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Variations of Growing Media and Light Emitting Diode (LED) Colors in Red Spinach Microgreens

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A R T I C L E I N F O

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A B S T R A C T

Microgreens have higher nutrition than mature plants. Microgreens are popular for garnishing dishes and are a choice for those living a healthy life. Red spinach microgreens are preferred and contain many vitamins. The type of the growing media used will influence the growth of microgreens. Growing media can vary in texture, nutrient, and mineral content. Lighting also required by microgreens may require choosing the right type of LED light color because generally microgreen cultivation is indoor. The aims of this research is to determine the growth of red spinach microgreens on various types of growing media and on several types of LED colors. The result showed that, the best results for germination, plant height, and number of leaves are red and blue LEDs on all media, while for the best fresh weight using red LEDs on sand-compost media.

INTRODUCTION

The little form of vegetables known as microgreens rise in poplarity in Indonesia recently. It can be from any different plant species (Nurwahyudin & Rintyarna, 2023). Microgreens are popular because their nutritional content is much higher than mature vegetables. Based on Xiao *et al*. (2016), nutrient density in microgreen exceeds 40 times than mature leaves. Apart from their nutritional content, microgreens have a unique taste and crunchy texture and are generally used to enhance dishes and garnishes. Microgreens are a choice for those who live healthy lives. Cultivating microgreens is relatively easy and can be done in small areas of land, even indoors. This makes microgreen cultivation an ideal alternative for urban communities.

Red spinach microgreens are preferred (Senevirathne et al., 2019). Red spinach microgreens are high in beta-carotene, vitamin C, vitamin K, vitamin E, and others (Manurung, 2021). Red spinach also contains anthocyanin, a purplish red pigment that acts as an antioxidant (Lingga, 2012). Ghoora et al. (2020) have found that microgreens contain low oxalate levels, a compound that can disturb nutrient content in vegetables. Using ten species of vegetables, it was also reported that all microgreens in the research, including spinach, have 2 to 3.5 nutrient-dense compared to mature spinach leaves. The benefit of microgreens then will depend on cultivation technology. One of them is urban farming. The microgreens get their hygienic image and proper handling in a modern way. Thus, this narrow land technology may save place (Sulistyo et al., 2023), resources such as water (Rufí-Salís et al. 2020), and time (Tan et al., 2020).

Cultivating microgreens is the process of planting vegetable seeds and harvesting them at the early stages of growth, when the cotyledons (embryo leaves) and first leaves appear. In the cultivation process, seeds are sown in the planting medium, then watered and kept moist. Choosing the right planting medium can also influence the growth of microgreens. Based on Wijaya et al. (2020), good growth requires a medium that is equipped with the elements that plants need. Sriwahyuni (2021) added that in cultivating microgreens, the type and nature of the growing media used will influence the availability of nutrients and water for the growth of microgreens. Growing media can vary in texture, nutrient, and mineral content. For example, compost's humid, solid-like texture may look the same but have different nutrient content depending on the origin, what kind of animal, or what part of a plant. Mixed cow dung and leaf litter may contain less nitrogen and potassium than mixed chicken manure and leaf litter (Sofa et al., 2022). Sandy media has a dry and porous texture and also lacks nutrients. The structure has a low capability for water retention (Huang & Hartemink, 2020).

Plants also need appropriate light as sunlight. Urban farming techniques provide more ways to imitate sunlight by using lamps. The light from the lamp can be manipulated according to the refracted light from the sun, for example red, blue, green, and yellow light. Light-emitting diode (LED) for electrical has the advantage of being more energy efficient than tungsten filament lamps (Schade et al., 2015) and better affecting the results of secondary metabolites produced by plants (Lee et al., 2022).

Microgreens are plants that are cultivated indoors, their need for sunlight can be manipulated using LED lights. However, plant physiological processes such as photosynthesis, transpiration, and respiration really require the appropriate color of light (Lutfi et al., 2022). Red and blue light reported have a positive impact on photosynthesis activities (Dou et al., 2017). Ikarwati et al. (2020) stated that the lighting required by microgreens may require time and choosing the right type of LED light color because generally microgreen cultivation is in a room that is not exposed to sunlight. This research aims to determine the growth of red spinach microgreens on various types of growing media and on several types of LED colors.

