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The Effect of LED Light Intensity and Types of Planting Media on the Growth and Yield of Basil Plants (*Ocimum basilicum* L.) Indoor Hydroponic Wick System

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Abstract

Background: Basil plants (*Ocimum basilicum* L.) have a distinctive mint-like aroma and a fresh taste, but their cultivation and agricultural land are increasingly limited. This problem can be overcome by indoor hydroponic cultivation using artificial lights. The study was conducted in a house on Jl. Ngagel Rejo Utara No. 24, Surabaya City, East Java, from October to November 2022, using artificial LED light installations in a closed room. **Method:** This study is a factorial experiment arranged using a Split Plot Design (RPT) consisting of two factors and repeated three times. The first factor is the intensity of LED light (C) as the main plot consisting of 4 treatment levels, namely 1,500 lux (C1), 1,700 lux (C2), 2,000 lux (C3), 2,200 lux (C4) and the second factor is the type of planting media (M) as a sub-plot consisting of 3 treatment levels, namely rice husk charcoal (M1), cocopeat (M2), Rockwool (M3). **Results:** The results of the study showed that the combination of light intensity treatment of 2,200 lux and the type of Rockwool planting media was able to increase the parameters of plant height, number of leaves, wet stubble weight, dry stubble weight, and volume of nutrient absorption by plants. **Conclusion:** The combination of light intensity treatment of 2,200 lux and Rockwool planting media is the best combination for the parameters of plant height, number of leaves, wet stubble weight, dry stubble weight, and volume of nutrient absorption of basil plants (*Ocimum basilicum* L.) indoor hydroponic wick system.

Keywords: Light intensity; Types of planting media; Basil plants

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Introduction

Basil (*Ocimum basilicum* L.), nicknamed the Queen of Herbs, is a seasonal plant with high economic value and a distinctive aroma like mint and a fresh taste. Some other properties of basil are that it can eliminate body odor and bad breath, stimulate central nervous system activity, dilate capillaries, strengthen the liver, stimulate immune factors, stimulate breast milk, dilate blood vessels, prevent infertility, and many more (Hariana, 2013). Basil plants can grow well in both lowlands and highlands. Basil plants can be used as vegetables, salads, and cooking flavorings (Almanac, 2020).

Light intensity is closely related to the growth and yield of basil plants. Light intensity (luminous intensity) is the strength of light emitted by a light source in a specific direction measured by Candela. The high and low light intensity affects the rate of photosynthesis. Plants with low light intensity cause active chlorophyll to become less, so photosynthesis results decrease (Lindawati, 2015).On the other hand, high light intensity causes activated chlorophyll to increase, increasing photosynthesis results. This can affect the plant growth process. One effort to increase plant light intensity is by using LED lights. LED lights here act as a light source replacing sunlight for indoor agricultural plants for photosynthesis because of their relatively small size, long durability, specific wavelength, and efficiency in

producing photosynthetic active radiation at a lower cost (Limaje, 2019). Indoor farming allows plant cultivation to be carried out vertically or hydroponically, considering that light requirements can be met by adding LED lights because their wavelengths are included in visible light (ƛ = 400 - 700 µm) (Hosfelt, 2018).

Hydroponics is a technique of growing plants without soil media but with nutrients dissolved in water (Istiqomah, 2016). Hydroponics is one alternative that can be used to increase plant productivity, especially in narrow areas (Siswandi, 2017). Hydroponic plant cultivation can be done in narrow spaces outside or inside the house, such as the yard, kitchen, and garage. The advantages of hydroponic farming are that plant cleanliness is easier to maintain. There is no need to process land and control weeds, sterile planting media, the use of water and fertilizer is very efficient, plants can be cultivated continuously without depending on the season, can be done on narrow land, and protected from rain and direct sunlight (Silvina, 2018).

Hydroponics can use a wick system, namely a hydroponic method that utilizes the principle of water capillarity, the nutrient solution from the reservoir to the plant roots in the upper position through a wick or cloth that is easy to absorb water (Hendra & Andoko, 2014). The wick system is one of the easiest and simplest hydroponic systems in terms of cost and maintenance. The role of the wick is used as a means of connecting the nutrient solution and the planting medium as a place for plant roots to grow; the nutrient solution can rise due to the capillary force of the wick, in this case, does not require a pump that requires electricity and tends to be more expensive (Aini & Azizah, 2018).

