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Analysis of Light Intensity from Various Types of Light Bulbs, Distance, and Time on Fruit Plants Dragon Fruit (*Hylocereus Polyrhizus*) in the Generative Phase

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Abstract: The study entitled analysis of light intensity from various types of distance and time bulbs with the aim of getting the appropriate type of light bulb, distance and time to increase dragon fruit production. The study was conducted in Kampung Melayu Village, Ujung Padang District, Simalungun Regency, North Sumatra Province with an altitude of ± 25 m above sea level. in April to June 2025. The study used Factorial RAK with 3 factors and 2 replications. The first factor of the type of light bulb consists of B_1 = special light bulb for dragon fruit plants, B_2 = LED light bulb, B_3 = Special light bulb for chicken farms B_4 = Incandescent light bulb. The second factor of the irradiation distance consists of J_1 = 50 cm, J_2 = 100 cm, J_3 = 150 cm. The third factor of irradiation time W_1 = 10 days of irradiation time W_2 = 20 days of irradiation time W_3 = 30 days of irradiation time The results of the study showed that treatment $B_1J_2W_2$. Shows the highest dragon fruit production. This is because the light produced is like sunlight, the distance of the light from the plant is not close and not far from the distance of the dragon fruit plant and the lighting time is appropriate throughout the year because the light requirements for each month are different depending on the season.

Keywords: Intensitas; Irradiation; Lamp.

Introduction

Dragon fruit plants, which have a morphology similar to cacti, are plants that require long periods of sunlight exposure (long-day *plants*), meaning that during the vegetative and generative phases, they require at least 12 hours of light or more. Light from light bulbs is an appropriate way to overcome light deficiencies in dragon fruit cultivation.

Dragon fruit farmers in the use of light bulbs do not know the intensity, distance and time they usually learn from their friends who are successful in cultivating light bulbs. The light bulbs used must be low intensity in color according to sunlight, namely yellow because yellow light has a low light intensity. By knowing this, they can distinguish between white light bulbs compared to yellow light, because yellow light does not produce high heat energy so that the temperature is always optimal. The distance of light used by dragon fruit farmers is based on desire. Meanwhile, if examined carefully, the distance determines the light entering evenly on the plant and avoids the amount of energy given by light to the plant. If it is too close, the dragon fruit plant will dry out because the temperature is generated to be higher, so the appropriate distance is in the middle between 4 plants according to the distance of the dragon fruit. The lighting time must be determined that can represent the whole year because the amount of lighting each month is different while dragon fruit plants are long-day plants, therefore to anticipate the optimal lighting time, there is no shortage and no excess, so that from this research the optimal lighting time will be obtained.

In plant physiology studies, providing light during cultivation to induce flowering and increase yield is a

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key factor in flowering induction. Dragon fruit plants (*Hylocereus spp*.) are long-day plants (LDP), so flowering induction occurs during long days. This is related to photoperiod. Photoperiod is a phenomenon in various plant species in which the length of the day determines whether the apical or lateral meristem can form flowers (Setyawati, 2020).

Dragon fruit plants can grow in lowlands at altitudes of 20–500 meters above sea level, in loose, porous soil rich in organic matter and nutrients, with a pH of 5–7. Additionally, water must be sufficiently available, as the plants require full sunlight for photosynthesis and to accelerate flowering. Dragon fruit plants are spaced 2 m x 2.5 m apart. The optimal temperature for dragon fruit plant growth ranges from 26–36°Cand humidity from 70%–90% (Zahrotun and Taufiqurrohman 2019; Darmajaya 2017).

Farmers use light to increase their production. Farmers mostly use LED lights, including white and yellow. The addition of artificial light to create long-day conditions in the equatorial region can be done for three to four hours at a light intensity range of 32–108 lux to determine the effect of LED light on flower emergence. To determine the most effective LED light for stimulating flowering. The hypothesis is that LED light can stimulate flowering. Blue LED light is more effective at stimulating flowering in red dragon fruit (*H. polyrhizus)* (Saputra and Wiraatmaja, 2020).

Light-emitting diodes (LEDs) have great potential for horticultural applications due to their energy efficiency, long life, and flexibility of application. LEDs are increasingly suitable for research and commercial agriculture under controlled conditions due to their low radiation, heat, and broad spectral adaptation. LEDs can regulate total phenol and total flavonoid concentrations by increasing the expression of genes involved in the biosynthesis of secondary compounds, either directly or indirectly by increasing the levels of these molecules, thereby enhancing plant development (Fadila et al, 2024).

Incandescent lamps tend to generate more heat, are less energy efficient, and have a limited light spectrum. However, incandescent lamps have a warm color temperature that can provide beneficial light for photosynthetic plants (Jannah & Asran, 2023). In candescent lamps produce a continuous spectrum that covers the entire visible spectrum, resembling the energy distribution of blackbody radiation. The intensity of this spectrum depends on the filament temperature; increasing the filament voltage in an incandescent lamp shifts the spectrum to shorter wavelengths, increasing light emission at those wavelengths (Aswandi & Umar, 2020).

Ideal light exposure also affects flower and fruit formation. Sufficient light will stimulate the formation of more flowers and increase the chances of fertilization. If the light intensity received is too low due to inadequate exposure, plants may experience delayed flowering or even fail to bear fruit. Additionally, the color and taste of dragon fruit can be influenced by the amount of light received, with sufficient light helping produce fruit with a bright red color and a sweeter taste (Hylocereus & Biaya, 2011). Dragon fruit plants require sufficient light for optimal growth and productivity. If lighting is too close, especially when using additional lamps in plantations, plants may experience stress due to excessively high temperatures. Conversely, if lighting is too far away, the intensity of the light received decreases, thereby inhibiting plant growth and fruit production (Purnama & Ilmi, 2019).