METHODS

Location and Time

This research was conducted in May-June 2024 at the Plant Breeding and Biometrics Laboratory, Faculty of Agriculture, Jember University.

Material and Tools

The tools used in this research were plastic containers, rulers, scales, sprayers, and blue, red, yellow, and green LED lights, while the materials needed were compost, sand, husk charcoal, and red spinach seeds. Variation the LED lights used, namely; red, yellow, blue, and green light.

Method of Collecting Data

Microgreens growing in this research follow the following steps: Pesticide-free red spinach seeds were utilized. Planting involves preparing a sterile container, adding the growing medium that is appropriate for the treatments, evenly spreading the seeds over the medium, and then covering the seeds with a thin layer of growing medium. Maintenance: For several days, the seed container is placed under an LED lamp according to the treatment. Microgreens are harvested in 14 days.

The type of this research is experimental and modeling. Plants in containers are placed on shelves in a room where each partition is lit. There are 5 types of lighting, room light as a controller, red LED, blue LED, yellow LED and green LED. Each partition consists of 4 containers, each containing a different growing medium, namely P1 (sand); P2 (sand + husk charcoal); P3 (husk charcoal); P4 (sand + compost). Each container contains 150 plants. A total of 30 plants were observed every 2 days.

Data Analysis

The quantitative data analysis method uses descriptive analysis techniques, namely describing the results of the data collected as they are through statistical measures. Data graphs were produced using Microsoft Excel.

RESULTS AND DISCUSSIONS

Plant growth is influenced by metabolic activities, one of which is photosynthesis. This process involves various complex reactions at the organ, tissue, and cellular levels. Under normal conditions using sunlight, at a wavelength of 400 nm - 700 nm as photosynthetically active radiation (Anindito et al., 2018), the water used in the process undergoes photolysis in the light dependent reaction to produce ATP, NADPH, and by-products in the form of O_2. The results of the study showed that using various LED colors as shown in **Fig 1.** produced the best average plant height with blue LEDs with various growing media, followed by red LEDs with the best media using rice husk charcoal. The results of this study are in line with research conducted by Lu (2021), where red and blue light can be absorbed by plants at once. This is influenced by photoreceptors that capture photons from various LED color light intensities. Chlorophyll and carotene absorb only 20-30% of green light at a time. However, chlorophyll is the most abundant pigment in plants. Absorption of red and blue light occurs directly in the part of the leaf that is exposed to light while green light penetrates deeper into the leaf. The incoming yellow and green light is reflected by the plant but if it is forwarded back to the plant, it will be continued in the process of photosynthesis (Musdarina et al., 2019).

Both light-dependent reaction and light-independent reaction process that occur in plants involves the role of stomata activity that can open and close at a certain intensity. Based on research by Roni et al. (2017), the blue LED stimulates the stomata to open more, followed by red LEDs, then white LEDs. The response is intended for the exchange of O_2 and CO_2 that occurs in photosynthesis. If O_2 is produced in the light-dependent reaction, then CO_2 is needed in the light-independent reaction (Calvin Cycle) which will eventually form glucose. This glucose formation process will occur continuously so that the stroma space in the chloroplast will be filled with starch. then the starch will be distributed to the vacuole as a food reserve (Merida & Fettke, 2021). The next process will involve the work of the mitochondrial organelle in producing energy through the conversion of glucose, known as cellular respiration. This energy is needed in plant growth. In the case of microgreens, the energy needed is fully used in vegetative growth. That is why red and blue LEDs have a direct effect on germination (**Fig 3**), plant height (**Fig 1**), and number of leaves (**Fig 2**). Meanwhile, green LEDs only show their effect in terms of the fresh weight (**Fig 4**) of microgreens, because in reality green light is still absorbed by plants and contributes a lot to the formation of starch because of the many chlorophyll receptors after the number of leaves increases. Although in this study green LEDs showed fewer leaves compared to other LED light treatments. However, overall the best average production response was achieved when irradiated with red LEDs and yellow LEDs.