A suitable planting medium can support the growth and life of plants. Supporting the success of the hydroponic cultivation system is a porous medium with good aeration and sufficient nutrients for plant growth. According to Perwatasari (2015), in his research, Rockwool planting media with grow light showed the best Height and fresh weight parameters in hydroponic pak choi plants compared to other treatments. Therefore, this study aims to develop and determine how much influence the intensity of LED light and the type of planting media are best on the growth and yield of basil plants (*Ocimum basilicum* L.) indoor hydroponic wick system.

Method

Time and Location of the Research

This research was conducted at Jl. Ngagel Rejo Utara No. 24, Surabaya City, East Java. The implementation time is October-November 2022.

Tools and Materials

The tools used in this study include experimental installation racks, LED TL (Tube Lamp) lamps, scissors, solder, black tape, test pens, trim saws, measuring cups, flat screwdrivers, spectrophotometers, lux meters, computers, ImageJ software, Thermino Spectrophotometer Software, hygrometers, thermometers, nutrient containers, net pots, TDS meters, PH meters, and rulers. The materials used include basil plant seeds of the Genovese variety, AB mix hydroponic nutrients for leafy vegetables, pH up (Potassium Hydroxide), pH down (Phosphoric Acid), water, Rockwool, Rice Husk Charcoal, Cocopeat, flannel cloth, labels, and yellow traps.

Type of Research

This research is a factorial experiment arranged using a Split Plot Design (RPT) consisting of two treatment factors: LED light intensity as the main plot and the planting media as a subplot. LED light intensity (C) consists of 4 treatment levels, namely 1,500 lux (C1), 1,700 lux (C2), 2,000 lux (C3), 2,200 lux (C4), and the planting media (M) consisting of 3 treatment levels, namely rice husk charcoal (M1), cocopeat (M2), rockwood (M3). For treatment factors with each predetermined level, 12 treatment combinations were obtained and repeated three times so that 36 experimental units were obtained. Each experimental unit consisted of three plants, with 108 experimental plants.

Working Procedure

1. Shelf Preparation and Lamp Installation

The experimental shelf for each treatment measures 360 x 60 x 120 cm (Length x Width x Height). The top arrangement is 2, and the bottom is 2, with each arrangement containing nine repetitions and each repetition containing three plant samples so that each shelf arrangement contains 27 plants placed in a 10 cm jar. Then, the distance between the labels is adjusted to the recommended distance of plants from the basil plant, which is 12 cm per plant. The lamp is installed at the top of the plant at a 90^{o} angle, aiming to resemble the direction of the incoming sunlight. The lamp used is the LED TL (Tube Lamp) type. The planting medium is arranged based on the experimental plan, and its placement is according to each treatment.

2. Preparation of Nutrients and Nutrient Containers

Fertilization in hydroponic cultivation is called nutrient administration. The nutrients commonly used by hydroponic farmers are AB-mix nutrients. The nutrient solution is given every three days in the morning between 06:30 and 09:00. The solution is stirred every day to meet the dissolved oxygen levels needed by the plants. The initial nutrients given are 450 ml in a jar container; along with the plant's growth, the nutrients will decrease due to plant absorption and evaporation. The addition of nutrients needs to be done to maintain the availability of plant nutrients in the container. The addition of nutrients is done until the volume in the jar reaches 450 ml every three days. Plant nutrients are monitored with PPM criteria of 1200 - 1500 and pH 5.5 - 7.

3. Planting

Genovese basil seeds are sown first for two weeks with Rockwool planting media that has been cut with a distance between planting holes measuring 2 × 2 cm with a hole depth of about 0.5 cm, also sown in rice husk charcoal and cocopeat planting media in net pots with a diameter of 2 cm and have been given flannel as a wick and then placed in a plastic tray that has been filled with Aquadest. The seeds sown are 108 seeds. The criteria for seedlings ready for planting include basil seeds that have germinated and have a pair of perfect leaves or more and are homogeneous, then transferred into a jar of nutrient containers that have been provided.

4. Harvesting

Harvesting of basil plants is carried out when the plants have mature leaves that have opened perfectly, namely when the plants are 40 days after planting (DAP) or when their Height is around 12-20 cm. Harvesting is done by cutting the leaf tips to the leaf axils. The basil harvesting technique is carried out manually by taking the best plant leaves with the criteria of being fresh green, not being attacked by pests or diseases, and having broad leaves.