In general, the closer the lamp to the plant, the higher the light intensity. This is because light intensity is influenced by the area size; the greater the vertical distance to the light, the larger the area becomes, resulting in a lower light intensity. High light intensity values occur because the greater the distance between the light source and the surface, the smaller the area becomes, which affects the lumen/m² value (Lutfi et al., 2022). To achieve good lighting results, it is necessary to consider the type of lamp and the required lamp height depending on the lighting (lighting intensity) and the lighting angle of the lamp, so that optimal production results can be obtained (Ayu et al, 2023). The purpose of this study is to determine the light intensity of various types of light bulbs, the distance and time required for light intensity from various types of light bulbs, and the distance and time required for dragon fruit plants (*Hylocereus Polyrhizus)* in the generative phase.

Photosynthesis is a vital process for plants, in which solar energy is converted into chemical energy stored as organic compounds (Zahara & Fuadiyah, 2021). One of the main factors affecting photosynthetic efficiency and photosynthetic rate is light intensity. Light, as the primary energy source, plays a direct role in regulating the rate of photosynthesis occurring in plant leaves (Putri et al., 2021).

Light is a form of electromagnetic wave with a wavelength ranging from 380 to 750 nanometers. Light intensity itself is a physical quantity used to indicate the amount of light energy emitted by a source in a certain direction in a unit angle. Conventionally, if a light source has an intensity of 1 candela and is placed at the center of a sphere with a radius of 1 meter, the inner surface of the sphere will receive a light flux of 1 lumen. The level of illumination on the surface of the sphere is 1 lumen per square meter, which is called lux. With the surface area of the sphere calculated as $4\pi r^2$ or approximately 12.57 square meters, a source with an intensity of 1 candela will emit a total of 12.57 lumens in all directions (Satwiko, 2008). According to Wiguna et al (2015), the addition of artificial light to create long day conditions in the equatorial region is around 3-4 hours with a light intensity ranging from 32-108 lux. Light is the most important external factor in controlling plant growth and development. The part of sunlight visible to the human eye has a wavelength range of 400 nm to 700 nm. This part of light is converted by plants into chemical energy during photosynthesis, so it is called photosynthetic light (Kania & Giacomelli, 2001).

The portion of sunlight visible to the human eye has wavelengths between 400 nm and 700 nm. This portion of light is converted by plants into chemical energy through photosynthesis, and is therefore called photosynthetic light (Kania & Giacomelli, 2001). Red and blue light are the most beneficial light spectra for plants, with red light (610–750 nm) stimulating vegetative growth and flowering. However, if a plant receives too much red light, it will become taller and slimmer. Blue light (400–520 nm) helps maintain plant growth rates, enabling plants to grow optimally, especially in the cultivation of broad-leaved and short plants. Blue light is very important for promoting the growth and flowering of healthy plants, while red light offers the most effective light waves for photosynthesis. According to research (Rizaludin et al., 2020), white LED lights have a wider average leaf width than blue LED lights, presumably because blue LED lights produce lower light intensity than white lights, and the wavelength range (PAR) absorbed by plants is not yet optimal for photosynthesis. The color of the LED light provided will affect the outcome because each color has a specific wavelength range absorbed by plants during photosynthesis and other processes Campbell & Reece (2010).

The intensity of sunlight received by plants affects their physiological processes. Sunlight provides the energy plants need to perform photosynthesis. Light has wave properties, and the wavelengths that can affect plant biological activity are between 380 and 750nm.

The success rate of the influence of yellow and white LED lights depends on the intensity of the light delivered to the plants. This occurs when the lux value provided by the LED light's strength is close to the lux value influenced by sunlight intensity. Sunlight intensity reaches its highest value of 10,000 lux at 10:27 AM WIB, while yellow LED light has a maximum value of 3,538 lux, 880 lux for white LED light, and 550 lux for blue LED light, calculated from the closest distance between the plants (20 cm) and the lights at the same time (7:46 PM to 7:48 PM). The very low intensity of the blue LED light slowed the stimulation process for flower bud emergence. This was reinforced by data from the sixth week of observation, which showed the emergence of flower buds. The lux values for sunlight intensity and for each treatment are shown in more detail in the lux value comparison (Figure 7). As previously explained, the lux value closest to sunlight is the yellow LED light, as it consistently had the highest values across all three variables. To maintain plant health, plants require 14–16 hours of light exposure daily (Haryadi 2017). As light intensity increases, the rate of photosynthesis decreases or remains unchanged. LED lights are the first type of light tested for hydroponics because their wavelengths are suitable for plant photosynthesis. These lights can enhance plant growth, resulting in more optimal production. LED lights are safer to use because they do not use glass coatings, do not produce high temperatures, and do not contain mercury (Morrow, 2008).

Light intensity itself is a physical quantity used to indicate the amount of light energy emitted by a source in a certain direction in a unit angle. Conventionally, if a light source has an intensity of 1 candela and is placed at the center of a sphere with a radius of 1 meter, then the inner surface of the sphere will receive a light flux of 1 lumen. The level of illumination on the surface of the sphere is 1 lumen per square meter, which is called lux. With the surface area of the sphere calculated as $4\pi r^2$ or approximately 12.57 square meters, a source with an intensity of 1 candela will emit a total of 12.57 lumens in all directions (Satwiko, 2008). Theoretically, light intensity will increase as the light flux increases, but it will decrease if the angle of dispersion is widened. The intensity of a light source remains constant whether the light is emitted in a focused or scattered manner. In addition to light intensity, exposure duration also plays an important role. Dragon fruit plants are long-day plants (plants that require long exposure to sunlight), meaning that for these plants to produce fruit, they require at least 12 hours of sunlight or more. Dragon fruit plants are not greatly affected by wind and are relatively resistant to wind speeds. However, strong winds can knock down the trellis poles. The solution to this problem is to build permanent trellis poles. (Warisno & Dahana, 2010). Light intensity is regulated by placing a certain number of lamps with specific wattage at a distance of 40-50 cm from the crop, for a specific area. The purpose of this study is to analyze the light intensity of various types of light bulbs, distances, and times on dragon fruit plants (*Hylocereus polyrhizus)* in the generative phase.