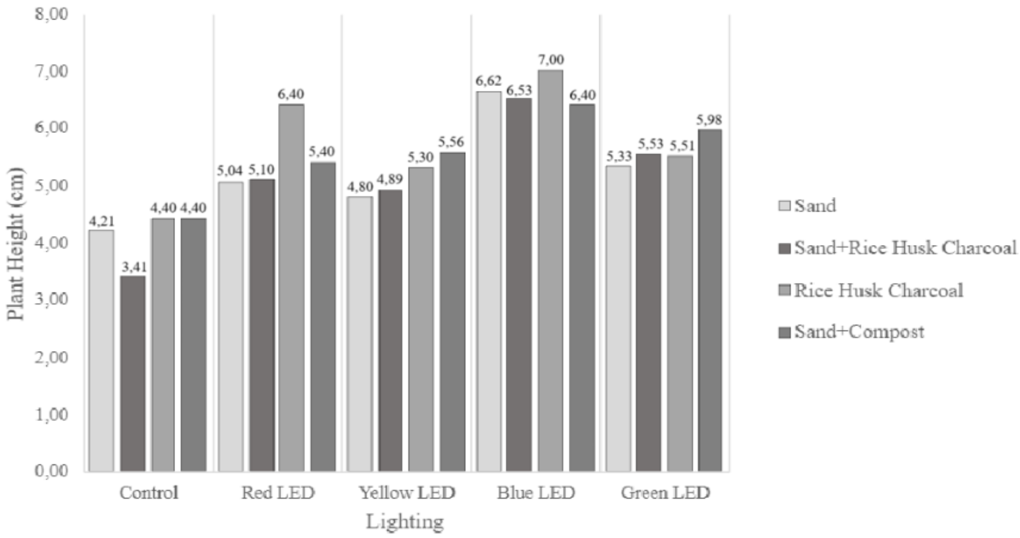

Fig 1. Average plant height of red spinach plants on various types of LEDs and various types of growing media

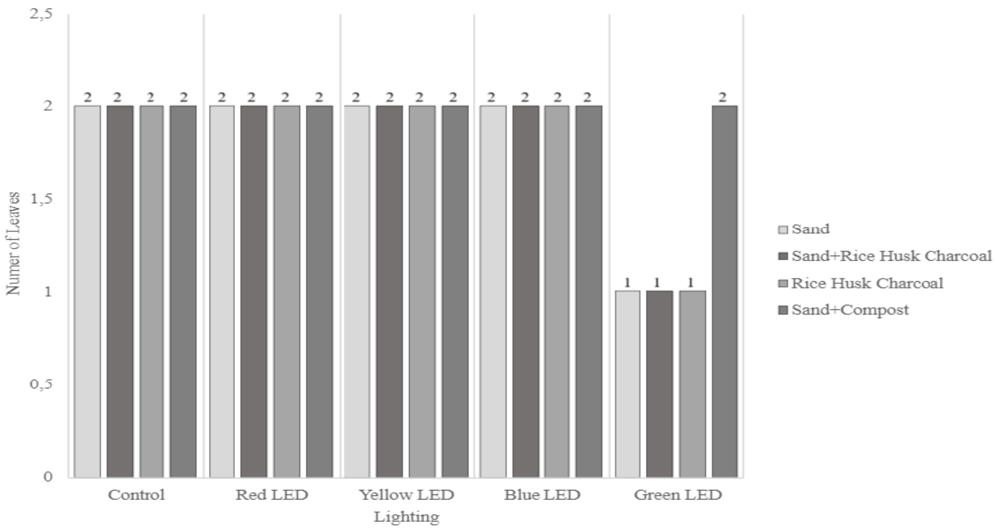

Fig. 2. Average number of leaves of red spinach plants on various types of LEDs and various types of growing media