Data Analysis

Plant observation parameters include plant height, number of leaves, wet stubble weight, dry stubble weight, and plant nutrient absorption volume. Data analysis used includes ANOVA analysis of variance. Suppose the combination of treatments has a significant effect, or the calculated F value is greater than the F table value at a significance level of 5%. In that case, further testing will be carried out with the Honestly Significant Difference (HSD) test at a level of 5%.

Result

Plant Height

The results of basil plant height growth in combination with light intensity and types of planting media at 10, 15, 20, and 25 HST are presented in Table 1.

Table 1. Average Height of Basil Plants at 10-25 HST Combination of Light Intensity Treatment and Types of Planting Media

Average Height of Basil Plants (cm)				
Age	**Planting Media (lux)**	**Planting Media**		
		Husk Charcoal	**Cocopeat**	**Rockwool**
10 HST	1.500	2,22a	2,44ab	2,72ab
	1.700	3,06b	3,17b	3,44bc
	2.000	3,94c	4,00c	4,06c
	2.200	4,44cd	4,56cd	4,72d
	BNJ 5%		0,63	
15 HST	1.500	4,89a	5,00a	5,22a
	1.700	5,44ab	6,00b	6,44b
	2.000	6,44b	7,22c	7,56c
	2.200	7,78c	7,78c	7,89c
	BNJ 5%		0,71	
20 HST	1.500	9,11a	9,44ab	9,56ab
	1.700	9,78ab	9,89ab	10,22b
	2.000	11,11bc	11,33c	12,00cd
	2.200	12,33d	12,33d	12,67d
	BNJ 5%		0,92	
25 HST	1.500	12,22a	12,33ab	12,78ab
	1.700	12,78ab	13,11ab	13,33ab
	2.000	13,78b	14,00b	16,78c
	2.200	17,44cd	17,89cd	18,67d
	BNJ 5%		**1,51**	

Description: Numbers followed by the same letter at the same observation age show no significant difference in the 5% BNJ test.

Average results of basil plant height at the age of 10-25 HST Table 1. It is known that the combination of LED light intensity treatment of 2,200 lux with Rockwool planting media produces the highest plant height at the age of 10-25 HST and is significantly different from other treatment combinations, except for the LED light intensity treatment of 2,200 lux on various planting media (rice husk charcoal and cocopeat).

Number of Leaves

The results of the number of basil plant leaves in the combination of light intensity and types of planting media at the ages of 15 and 25 HST are presented in Table 2.

Table 2. Average Number of Basil Plant Leaves Combination of Light Intensity Treatment and Types of Planting Media at the ages of 15 and 25 HST

Average Number of Basil Plant Leaves (strands)				
Age	**Light Intensity (Lux)**	**Planting Media**		
		Husk Charcoal	**Cocopeat**	**Rockwool**
15 HST	1.500	2,89a	3,11a	3,22a
	1.700	3,89ab	4,00ab	4,22ab
	2.000	4,45ab	4,89b	5,56b
	2.200	5,56b	7,33c	9,33d
	BNJ 5%		**1,57**	
25 HST	1.500	7,38a	9,34a	10,00a
	1.700	10,33ab	12,00ab	12,22ab
	2.000	14,89ab	18,11b	24,33bc
	2.200	31,33c	34,67cd	41,11d
	BNJ 5%		**7,95**	

Description: Numbers followed by the same letter at the same observation age show no significant difference in the 5% BNJ test.

The average number of basil plant leaves at the ages of 15 and 25 HST Table 2. It is known that the combination of LED light intensity treatment of 2,200 lux with Rockwool planting media produces the highest number of leaves at 15 and 25 HST. However, at the age of 15 HST, it was significantly different from other treatment combinations. In comparison,

at the age of 25 HST, the combination of LED light intensity treatment of 2,200 lux and Rockwool planting media was significantly different from other treatment combinations, except for the combination of LED light intensity treatment of 2,200 lux and cocopeat planting media.

Wet Stork Weight

The results of the wet stork weight of basil plants treated with a combination of light intensity and types of planting media at the ages of 15 and 25 HST are presented in Table 3.

