JURNAL UPI

Journal of BioSustainability
ISSN 3063-2129 (Online)
Journal homepage: https://ejournal.upi.edu/index.php/JoBS/

JOBS

The Effect of Differences in Light Color Filters on Potato (*Solanum tuberosum*) Shoot Growth

Salma Fitriani, Nabila Khairunnisa, Nisrina Najla Lafairuz, Savitri Novantira Putri, Najwa Syahrani, Gilang Setiawan, Devita Fitriana, Taufik Rahman*, Tri Suwandi

Study Program of Biology Education, Universitas Pendidikan Indonesia, Indonesia
*Corresponding E-mail: taufikrahman@upi.edu

ABSTRACT

Potato (*Solanum tuberosum*) is a plant that plays an important role as a source of food and carbohydrates for the world community after maize, wheat, and rice. The lack of sufficient demand for low yields in Indonesia can be caused by many factors, one of which is environmental factors, which greatly affect the process of growing potatoes. They are temperature, duration of irradiation, light intensity, growing media, and humidity. Because the growth and process of photosynthesis in plants can be affected by the light factor, therefore our aim in conducting this research was to determine the effect of different light color filters on potato mass, number of shoots, shoot length, number of roots, and root length. The research method used was a completely randomized design (CRD) using 4 (four) treatments. The treatment that was given was P1 on potato shoots which were given a clear plastic filter cover (control), P2 with a blue plastic filter cover, P3 with a plastic filter cover, and P4 which was green. Each treatment was repeated three times for 2 weeks with observations every 2 days. The parameters observed were potato mass, number of shoots, shoot length, number of roots, and root length. The data is then analyzed descriptively using the average and standard deviation. There are differences in the average mass of potatoes, number of shoots, shoot length, number of roots, and root length given different light color filter treatments. The color filter treatment that gives the best results for all parameters is the blue filter.

ARTICLE INFO

Article History:
Submitted/Received: 01 May 2024
First Revised: 30 May 2024
Accepted: 20 June 2024
First Available Online: 27 June 2024
Publication Date: 27 June 2024

Keyword:
light color filter,
potato,
Solanum tuberosum,
shoot growth

1. INTRODUCTION

Potato (*Solanum tuberosum*) is one of the plants that plays an important role as a source of food and carbohydrates for the world community after corn, wheat, and rice (Asgar, 2013). Likewise in Indonesia, in addition to rice which is a staple food source, potatoes are also an important raw material with abundant nutritional content. Potatoes contain carbohydrates, minerals (iron, phosphorus, magnesium, sodium, calcium, and potassium), protein, and 9 vitamins, especially vitamins C and B1. In addition, potatoes also contain a relatively small amount of fat, which is 1.0 - 1.5%. Potatoes are included in the group of alternative foods and fresh vegetables whose demand is always increasing in line with the increasing population of Indonesia, which is recorded on the website of the Central Statistics Agency (BPS) provisional calculation of the population until mid-2022, totaling 275, 773 million people. In addition, the increasing demand for potatoes is also caused by the increase in people's income, awareness of people's nutritional needs, and the development of the fast food industry and other potato processing industries.

However, Indonesia's potato production has not been able to meet the domestic demand for potatoes, as evidenced by the import of potatoes recorded at the beginning of the year potato imports reached 7.16 million kilograms (Central Bureau of Statistics page). This indicates that potato production needs to be improved both in quality and quantity so that availability and demand can be met. The insufficient demand for low yields in Indonesia can be caused by many factors, one of which is environmental factors, which greatly affect the growth process of potatoes. These include temperature, length of irradiation, light intensity, growing medium, and humidity (Smith 1968).

Of the various potato varieties available, Indonesia generally cultivates cipanas, atlantic, and granola varieties. The Granola potato variety is one of the varieties that has high productivity reaching 38-50 tons/ha, the number of tubers per plant can reach 12-20 tubers, and is resistant to late blight (*Phytophthora infestans*) (Prahardini, 2013).

In the research of Syarifudin et. al. in 2015, light color variables affect plant growth. The research was given on chrysanthemum plants of the Fiji variety, and the results obtained were that green light is not good for the photosynthesis process, this happens because green plants cannot absorb green light. Blue and red lights are good for the growth of leaf width and stem height because chlorophyll absorbs a lot of blue light. Another study conducted on Green Beans (*Vigna Radiata* L.) by Hasanah et. al. in 2018, found the results of the influence of the red color light spectrum which resulted in the growth of green beans being faster than the green color spectrum. This is because the wavelength of the red color spectrum is most effective for chlorophyll to carry out photosynthesis and growth. While the green color spectrum waves are mostly reflected by photosynthetic pigments in chloroplasts.