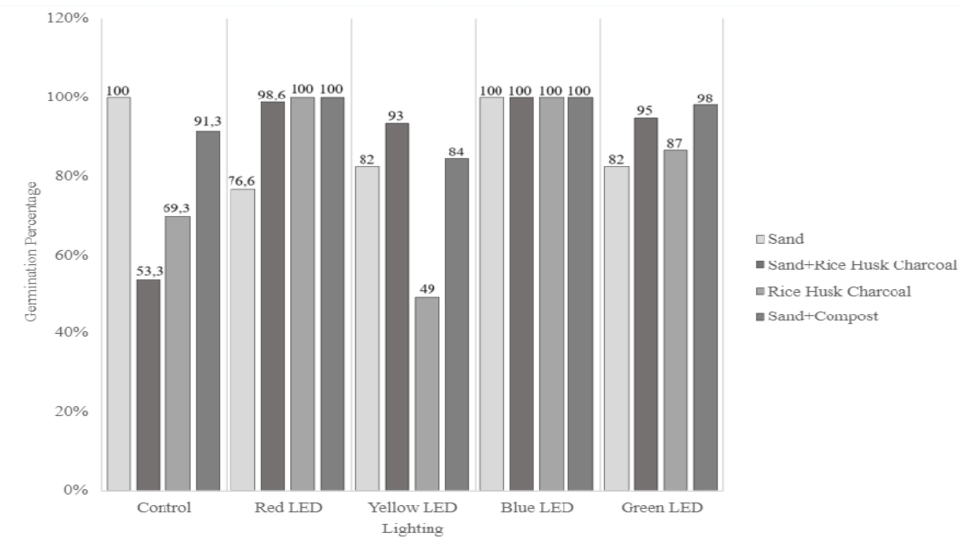

Fig. 3. Average germination capacity of red spinach plants on various types of LEDs and various types of growing media

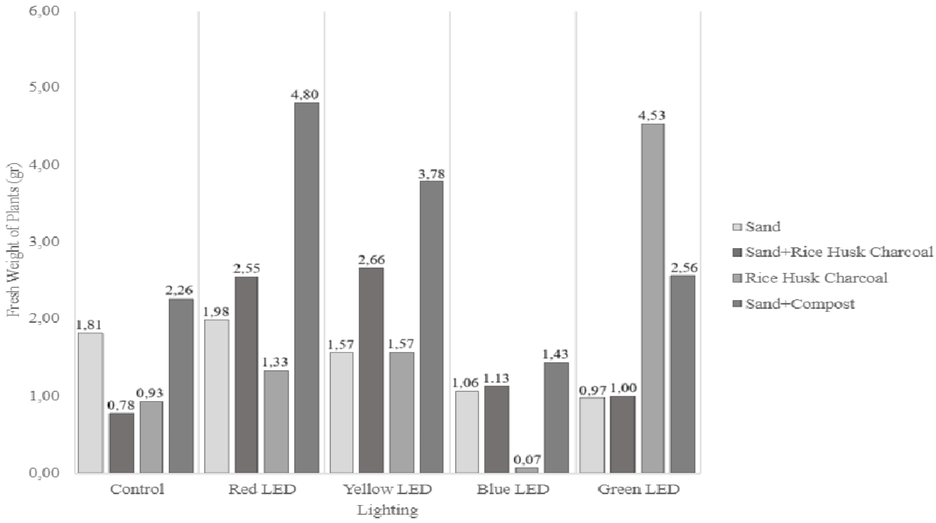

Fig. 4. Average fresh weight of red spinach plants on various types of LEDs and various types of growing media

Research data shows a consistent graphic trend for media consisting of rice husk charcoal and sand compost as the best data. This is thought to be due to the media's ability to store water. Rice husk charcoal media has the ability to store and maintain humidity because water can be stored longer and provide water supply to microgreen roots (Nurmalasari et al, 2021). Rice husk charcoal media does not meet the nutrients in plants, while as organic material, rice husk charcoal will take longer to decompose to contribute carbon nutrients. Meanwhile, sand media provides an opportunity for plant root aeration but does not retain water because of its porous nature. Compost media can function dually, providing a moist effect on the media because it is able to bind water and provide additional nutrients for microgreen roots. Although compost is classified as a slow-release fertilizer, after decomposing the compost will provide nitrogen (N) intake for plants. Compost contains a lot of nitrogen, as well as a little potassium and phosphorus (Stehouwer et al., 2022). This is very helpful in the process of forming chlorophyll as a light receptor. The presence of water in the media makes it easier for roots to absorb the water needed in all metabolic processes so that vegetative growth will take place better. In addition, stomatal activity is influenced by the water content in the guard cells. In the transpiration process, most of the water in plants will be released through the stomata. The opening and closing of the stomata is influenced by H^+ and K^+ ions. The addition of H^+ ions in the guard cells will cause turgid pressure so that the cells will enlarge and the stomata will open when K^+ ions accumulate in the cells, while H^+ ions slowly exit the cells through active transport events. The stomata will close when K+ and H^+ ions exit the cells through osmosis (Cong et al., 2024). H^+ ions are obtained from the ionization of water, while K^+ ions can be obtained from the decomposition of compost. This is what causes the rice husk charcoal and sand-compost media to be the best results in this study.