Method

Place and Time

This study was conducted in Kampung Melayu Village, Ujung Padang District, Simalungun Regency, North Sumatra Province, at an altitude of ±25 m above sea level, with flat topography. The study was conducted from January to March 2025.

Materials and Equipment

The materials used is, manure, NPK 1616 fertilizer, KCL fertilizer, TSP fertilizer, Antracol powder, and other necessary materials. The tools used include: special dragon fruit light bulbs 12 Watt, LED light bulbs, and incandescent light bulbs for chicken farmers. Wire, screwdrivers, scissors, knives, lux meter and other necessary tools. LED bulbs, incandescent bulbs, and Chicken farmer bulbs. Wire, screwdrivers, scissors, lux meter, knives, and other necessary tools.

Research Method

This study used a Factorial Randomized Block Design (RAK) with 3 factors, namely: Light bulb type factor with 3 levels:

B1 = special light bulb for dragon fruit plants
B2 = LED light bulb
B3 = Special light bulb for chicken farming
B4 = Incandescent bulb
The second factor is the treatment with light duration (J) with 3 levels:
J1 = Horizontal distance of 50 cm
J2 = Horizontal distance of 100 cm
J3 = Horizontal distance of 150 cm
The third factor is treatment with light duration or (W) with 3 levels:
W1 = Irradiation time for 10 days
W2 = Irradiation time for 15 days
W3 = Irradiation time for 30 days

E. The observed variables were light intensity, number of buds, number of flowers, and fruit yield.

Result and Discussion

Result

Number of flower buds (buds) of dragon fruit plants

From the analysis of variance, the average difference test results for light intensity, bulb type, distance, and time on the number of flower buds at 2 MSA are shown in Table 1.

Table 1. Results of the mean difference test of light intensity analysis from various types of light bulbs, distance, and time on dragon fruit plants (*Hylocereus polyrhizus*) on the number of flower buds at 2 MSA.

	Single factor									
	Light bulb type				Illumination distance			Lighting time		
Treatment	B_1	B_2	B_3	B_4	J_1	J_2	J_3	W_1	W_2	W_3
Average	66 a	56 b	28.50 c	32 c	69.50 a	72 a	41 b	57.50 a	65.50 a	59.50 a

Note: Numbers followed by the same letter in the same row or column indicate no significant difference at the 5% level

From Table 1, in the first single factor, namely the type of light bulb treatment (B), there was a significant difference between (B1), (B2), and (B3), while treatments (B3) and (B4) were not significant. The highest number of flower buds was found in treatment (B (1)), which was 66, while the lowest was in treatment (B (3)), which was 28.5. In the second single factor, namely the lighting distance treatment (J), there was no significant difference between (J (1)) and (J2), and significantly different from (J3) for the highest number of flower buds in treatment (J2) at 72, while the lowest was in treatment (J3) at 41. For the third single factor, namely the lighting time treatment (W), there was no significant difference between (W1), (W2), and (W3) for the highest number of flower buds in treatment (W2), which was 65.5, while the lowest was in treatment (W1), which was 57.5.

From the analysis of variance for the interaction between light bulb type and distance, the results of the mean difference test for the number of flower buds at 2 MSA are shown in Table 2.

Table 2. Interaction of the results of the mean difference test of light intensity analysis from various types of light bulbs and distance on dragon fruit plants (*Hylocereus polyrhizus)* on the number of flower buds at 2 MSA

	Interaction factor between light bulb type and irradiation distance											
Treatment	B_1J_1	B_1J_2	B_1J_3	B_2J_1	B_2J_2	B_2J_3	B_3J_1	B_3J_2	B_3J_3	B_4J_1	B_4J_2	B_4J_3
Average	23.50 b	30 a	12.50 c	21.50 b	23.50 b	11 c	10 c	10 c	8.50 c	14.50 c	8.50 c	9 c

Note: Numbers followed by the same letter in the same row or column indicate no significant difference at the 5% level

From Table 2, it can be seen that the interaction between the type of light bulb (B) and distance (J) treatments, namely B1J (2), is significantly different from the treatments B2J2 and B4J1, while the treatments (B1J1), (B2J1), and (B2J2) are not significant. The treatments (B (1)J(3)), (B (2)J(3)), (B (3)J(1)), (B (3)J(2)), (B (3)J(3)), (B (4)J(1)), (B (4)J2) and (B3J1) are not significant. The highest number of flower buds was found in treatment (B1J2) at 30, while the lowest was found in treatment (B3J3) at 8.5.

From the analysis of variance for the interaction between light bulb type and time, the results of the mean difference test for the number of flower buds at 2 MSA are shown in Table 3.