Due to the growth and photosynthesis process in plants can be influenced by light factors, therefore our goal in conducting this research is to determine the effect of different color light filters on potato mass, number of shoots, shoot length, number of roots, and root length. In this study, we focused on red, green, blue, and clear (control) light filters. This study also aims to prove that variable light color affects plant growth. The experimental plant used in this study is potato (*Solanum tuberosum*).

Shoot length and tuber size are one of the main criteria for determining the visibility of potato tubers. Potato tubers of different sizes when stored in the same period and conditions do not always produce buds of the same length. Tubers that have not begun to sprout or are in dormancy do not have good conditions for planting because growth will be slow and produce low tubers (Sihombing and Sinaga, 2017).

2. METHODS

This research was conducted at the Physiology Laboratory, Department of Biology Education, FPMIPA, Universitas Pendidikan Indonesia. The research implementation time began on November 30, 2022, until December 16, 2022.

The equipment used in the study included color filter plastic (HDPE) size 15x30 cm with a thickness of 15 µm with variations in red, green, blue, and clear colors; polybag size 30x30 cm with a thickness of 40 µm and a capacity of 5.5 liters; measuring cup 50 mL; ruler; scales; mobile phone camera for documentation; Lux meter application (Light meter scientific lux meter); and stationery.

The materials used for the study were 12 (twelve) potato (*Solanum tuberosum*) shoots with homogeneous weight obtained from the Bandung district area; planting media in the form of soil with a mass of 1500 gr/polybag obtained from the UPI Botany Garden, and water as much as 50 mL/polybag for each watering.

The research method used was a completely randomized design (CRD) using 4 (four) treatments. The treatment given was P1 on potato shoots that were given a clear plastic filter cover (control). P2 treatment is potato shoots that are given a blue plastic filter cover. P3 treatment is potato buds that are given a red plastic filter cover. The P4 treatment is potato shoots that are given a green plastic filter cover. Each treatment was repeated 3 (three) times. The treatment was given for 2 (two) weeks with observations every 2 (two) days.

Observations of this study have several parameters, including potato mass, number of shoots, shoot length, number of roots, and root length. The data obtained were then analyzed descriptively using the mean and standard deviation.

3. RESULTS AND DISCUSSION

Based on the results of descriptive analysis using the mean and standard deviation, the average mass of potatoes is the heaviest in the P2 (blue color filter) treatment of 21.33 grams, followed by P3 (red color filter) treatment of 18.33 grams, P4 (green color filter) treatment of 17 grams, and P1 (control) treatment of 15.67 grams. The average number of shoots is the highest in the P2 treatment (blue color filter) with 10 shoots, followed by the P3 treatment (red color filter) with 9 shoots, the P4 treatment (green color filter) with 8 shoots, and the P1 treatment (control) with 6 shoots. The highest average shoot length was found in the P2 (blue filter) treatment of 10.17 cm, followed by the P1 (control) treatment of 10 cm, the P4 (green filter) treatment of 9.50 cm, and the P3 (red filter) treatment of 4.17 cm. The average number of roots was highest in the P2 (blue filter) treatment, which was 38 roots, followed by the P3 (red filter) treatment with 32 roots, the P4 (green filter) treatment with 27 roots, and the P1 (control) treatment with 21 roots. The longest average root length was found in the P2 (blue filter) treatment, which was 24.50 cm long, followed by the P1 (control) treatment of 20.10 cm long, P3 (red filter) treatment of 18.67 cm long, and P4 (green filter) treatment of 16.83 cm long.

3.1. Different light filters affect bud length

Shoot length in bulbs can be influenced by several factors, one of which is the effect of the use of intensity and differences in light filters on shoot length growth. The use of different light irradiation will have different effects on shoot elongation. In this case, differences in the color of the mask cause the intensity of light entering the plant to be different. When compared, there are differences in the results of shoot length in brightly colored hoods with fairly dark colored hoods. Morphologically, the length of shoots in blue and control, which is clear, shows a significant difference with the red mask media. This can be caused by the intensity of light entering through the color mask, in this case, the light-colored mask can facilitate the process of tuber physiology, namely hormones in potato tubers to accelerate shoot growth (Sihombing and Sinaga 1983; CIP 1981; Potts 1983, 1983b). In addition, potato storage with greater light intensity will affect the breaking of dormancy in potato tubers with an increase in temperature and along with the length of storage time (Gunawan, 2006).