Table 3. Average Wet Stork Weight of Basil Plants Treatment Combination of Light Intensity and Types of Planting Media at the age of 25 HST

Average Wet Struct Weight of Basil Plants (gr)				
Age	**Light Intensity (Lux)**	**Planting Media**		
		Husk Charcoal	**Cocopeat**	**Rockwool**
25 HST	1.500	12,54a	13,86a	14,86a
	1.700	18,70b	21,65bc	21,82bc
	2.000	22,30bc	23,83c	24,93cd
	2.200	25,37cd	25,91cd	27,97d
	BNJ 5%		**3,68**	

Description: Numbers followed by the same letter indicate no significant difference in the 5% BNJ test.

Based on Table 3. it is known that the combination of LED light intensity treatment of 2,200 lux and Rockwool planting media produces the highest wet stover weight and is significantly different from other treatment combinations except for the combination of LED light intensity treatment of 2,000 lux and Rockwool planting media, as well as the combination of LED light intensity treatment of 2,200 lux with various types of rice husk charcoal and cocopeat planting media.

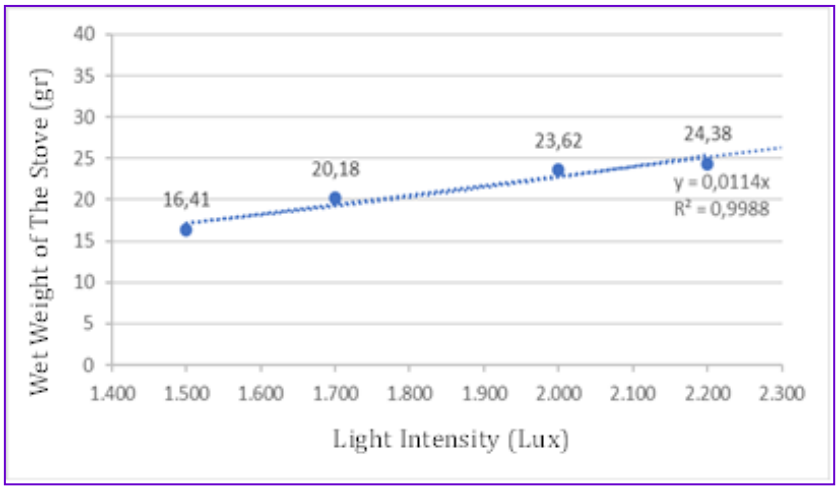

Figure 1. Wet Stork Weight Graph and LED Light Intensity

The wet stork weight graph and LED light intensity treatment can be seen in Figure 1. The resulting linear regression equation is y = 0.0114x. This equation shows a positive relationship between LED light intensity and the wet stork weight of basil plants. This positive relationship indicates that the greater the LED light intensity, the greater the wet stork weight produced.

Dry Stork Weight

The results of the wet stork weight of basil plants treated with a combination of light intensity and types of planting media at 15 and 25 HST are presented in Table 4.

Table 4. Average Dry Stork Weight of Basil Plants Treated with a Combination of Light Intensity and Types of Planting Media at 25 HST

Average Dry Struct Weight of Basil Plants (gr)				
Age	**Light Intensity (Lux)**	**Planting Media**		
		Husk Charcoal	**Cocopeat**	**Rockwool**
25 HST	1.500	1,11a	1,49b	1,62b
	1.700	1,68b	1,71b	1,91bc
	2.000	2,25c	2,28cd	2,32cd
	2.200	2,41cd	2,45cd	2,63d
	BNJ 5%		0,36	

Description: Numbers followed by the same letter indicate no significant difference in the 5% BNJ test.

Based on Table 4. it is known that the combination of LED light intensity treatment of 2,200 lux and Rockwool planting media produces the highest dry stover weight and is significantly different from other treatment combinations except for the combination of LED light intensity treatment of 2,000 lux and cocopeat or Rockwool planting media, and the combination of LED light intensity treatment of 2,200 lux with rice husk charcoal or cocopeat planting media.

Plant Nutrient Absorption Volume

Table 5. presents the results of the volume of nutrient absorption of basil plants treated with a combination of light intensity and planting media at the ages of 15 and 25 HST.