Table 3. Interaction of the results of the mean difference test of light intensity analysis from various types of light bulbs and time on dragon fruit plants (*Hylocereus polyrhizus)* for the number of flower buds at 2 MSA

	Interaction factor between light bulb type and irradiation time											
Treatment	B_1W_1	B_1W_2	B_1W_3	B_2W_1	B_2W_2	B_2W_3	B_3W_1	B_3W_2	B_3W_3	B_4W_1	B_4W_2	B_4W_3
Average	17 b	23 a	26 a	16.50 b	25 a	14.50 b	10.50 c	8.50 c	9.50 c	13.50 c	9 c	9.50 c

From Table 3, it can be seen that the interaction between the type of light bulb (B) and time (W) treatments, namely B1W3, is significantly different from the treatments (B2W3), (B1W3), while the treatments (B1W1), (B2W3), and (B2W (2)) are not significant. The treatments (B1 W (1)), (B2 W (1)), and (B2 W (3)) are not significant. The treatments (B (3)W(1)), (B (3)W(2)), (B (3) W (3)), (B (4)W(1)), (B (4)W(2)), and (B (4)W(3)) are not significant. The highest number of flower buds in the treatment interaction (B(1) W(3))was 26, while the lowest was in treatment (B(4) W(2))at 9. The interaction of the three factors from the analysis of variance results was not significant, nor was the interaction of the two factors, distance (J) and time (W).

Number of dragon fruit flower

From the analysis of variance, the results of the mean-difference test for light intensity, distance, and time on the number of flowers at 4 MSA are shown in Table 4.

Table 4. Results of the analysis of variance of light intensity from various types of light bulbs, distances, and times on dragon fruit plants (*Hylocereus polyrhizus*) on the number of flowers at 4 MSA

	Single factor									
	Light bulb type				Illumination distance			Illumination time		
Treatment	B_1	B_2	B_3	B_4	J_1	J_2	J_3	W_1	W_2	W_3
Average	75.50 a	63 b	34.50 c	31 c	85 a	78.80 a	40.50 b	67 ab	77.50 a	59.50 b

Note: Numbers followed by the same letter in the same row or column indicate no significant difference at the 5% level

From Table 4, in the first single factor, namely the type of light bulb (B) treatment, there was a significant difference between (B1), (B2), and (B3), while there was no significant difference between (B3) and (B4). The highest number of flowers was observed in treatment (B (1)), with 75.5, while the lowest was in treatment (B (4)), with 31. In the second single factor, namely the lighting distance treatment (J), there was no significant difference between (J (1)) and (J (2)), but there was a significant difference with (J (3)). The highest number of flowers was in treatment (J (1)), namely 85, while the lowest was in treatment (J (3)), namely 40.5. In the third single factor, namely the lighting time treatment (W), there was no significant difference between (W2) is not significantly different from (W1) and is not significantly different from (W3) for the highest number of flower buds in treatment (W2), which is 77.5, while the lowest is in treatment (W3), which is 59.5.

From the analysis of variance for the interaction between bulb type and distance, the results of the mean-difference test for the number of flowers at 4 MSA are shown in Table 5.

Table 5. Interaction of the results of the mean difference test of light intensity analysis from various types of light bulbs and distance on dragon fruit plants (*Hylocereus polyrhizus) and* the number of flowers at 4 MSA

	Interaction factor: type of light bulb and irradiation distance											
Treatment	B_1J_1	B_1J_2	B_1J_3	$B_2 J_1$	$B_2 J_2$	$B_2 J_3$	$B_3 J_1$	$B_3 J_2$	$B_3 J_3$	$B_4 J_1$	$B_4 J_2$	$B_4 J_3$
Average	28 ab	35 a	12.50 c	26 b	25.50 b	11.50 c	15.50 c	10 c	9 c	15.50 c	8 c	7.50 c

From Table 5, it can be seen that the interaction between the type of light bulb (B) and distance (J) treatments, namely (B1 J2), is not significantly different from the (B1 J1) treatment and is not significantly different from the (B2J1) and (B2J1), while the treatment (B1J2) is significantly different from (B2J1), (B2J(1)), and (B2J(1)).In treatment (B(2)J(1)),(B(2)J(1)) was not significant, then the treatment was not significant in (B(1)J(3)),(B(2)J(3)),(B(3)J(1)),(B(3)J2), (B3J3), (B4 J1), (B4J2) and (B4J3). The highest number of flowers was found in treatment (B (1)J(2)) with 35 flowers, while the lowest number was found in treatment (B (4)J(3)) with 7.5 flowers. From the analysis of variance for the interaction between light bulb type and time, the results of the mean difference test for the number of flower buds at 4 MSA are shown in Table 6.

Table 6. Interaction of the results of the mean difference test of light intensity analysis from various types of light bulbs and Time on dragon fruit plants (*Hylocereus polyrhizus)* in relation to the number of flowers at 4 MSA

	Interaction factor of light bulb type with irradiation time											
Treatment	B_1W_1	B_1W_2	B_1W_3	B_2W_1	B_2W_2	B_2W_3	B_3W_1	B_3W_2	B_3W_3	B_4W_1	B_4W_2	B_4W_3
Average	24 b	24.50 b	27 a	18.50 c	29.50 a	15 c	12 d	13.50 cd	9 d	12.50 d	10 d	8.50 d

Note: Numbers followed by the same letter in the same row or column indicate no significant difference at the 5% level.