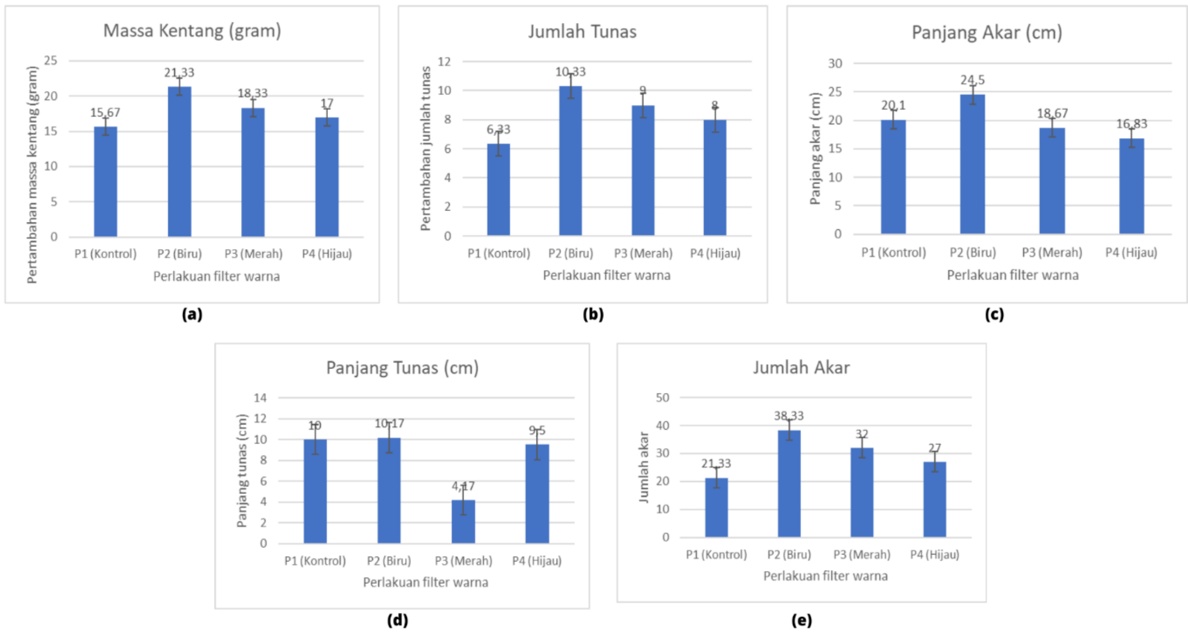

Figure 1. Mean analysis of the effect of color filter treatment on (a) potato mass, (b) number of shoots, (c) root length, (d) shoot length, and (e) number of roots.

The results of this study are in line with the results of research (Sihombing and Sinaga, 1983) where the longest shoots were found in the blue lid with a length of 10.17 cm, then next to the control (clear) lid with a length of 10 cm. So, brightly colored hoods can accelerate the physiological process of tubers so that the process of shoot growth.

3.2. Different light filters affect the mass of potatoes

Pigments are substances that absorb visible light. Different pigments will absorb light of different wavelengths. Photosynthetic pigments when light hits the surface of matter, it may be reflected, transmitted, or absorbed. Agnestika *et al.* (2017) stated that the interaction that occurs in plant growth is also caused by differences in light wavelengths. When light with various wavelengths hits a plant, the chlorophyll molecule will absorb photons (light particles) which then cause the transition of the chlorophyll molecule from the ground state to the excited state. Then the photons push the electrons into an orbit where the electrons have more potential energy. Then if the irradiated molecule is in an isolated condition, the excited electrons will immediately fall back to the ground state orbital, and any excess energy will be released as heat and fluorescence (light). So that will affect the photosynthesis process and also the mass of the plant under study.

Part (a) shows the results of the potato mass parameter with the results of the blue color filter which has a high influence on potato growth with the average result of several treatments weighing 21.33 grams of potato mass. The red color filter that shows pretty good results is obtained by the mass of potatoes of 15.67 grams. The color filter that produces the smallest plant mass is the green color filter which is 17 grams. According to Glowacka (2004) in his research on tomato commodities, explaining that the provision of blue light with a wavelength range (490-435 nm) in tomato commodities will cause protein accumulation, where blue light produces materials to promote the accumulation of proteins and non-carbohydrates, so that plants exposed to blue light with a long exposure time of 3 hours resulted in higher plant growth and increased plant mass, compared to plants without exposure to blue light. Exposure to red light with a wavelength range (750-626 nm) for 3 hours at night in spinach plants can significantly support chlorophyll synthesis because chlorophyll absorbs light so that the photosynthesis process occurs. The photosynthesis process will produce a larger plant size and affect the mass of the plant (leaf length and leaf shape reach the ideal size) compared to plants that are not exposed to light color filters.