Table 5. Average Volume of Nutrient Absorption of Basil Plants Treatment of Combination of Light Intensity and Types of Planting Media at the ages of 21 and 24 HST

Average Volume of Nutrient Absorption of Basil Plants (ml)				
Age	**Light Intensity (Lux)**	**Planting Media**		
		Husk Charcoal	**Cocopeat**	**Rockwool**
21 HST	1.500	9,45a	14,50ab	15,12ab
	1.700	17,01ab	18,28ab	18,28ab
	2.000	18,91ab	19,54ab	20,80ab
	2.200	25,21b	24,58b	46,64c
	BNJ 5%		10,59	
24 HST	1.500	18,28a	19,54ab	19,54ab
	1.700	22,69ab	23,95ab	23,95ab
	2.000	25,84ab	27,10b	27,73b
	2.200	29,62b	30,88b	48,53c
	BNJ 5%		8,48	

Description: Numbers followed by the same letter in the same observation age show no significant difference in the 5% BNJ test.

Based on Table 5. it is known that the combination of LED light intensity treatment of 2,200 lux and Rockwool planting media aged 21 and 24 HST produced the highest volume of basil plant nutrient absorption and significantly differed from other treatment combinations.

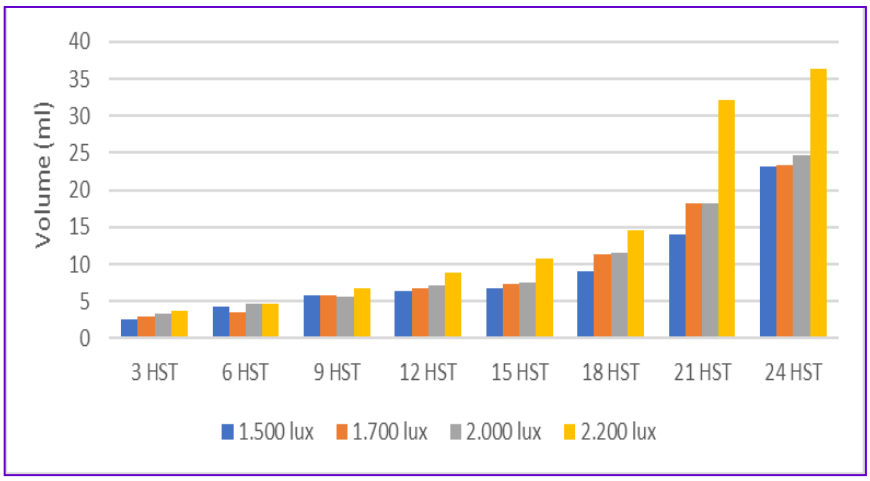

Figure 2. Histogram of Nutrient Absorption Volume by the Effect of LED Light Intensity

The addition of nutrient absorption volume of basil plants aged 3 HST – 24 HST in the LED light intensity treatment can be seen in Figure 2. The best addition rate is shown by the LED light intensity treatment of 2,200 lux, followed by the LED light intensity treatment of 2,000 lux, 1,700 lux, and 1,500 lux.

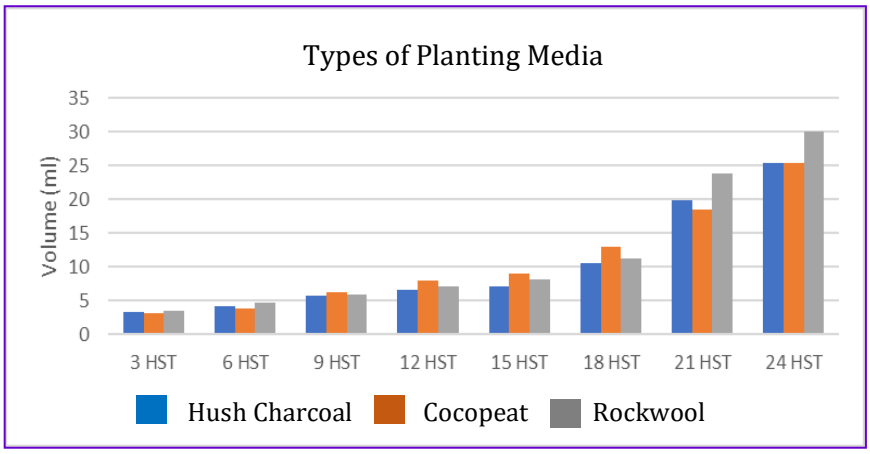

Figure 3. Histogram of Nutrient Absorption Volume

The addition of nutrient absorption volume of basil plants aged 3 HST – 24 HST in the treatment of various planting media can be seen in Figure 3. The Rockwool planting media treatment shows the best addition rate, followed by the cocopeat and husk charcoal planting media.