From Table 6, it can be seen that there is an interaction between the light bulb treatment (B) and Time (W). Treatment (B1 W3) is not significant with (B2 W2). and is significantly different in treatments (B1 W (2)) and (B1W1). The treatments (B (1) W (2)) and (B (1)W(1)) are not significant. Treatment (B(1) W(2))and (B(1)W(1))are not significantly different from treatment (B(2) W(1)), (B(2) W(3)), and are not significantly different from (B(2) W(3)).Treatment (B(2) W(3))is not significantly different from (B(4) W(1)).There is no significant difference in treatments (B(3)W(1)), (B(3)W(3))(B(4)W(1)),(B(4)W(2)),and (B(4)W(3)).The highest number of flowers in the treatment interaction (B(2) W(2))was 26, while the lowest was in treatment (B(4) W(3))at 8.5. The analysis of variance results showed no significant interaction between the two factors, distance (J) and time (W). From the analysis of variance for light intensity from various types of light bulbs, distance, and time, the mean difference test for the number of flowers at 4 MSA was significant, as shown in Table 7.

From Table 7, it can be seen that the interaction among the three factors—light intensity from various types of light bulbs, distance, and time —results in a significant effect. Treatment of light bulb type (B), distance (J), and time (W). Treatment.

Treatment (B1J1W3), (B1J2W1), (B1J2W2), (B2 J1 W2), (B2 J2 W2) were significantly different from the treatments, (B1J1W2), (B1J2W3), (B2J1W(1)), significantly different (B1J3W2), (B2J2W(1)), (B3J1W2), (B3J3W2), (B4J1W(2)), (B4J1W3), and significantly different (B3J1W(3)), (B3 J2 W2), (B3 J3 W1), (B3 J3 W3), (B4 J2 W1), (B4 J2 W2), (B4 J2 W3), (B4 J3 W2), (B4 J3 W3) are significantly different from treatments (B1 J3 W2), (B2 J2 W1), (B3 J1 W2), (B3 J3 W(2)), (B4 J1 W(2)), (B4J1 W3) and significantly different from treatments (B3 J1 W3), (B3 J2 W2), (B3 3J3 W1), (B3 J3 W3), (B4J2 W1), (B4 J2 W2), (B4 J2 W3), (B4 J3 W2), (B4J3 W3)while treatment (B1 J1 W2), (B1 J2 W3), (B2 J(1)W(1))are not significantly different from treatments (B(1)J(1)W(1)),(B(2)J(2)W(3)),(B(3)J(1)W(1)),(B(4)J(1)W(1)),as well as treatments (B1J3W2), (B2J2W1), (B3J1W2), (B3J3W(2)), (B4J1W(2)), (B(4)J(1)W(3)),are not significantly different from treatments (B(1)J(3)W(1)),(B(1)J(3)W(3)), (B(2)J(1)W(3)), (B(2)J(3)W(1)), (B2 J3 W2), (B2 J3 W3), (B3 J2 W1), (B3 J2 W3), (B4 J3 W1).The highest flower count from the interaction of these three factors was found in treatment (B(1)J(2)W(1))at 13.5, while the lowest was foundin treatment (B(4)J(3)W(3)) as 1.5.

Table 7. The results of the analysis of variance for the interaction of the three factors of light intensity from various types of light bulbs, distance, and time on dragon fruit plants (*Hylocereus polyrhizus*) on the number of flowers at 4 MSA

Treatment	Mean
B1 J1 W1	6.50 bc
B1 J1 W2	8.50 b
B1 J1 W3	13 a
B1 J2 W1	13.50 a
B1 J2 W2	11.50 a
B1 J2 W3	10 b
B1 J3 W1	4 cd
B1 J3 W2	4.50 c
B1 J3 W3	4 cd
B2 J1 W1	9 b
B2 J1 W2	13 a
B2 J1 W3	4 cd
B2 J2 W1	6 c
B2 J2 W2	12.50 a
B2 J2 W3	7 bc
B2 J3 W1	3.50 cd
B2 J3 W2	4 cd
B2 J3 W3	4 cd
B3 J1 W1	6.50 bc
B3 J1 W2	6 c
B3 J1 W3	3 d
B3 J2 W1	3.50 cd
B3 J2 W2	3 d
B3 J2 W3	3.50 cd
B3 J3 W1	2 d
B3 J3 W2	4.50 c
B3 J3 W3	2.50 d
B4 J1 W1	6.50 bc
B4 J1 W2	4.50 c
B4 J1 W3	4.50 c
B4 J2 W1	2.50 d
B4 J2 W2	3 d
B4 J2 W3	2.50 d
B4 J3 W1	3.50 cd
B4 J3 W2	2.50 d
B4 J3 W3	1.50 d

Note: Numbers followed by the same letter in the same row or column indicate no significant difference at the 5% level

Number of dragon fruit

From the results of the variance analysis, the average difference test for light intensity, bulb type, distance, and time on the number of fruits aged 6 MSA is shown in Table 8.

Table 8. Results of the mean difference test of light intensity analysis from various types of light bulbs, distance, and time on dragon fruit plants (*Hylocereus polyrhizus*) on the number of fruits aged 6 MSA

	Single factor									
	Light bulb type				Illumination distance			Illumination time		
Treatment	B_1	B_2	B_3	B_4	J_1	J_2	J_3	W_1	W_2	W_3
Average	78 a	59.50 b	33 c	36.50 c	92.50 a	76 a	38.05 b	67.50 a	77.50 a	62 a

Note: Numbers followed by the same letter in the same row or column indicate no significant difference at the 5% level.

From Table 8, in the first single factor, namely the type of light bulb (B) treatment, there was a significant difference between (B1), (B2), and (B3), while there was no significant difference between (B3) and (B4). The highest number of flowers was found in treatment (B (1)), which was 78, while the lowest was in treatment (B (4)), which was 36.5. In the second single factor, namely the lighting distance treatment (J), there was no significant difference between (J (1)) and (J (2)), but there was a significant difference with (J (3)). The highest number of flowers was found in treatment (J (1)) at 92.5, while the lowest was found in treatment (J (3)) at 38.5. In the third single factor, namely the lighting time treatment (W), there was no significant difference between treatments (W (1)), (W (2)), and (W (3)). The highest number of flower buds was in treatment (W (2)), which was 77.5, while the lowest was in treatment (W (3)), which was 62.