The energy contained in blue light and red light is equally effective in affecting the photosynthesis process. However, chlorophyll and other pigments are more effective in absorbing red light energy than blue light. This is because, after excitation with blue photons, the electrons in chlorophyll are always destroyed very quickly by releasing heat. In addition, blue light is captured more by carotenoid or flavonoid pigments. These pigments are photosynthetic complementary pigments because the radiation they absorb will be transferred to chlorophyll before being used in the photosynthesis process. If analyzed, the results that cause the heaviest plant mass is the use of blue filters. When given a red filter, the plant growth process can also be influenced, but not as much as the effect on blue filter exposure. Meanwhile, when given a green filter, the results of plant growth are slower than the provision of blue and red filters.

The results of the research conducted are inversely proportional to the results of the literature review. Supposedly, the red-light filter causes more photosynthesis process and greater potato mass gain, because the red filter has the largest wavelength in the range of 626-750 nm, where chlorophyll absorbs a lot of red light filters so that photosynthesis runs optimally. The provision of blue filters also produces good growth, but not as good as the results of the growth of the number of leaves with red filters. This is because the wavelength of light needed for photosynthesis is around 400-700 nm, while blue light has a wavelength of 400-500 nm where this wavelength can also provide the light needed by green plants for growth, although not as much as the red filter. The green filter produces the least addition of potato mass compared to the red and blue filters, because the green filter with a wavelength of 565-590 nm only absorbs a small amount of chlorophyll, while the rest tends to be reflected by chlorophyll. The most effective colors of light to drive photosynthesis are red and blue because these colors of light can be absorbed by plants. Greenlight is an accessory pigment that includes carotenoids, which can pass energy to chlorophyll so that it can drive photosynthesis.

3.3. Different light filters affect the number of buds

The hormone gibberellin is needed to break dormancy in buds which results in bud growth (Suttle, 2004). Gibberellins can break down starch and sugar in the bulbs which are then used to trigger budding (Mustefa, 2017), as well as cytokinin hormones that play a role in stimulating cell division. Dormancy in plants is caused by meristem bud cells stuck in the G1 phase of the cell cycle. The presence of cytokinins is able to free the obstacles in the G1 phase of the cell cycle so that it can break the dormancy of the bulbs. Cytokinin can overcome apical dominance and induce axillary bud growth even though there is an apical meristem tip (terminal apex). The occurrence of apical dominance can inhibit lateral buds from growing because there is an excess of IAA hormone in the apical part of the tuber so even though there are many lateral buds in the tuber, the buds that successfully grow are only buds at the apical part.

The results of the study in **Figure 1.** show the highest number of shoots, found in potato plants covered with blue filter plastic with an average value of 10.33. This is in line with the results of the literature, which in research (Fankhauser and Chory, 1997) states that blue light has great energy. The large energy of blue light can reduce the hormone auxin (growth hormone) in plants so that at higher intensities, the concentration of auxin in plants decreases and makes the synthesis of excess cytokinin hormones and produces growth in shoots.

3.4. Different light filters affect root number and root length

The number and length of roots are important factors for any plant to grow. Roots help plants absorb water, nutrients, and nutrient elements. The more the number and length of roots, the easier it will be for plants to collect water, nutrients, and nutrient elements needed to grow. Differences in light color filters do not provide significant changes in the number and length of potato roots. However, it can show variations in the number and length of roots of each treated potato, as shown in **Figure 2**. Part (c) shows variations in the length of potato roots treated with different light filter colors. The potato with the longest roots is the potato treated with a blue light filter at 24.5 cm. Meanwhile, the potato with the shortest root is found in the potato treated with a green light filter at 16.83 cm. Part (e) shows the variation in the number of potato roots treated with different light filter colors. Potatoes that have the highest number of roots are found in potatoes treated with blue light filters with 38 roots. Meanwhile, the potato with the least number of roots is found in the potato treated with the control light filter (transparent) with 21 roots.