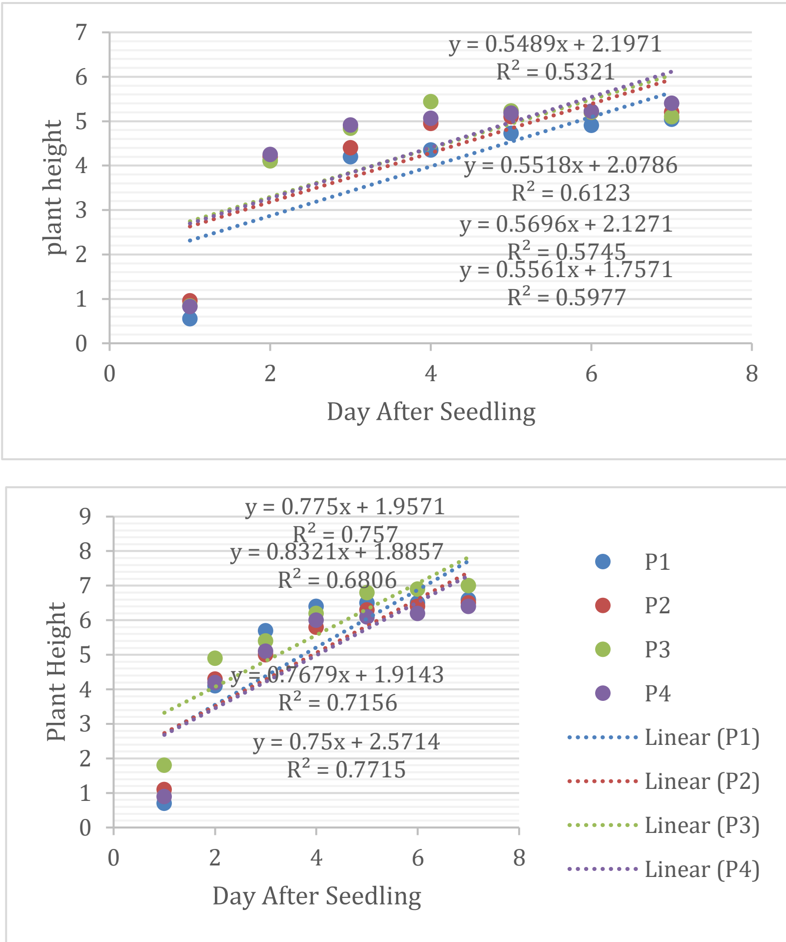

Fig. 5. Regression plots. Plant height irradiated with red LEDs (above) and blue LEDs (below). The corresponding R2 shown above each respective line.

Ghozali (2016) states that if the R2 value is closer to 1, the stronger the independent variable will influence the dependent variable or the accuracy of selecting the independent variable for the model will be better. According to (Hair et al., 2019), about the R2 value category where an R2 value of more than 75% is included in the strong category, then if it is more than 50% but less than 75% then it is considered moderate, then if it is less than 25% then including weak. Plant height is an indicator of plant growth and development. Under red LED lighting conditions (**Fig 5),** several days of observation (Day after seddling/DAS) showed an increase in plant height, and the four types of growing media showed an R2 value of more than 50% and was considered moderate. Meanwhile, with blue LED lighting, several types of growing media show an R2 value of around 75% and are included in the strong category. This shows that as the days increase, the plant height increases. Adequate nutrient and light requirements during the vegetative growth period cause plants to grow well.

CONCLUSIONS

Based on the research that has been done on the study of the growth of red spinach microgreens, it can be concluded that of all LED colors and all media used, the best results for germination, plant height, and number of leaves are red and blue LEDs on all media. While for the best fresh weight using red and yellow LEDs on sand-compost media and green LEDs on rice husk charcoal media.

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