From Table 1, it can be seen that the effect of the type of light bulb, with the special dragon fruit light bulb treatment (J1), produced the highest number of flower buds, namely 9.56. For treatments (J1) and (J2), there was no significant difference, but there was a significant difference with treatments (J3). For the height of illumination at 150 cm (P (3)), the highest number of flower buds was 7.22, while for treatments (P (2)), (P (1)), and (P (3)), there was no significant difference. Overall, the highest number of flower buds was obtained in the combination of treatments J (1) P (3), namely 11.00 flower buds.

The results of the analysis of variance for the interaction between bulb type and distance, as well as the results of the mean-difference test for the number of flowers at 6 MSA, are shown in Table 9.

Table 9. Interaction of the results of the mean difference test of light intensity analysis from various types of light bulbs and Time on dragon fruit plants (*Hylocereus polyrhizus)* in relation to the number of flowers at 6 MSA

	Interaction factors between light bulb type and illumination distance											
Treatment	B_1J_1	B_1J_2	B_1J_3	$B_2 J_1$	$B_2 J_2$	$B_2 J_3$	$B_3 J_1$	$B_3 J_2$	$B_3 J_3$	$B_4 J_1$	$B_4 J_2$	$B_4 J_3$
Average	30.50 a	35.50 a	12 c	25.50 b	23.50 b	10.50 c	15 c	9 c	9 c	21.50 b	8 c	7 c

Note: Numbers followed by the same letter in the same row or column indicate no significant difference at the 5% level.

From Table 9, it can be seen that the interaction between the light bulb type (B) and distance (J) treatments (B1 J1) and (B1 J2) is not significant and is significantly different from the treatments (B2 J1), (B2 J2), (B4J1), and significantly different from treatments (B1J3), (B2J3), (B3J1), (B3J2), (B3J3), (B4J2), and (B4J (3)). In treatments (B2J1), (B2J(2)), and (B4J(1)), there is no significant difference.And treatments (B(1) J(3)),(B(2) J(3)),(B(3) J(1)),(B(3) J(2)),(B(3) J(3)),(B4J1), (B4J2), and (B4J3) were not significant.The highest number of fruits was found in treatment (B1J(2)), which was 35.5, while the lowest was found in treatment (B4J3), which was 7.

Light Intensity

From the variance analysis, the average difference test results for light intensity from various types of light bulbs, distances, and times at 2 MSA are shown in Table 10

Table 10. Results of the mean difference test of light intensity analysis of various types of light bulbs, distance, and time on dragon fruit plants (*Hylocereus polyrhizus)* on the light intensity level at 2 MSA

	Single factor									
	Light bulb type				Illumination distance			Lighting time		
Treatment	B_1	B_2	B_3	B_4	J_1	J_2	J_3	W_1	W_2	W_3
Average	3351.50 b	21900 a	1862 c	1750 c	22888 a	4017.50 b	1958.50 c	9638.50 a	9660.50 a	9565 a

Note: Numbers followed by the same letter in the same row or column indicate no significant difference at the 5% level.

From Table 10, in the first single factor, namely the type of light bulb (B) treatment, there was a significant difference between (B1), (B2), and (B3), while there was no significant difference between (B3) and (B4). The highest number of flower buds was observed in treatment (B (2)), with 21,900, while the lowest was in treatment (B (4)), with 1,750. In the second single factor, namely the irradiation distance (J), treatment. Treatment (J (1)) was significantly different from (J (2)) and significantly different from (J (3)) for the highest number of flower buds in treatment (J (1)), which was 22,888, while the lowest was in treatment (J (3)), which was 1,958.5. In the third single factor, namely the lighting time treatment (W), there was no significant difference between (W (1)), (W (2)), and (W (3)) for the highest intensity in treatment (W (2)), which was 9660.5, while the lowest was in treatment (W (1)), which was 9565.
From the analysis of variance for the interaction between light bulb type and distance, the results of the mean-difference test for intensity at 2 MSA are shown in Table 11.

Table 11. Interaction of the results of the mean difference test of light intensity analysis from various types of light bulbs and distance on dragon fruit plants (*Hylocereus polyrhizus)* for the number of intensity ages 2 MSA

	Interaction factor: type of light bulb with irradiation distance											
Treatment	B_1J_1	B_1J_2	B_1J_3	B_2J_1	B_2J_2	B_2J_3	B_3J_1	B_3J_2	B_3J_3	B_4J_1	B_4J_2	B_4J_3
Average	2512 b	551 d	288.50 d	17676.50 a	2873 b	1351 c	1431 c	280.50 d	150.50 e	1268.50 c	313 d	168.50 e

Note: Numbers followed by the same letter in the same row or column indicate no significant difference at the 5% level.

From Table 11, it can be seen that the interaction between the type of light bulb (B) and distance (J) treatments B2J1is significantly different from the treatments B2J2and B1J1is significantly different (B2J3), (B3J1), (B4 J2) and significantly different from (B1 J2), (B1J3), (B3J2), (B4J2) significantly different in treatment (B3J3),(B(4) J(3)),while treatments (B(1) J(1))and (B(2) J(2))are not significantly different, as are treatments (B(2) J(3)),(B(3) J(1)),and (B(3) J(1)).The treatments (B(1) J(2)),B(1) J(3)),(B(1) J(3)), (B(3) J(3)), and (B(4) J(1))were also not significant. The highest intensity value was observed in treatment (B(2) J(1)), which was 17,676.5, while the lowest intensity value was observed in treatment (B(3) J(3)), which was 150.5.

