ns
C x T	2.0588	3.34	5.56	ns

Based on the analysis of variance, it can be seen that the LED color treatment (C) gives significantly different results. While the treatment duration of irradiation (T) and the interaction between LED color and duration of irradiation (C × T) did not give significantly different results. The LED color irradiation treatment (C) was continued with the 5% LSD test. The results of the 5% LSD test on lettuce root length can be seen in Table 19.

Table 19. The Results of LSD 5% for Lettuce Root Length

Treatment	**Mean**	**Notation LSD 5%**	**Notation LSD 1%**
C1	24.65	a	a
C2	23.04	a	a
C3	22.93	a	a
C4	25.04	a	a
LSD value		2.22611	3.08958

Based on the 5% LSD test, it can be concluded that the color combination (75% red, 10% blue, and 15% white or C4) has a good effect and is not significantly different from red (C1), blue (C2) and white (C3). So, the color combination (75% red, 10% blue, and 15% white or C4) gave the best increase in the length of the lettuce roots compared to other color treatments. The addition of LED lights provides a good role in irradiating plants because several wavelengths of light that plants need are found in LED lights. Giving additional light from lamps wrapped in the white, red and blue paper can increase plant growth [4]. So that the addition of LED lights using red, blue, white or a combination of these three colors can give the same good results. However, apart from the addition of light, a factor that can affect the growth of plant roots is the laying of lettuce seeds on rockwool. If the seeds are placed in a horizontal position, they can cause root growth to surround the rockwool and become clustered. Meanwhile, when the rockwool fiber is pointing upwards (vertically), the roots will grow downward [12].

4. Conclusion

This study shows that the addition of red LED (C1) has an effect on the number of lettuce leaves. Then the blue LED (C2) irradiation treatment gave good results on plant height and leaf area. The color combination (75% red, 10% blue, and 15% white) had an effect on fresh harvest weight and root length. Meanwhile, the irradiation duration of 3 hours (T1) and 12 hours (T2) had the same effect on the number of leaves. The interaction between the addition of blue light for 12 hours (C2T2) gave good results on the leaf area. The addition of the color of the LED light within a certain time has no effect on the greenness index of the leaves and lettuce leaf width. Based on the results of observations that have been made, the addition of a red LED for 3 hours (C1T1) gives the highest total average result for each parameter observed. This is because the red light wavelength is the most absorbed and utilized by plants during the growth period.

For further studies, to better understand the effect of adding LED light to plants, parameters such as leaf stomata can be added to determine differences in the width and length of stomata between plants in the LED light treatment compared to plants without the addition of LED light. It is necessary to periodically check the temperature of the lighting box and add air holes to facilitate air exchange so that the temperature in the lighting box room is not too hot.

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