Discussions

The best combination of treatments for basil plant growth is shown by the LED light intensity of 2,200 lux and Rockwool planting media. This is because the LED light intensity of 2,200 lux is sufficient to increase the rate of plant photosynthesis based on the harvest criteria where the basil has reached a height of 12 cm. Thus, the photosynthate produced can support the growth of basil plants, such as plant height, number of leaves, wet stalk weight, dry stalk weight, and the volume of nutrient absorption of basil plants (Sondang & Elita., 2020). In addition, the planting media can continuously provide various nutrients that basil plants can absorb directly; thus, basil plants' nutritional needs are met.

Previous studies have found that light controls plant growth and development through photosynthesis, including in the vegetative phase (Raharjeng, 2015; Rosa, 2017). Carbohydrates produced during photosynthesis are used for the formation of plant organs so that they can provide maximum results for plant growth. This statement is supported by Putri (2016), who stated that the increase in the rate of photosynthesis has been proven to increase plant growth and development. The availability of sufficient light can help the

photosynthesis process properly so that the provision of LED light intensity of 2000 lux can support the growth of hydroponic basil plants compared to the provision below 2000 lux in plant physiology. According to Rosa & Bustami (2017), plants need nutrients and light, essential materials for photosynthesis in the vegetative phase. Photosynthate produced from photosynthesis is used to form flowers and fruit in plants.

There was an increase in the number of leaves in the combination treatment of light intensity of 2,200 lux and Rockwool planting media in Table 2. due to the rate of photosynthesis and the photosynthate produced. According to Hamim's (2018) research, the more light energy is converted into chemical energy, the higher the photosynthate produced for forming leaves and other organs. In addition, providing AB-mix fertilizer to basil plants through rockwool planting media can meet the plant's nutrient needs. Rockwool planting media has advantages, including quickly absorbing nutrients in the initial nursery process (Warman, Syawaluddin, 2016).

The wet and dry weight parameters in Tables 4 and 5 show an increase because the provision of LED light intensity to basil plants with planting media for a specific time affects the fresh weight of the plant. According to Lingga & Marsono (2017), wet weight and dry weight indicate the results of the growth and development process; damp weight is the result of the accumulation of materials produced by plants during growth, while dry weight is the result of the net accumulation of CO2 assimilation during the growth period. This is by Buntoro & Rogomulyo (2014) that plants that receive more light will have broader leaves. An increase in the value of leaf area will cause the assimilation rate to increase and produce high wet and dry weights. This shows the accumulation of organic compounds that plants have successfully synthesized from inorganic compounds, especially CO2 and H2O (Susila AD, 2014).

The volume of nutrient absorption of basil plants shows the best treatment in the combination of LED light intensity of 2,200 lux and Rockwool planting media. This is because the process of water absorption by the roots is related to the transpiration process. Transpiration is a process of water loss from within the plant that evaporates through stomata, cuticle holes, and lenticels (Hafizh Bahzar & Santosa, 2018). Water lost through transpiration is replaced by water absorbed through the roots.

The combination treatment of LED light intensity 2,200 with Rockwool planting media shows that the amount of light energy produced is more incredible, resulting in a high plant transpiration rate. Hence, the rate of nutrient absorption by plant roots is also high. Rockwool planting media with high absorption capacity can increase water absorption by plant roots (Ramadhan., H., Ahmad T., Diding S., 2015). LED light's intensity significantly affects nutrient absorption volume parameters (Table 5) caused by plant transpiration. The addition of the volume of nutrient absorption of basil plants at the age of 3–24 HST (Figure 2 & Figure 3) shows that the higher the intensity of LED light, the greater the need for the nutrient solution and the larger the basil plant, the greater the need for the nutrient solution.

Conclusions

The combination of light intensity treatment of 2,200 lux and Rockwool planting media is the best combination for the parameters of plant height, number of leaves, wet stalk weight, dry stalk weight, and nutrient absorption volume of basil plants (*Ocimum basilicum* L.) in indoor hydroponic wick system.

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Declaration statement

The authors reported no potential conflict of interest.

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