Discussion

According to variance analysis, the type of special dragon fruit lamp shows the highest value across all observed variables: the number of flower buds, flowers, and fruits obtained in sequence, namely LED lamps, special chicken farm lamps, and incandescent lamps. This indicates that the special dragon fruit plant lamp is similar to an LED lamp, differing only in the color of the emitted light. The dragon fruit lamp emits yellow light, while the LED light is white. Yellow light is similar to sunlight and produces a high-quality light spectrum. This light color has the potential to stimulate flowering and fruiting, as reported in the literature (Imansyah & Romansah, 2019; Syamsiah et al., 2022). Yellow light is less efficient for photosynthesis than red and blue light, but it plays an important role in regulating plant growth, including triggering flowering and fruiting, and helping to regulate circadian rhythms and photoperiodism. Although not as important for photosynthesis, yellow light plays a role in maintaining overall plant health and development, especially when combined with other colors of light.

Essentially, dragon fruit-specific lamps are similar to LED lamps, with the only difference being the color of light they emit. Dragon fruit special lamps produce a yellow color similar to sunlight, while LED lamps produce white light. Therefore, the color spectrum produced by LEDs and dragon fruit special lamps is highly dependent on the semiconductor materials used in the devices, and variations in these materials enable the manufacture of LEDs with different colors and light intensities. Additionally, LEDs can be produced with varying levels of efficiency and power, which affects the energy required to produce light of a given quality (Wibawa, n.d.). To produce light with a wavelength of approximately 450 to 500 nm, it emits shorter blue light. (Sabila et al., 2024).

The types of chicken farm and incandescent light bulbs do produce yellow light, but they do not function as yellow light. The yellow light produced by special chicken farms and incandescent light bulbs is used for energy or to generate heat, not to stimulate flowering and fertilization, so plants can dry out due to the heat generated by these sources. Incandescent bulbs used in chicken farms and for fruit trees yield very low results across all observation parameters. This is because incandescent bulbs can also be used for photosynthesis, but their light spectrum is still limited compared to LED bulbs and specialized dragon fruit bulbs. Consequently, the light requirements for dragon fruit plant development are not optimally met, as noted in the literature by (Jannah & Asran, 2023). Incandescent bulbs tend to generate more heat, are less energy efficient, and have a limited light spectrum. However, incandescent bulbs have a warm color temperature that can provide beneficial light for photosynthetic plants. Chicken farm bulbs and incandescent bulbs have low wavelengths, so they produce only high-energy heat, as stated by Campbell & Reece (2010). Light has wave properties, and the wavelengths that can affect plant biological activity are between 380 nm and 750 nm. The wavelength of light affects the energy received by plants for metabolism within the plant body; the longer the wavelength, the lower the energy, and conversely, the shorter the wavelength, the higher the energy.

For the single factor of light bulb type, according to the analysis of variance on the intensity observation variable, LED light bulbs have the highest intensity compared to dragon fruit light bulbs. The high intensity of LED lights does not mean they produce more buds, flowers, or fruits; rather, they support vegetative growth, namely the multiplication of shoots and branches. This is consistent with the literature (Saputri et al., 2025). In plant growth and development, light intensity plays a crucial role in supporting photosynthesis, respiration, and transpiration. Plants that receive sufficient sunlight tend to grow better because high light intensity maximizes photosynthetic rate. In addition, the effect of light is evident in changes in plant morphological characteristics, such as leaf shape and number, stem thickness, and plant height. The increase in the number of branches and new shoots indicates that the light produced is of high intensity, as photosynthesis is increasingly optimal, in accordance with the literature (Pantilu et al., 2012). If a plant receives low light intensity, its leaves will absorb less light. Low light intensity also causes the leaves on plants to be larger but thinner, the stomata to be larger, the layer on the epidermal cells to thin, and to have more leaves and intercellular spaces (Pantilu et al., 2012) and literature (Hutapea et al., 2023). Photosynthesis will be optimal if the leaves are the primary site. The more leaves there are, the more photosynthesis occurs, and higher light intensity is better than lower intensity. The increase in the vegetative phase of plants. The higher the light intensity, the faster photosynthesis will proceed.

According to variance analysis, the 100 cm irradiation distance has the highest value for all observed variables - namely, the number of flower buds, flowers, and fruits —followed by the 50 cm and 150 cm distances, respectively. In terms of lighting, to achieve optimal lighting, the distance between light sources must be equal because the nature of light from light bulbs is determined by unit area and time. The planting distance of dragon fruit is fundamental in determining the amount of light received. The further the distance of the light from the plant, the less light the plant receives, and vice versa. The closer the distance, the morelight the plant receives, which can dry it out; in this case, the time factor determines whether a plant will dry out. Based on the results of the analysis of variance, an optimal distance is required so that time is not a problem in increasing the number of flower buds, flowers, and fruits, which is in accordance with the literature (Satwiko, 2008). Conventionally, if a light source has an intensity of 1 candela and is placed at the center of a sphere with a radius of 1 meter, the inner surface of the sphere will receive a light flux of 1 lumen. The level of illumination on the surface of the sphere is 1 lumen per square meter, which is called lux. With the surface area of the sphere calculated as $4\pi r^2$ or approximately 12.57 square meters, a source with an intensity of 1 candela will emit a total of 12.57 lumens in all directions. Theoretically, light intensity will increase as light flux increases, but decrease as the angle of dispersion widens. For a single factor of the type of light bulb, according to the analysis of variance on the observed variable of intensity, it was obtained that the 50 cm illumination distance had the highest value, followed by the 100 cm and 150 cm illumination distances, which had the second and third highest values, respectively. It is clear that the closer the light source is to the plants, the higher the light intensity received, but this does not necessarily result in a high number of buds, flowers, and fruits, because this intensity is related to unit area and time.

For single factors in the variance analysis, it was found that irradiation times of 10, 20, and 30 days did not produce significant effects on the variables observed, namely the number of flower buds, number of fruits, and intensity. For the number of flowers, the variance analysis did not produce significant results. This shows that dragon fruit plants require light during both the vegetative and generative phases. In dragon fruit cultivation, light is essential for successful harvests. Dragon fruit plants are long-day plants that require at least 12 hours of light after sunrise to induce flowering. This is consistent with the literature (Setyawati, 2020). Dragon fruit plants, which have a morphology similar to cacti, are plants that require prolonged exposure to sunlight (long-day *plants)*, meaning that during the vegetative and generative phases, they require at least 12 hours of light or more. Light from light bulbs is an appropriate way to address light deficiency in dragon fruit cultivation. In the observation variable for the number of flowers, based on variance analysis, the results showed no significant difference among the lighting times of 10 days, 20 days, and 30 days. This was determined by the dragon fruit plant variety exhibiting photoperiodic activity, in accordance with the literature. Setyawati (2020) In plant physiology studies, lighting in plant cultivation to induce flowering and increase yield is related to flowering induction. Dragon fruit plants (*Hylocereus spp.*) are long-day plants, so flowering induction occurs during long days. This is related to photoperiodism. Photoperiodism is a phenomenon in various plant species in which the length of the day determines whether the apical/lateral meristem forms flowers. For the observation variable

For the two interacting factors, namely the intensity of the light bulb type and the distance [of illumination in the treatment found in treatment (B1J2) on the observed variables of the number of flower buds, number of flowers, and number of fruits, it is clear that special dragon fruit light bulbs, namely LED light bulbs that emit yellow light, are essential for dragon fruit cultivation during the generative phase. The distance of these light bulbs from the dragon fruit plants is 100 m, which is in line with the spacing of dragon fruit plants, so that the required light can spread evenly. all of which has been explained in the single factor of the type of light bulb and the distance of light exposure on dragon fruit plants. For the two interacting factors — light bulb type, intensity, and lighting distance in the treatment (B2J1) — the observed variable is intensity. It is clear that white LED light bulbs have high light intensity at 50 cm. High light intensity is required during the vegetative phase, while lower intensity is needed during the generative phase, as high intensity can cause dragon fruit buds and flowers to fall off due to low humidity and excessive water requirements during the flowering process, which can fail due to excessive transpiration. This is in accordance with the literature

Plant growth is greatly influenced by temperature and humidity. If the environmental humidity is outside the normal range, plant growth will be disrupted. Each plant group requires different levels of air humidity for optimal development. The ideal humidity for plant growth is around 60% to 80%. Air temperature affects plant life activities, including photosynthesis, respiration, transpiration, growth, pollination, fertilization, and fruit drop. The extent of this temperature effect is influenced by other factors, such as humidity and water availability.

For the two interacting factors, light bulb intensity and exposure time in treatment (B1 W (3)), the highest value was observed in the number of flower buds, whereas in treatment (B2W2), the highest value was observed in the number of flowers. The results of the analysis of variance show that, with special dragon fruit light bulbs that produce yellow light at lower intensity, 30 days of lighting are required, whereas with LED lights that emit white light, 20 days are required. This proves that, for special dragon fruit light bulbs, producing more flower buds requires a lower light intensity; if the intensity is high, then 20 days of lighting are sufficient, 20 days of irradiation to prevent the flowers from falling off, as explained above.

For the three interacting factors —light bulb type, irradiation distance, and irradiation time in the treatment (B1J2W1) — the highest value was observed for the number of flowers. From the analysis of variance, the highest number of flowers will occur with special dragon fruit light bulbs, a distance of 100 cm, and 10 days of irradiation. This is proven by the fact that the special dragon fruit light bulb emits yellow light with low intensity and has an irradiation distance that is suitable for dragon fruit plants with an irradiation time of 10 days, meaning that the highest results were observed at 4 MSA. because the observation started from 2 MSA to 4 MSA, the exposure time was increased by another 10 days, so the flower yield became higher. If the exposure time were increased by another 10 days, the flowers would dry out, wilt, and fall off due to a lack of water. This aligns with the results of the variance analysis, which indicate that the number of fruits at 6 MSA is not significantly different, meaning that dragon fruit plants have sufficient time with 20 days of light exposure in dragon fruit cultivation.

Conclusion

Based on the research results, several conclusions: (1) The dragon fruit-specific light bulb showed significantly different results compared to other light bulb types and had the highest values for the observed variables of number of flower buds, number of flowers, and number of fruits. (2) For the observed variable of Light Intensity, the highest light bulb was obtained from the LED bulb type, namely 21,900 lux. (3) For the observed variable of number of flowers, the B1J2W1 treatment had the highest interaction value = 13.5 and was significantly different from the other interactions. (4) For the distance treatment, the 100 cm distance treatment had the highest value for the number of flower buds, J2 = 72.5 flowers. (5) For the observed variable of light treatment, there was no significant difference between 10 days, 20 days, and 30 days, except for the observed variable of number of flowers, which had the highest value, W2 = 77 flowers.

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Author Contributions
S.H: Developing ideas, overseeing data collection, data analyzing, writing, reviewing, responding to reviewers comments, overseeing data collection, reviewing scripts.

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The authors declare no conflict of interest.

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