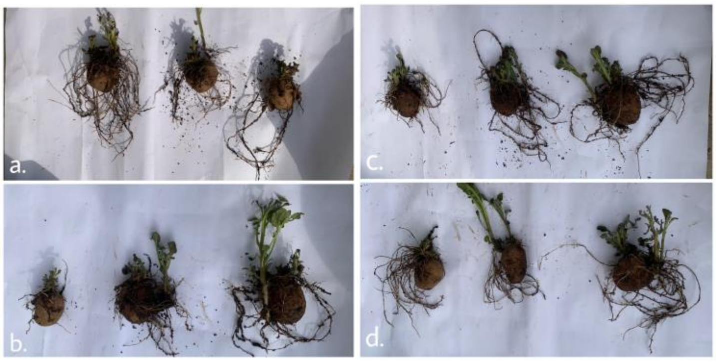

Figure 2. Differences in the number and length of potato roots. (a) Potato with red color filter; (b) potato with blue color filter; (c) Potato with green color filter; (d) Potato with clear color filter (control).

The results of this study are in line with the results of research conducted by Chen-Li *et al.* (2020) showing the highest order of variation in potato root activity occurred in potatoes exposed to blue, red, green, and control light filters. In addition, in-line research conducted by Ruining *et al.* (2018) showed the highest potato root activity occurred in potatoes exposed to blue, red, and yellow light color filters. The results of this observation are also in line with the theory or literature review, potatoes with blue light filters have high root growth and activity. Differences in the number and root variations of potatoes given different light color filter treatments can occur due to several factors, including differences in the spectrum / light waves of each color, plant stress conditions, high humidity, and low CO2 levels (Hazarika, 2006). Red light will cause an increase in environmental stress conditions in potatoes which causes lower root activity compared to blue light. Blue light will strengthen the defense system that reduces the sensitivity of potatoes to the environment which leads to increased root activity (Ouyang *et al.*, 2015). Previous research concluded that starch in chloroplasts can be more easily utilized in plants under blue light than red light (Li *et al.*, 2017). In addition, blue light is beneficial for protein accumulation and red light is beneficial for carbohydrate accumulation (Chen-Li *et al.*, 2020). Greenlight spectrum will mostly be reflected by photosynthetic pigments in chloroplasts, namely chlorophyll a, chlorophyll b, and carotenoids. Thus, makes the energy absorbed by plants little or none, which causes low plant growth and root activity (Susanti, 2009).

4. CONCLUSION

Based on the results of research and discussion, it can be concluded that there are differences in the average mass of potatoes, the number of buds, the length of buds, the number of roots, and the length of roots given different light color filter treatments. The color filter treatment that gives the best results on all parameters (potato mass, number of shoots, shoot length, number of roots, and root length) is the blue color filter.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

6. REFERENCES

Asgar, A. (2013). Kualitas umbi beberapa klon kentang (*Solanum tuberosum* L.) dataran medium untuk keripik. *Berita Biologi*, *12*(1), 29-37.

Chen-Li, L., Zhang, K., Gong, X., Wang, H., Gao, Y., Wang, X., Zeng, Z., and Hu, Y. (2020). Effects of different LEDs light spectrum on the growth, leaf anatomy, and chloroplast ultrastructure of potato plantlets in vitro and minituber production after transplanting in the greenhouse. *Journal of Integrative Agriculture*, *19*(1), 108-119.

Fankhauser, C. and Chory, J. (1997) Light control of plant development. *Annual Review of Cell and Developmental Biology*, *13*(1), 203–229.

Gunawan, O. S. (2006). Pengaruh cahaya dan tempat penyimpanan bibit kentang di gudang terhadap pertunasan dan serangan hama penyakit gudang. *Jurnal Hortikultura*, *16*(2), 142-150.

Glowacka, B. (2004). The Effect of Blue Light on the Height and Habit of the Tomato (*Lycopersicum esculentum* Mill) transplant. *Journal Folia Horticulture*, *16* (2), 3-10.

Hasanah, F., Sari, M. S., Legowo, S., Saefullah, A., and Fatimah, S. (2018). Pengaruh Intensitas Spektrum Cahaya Warna Merah Dan Hijau Terhadap Perkecambahan Dan Fotosintesis Kacang Hijau (*Vigna Radiata* L.). Gravity. *Jurnal Ilmiah Penelitian dan Pembelajaran Fisika*, *4*(2).

Hazarika, B. N. (2006). Morpho-physiological disorders in vitro culture of plants. *Scientia Horticulturae*, *108*, 105-120.

Agnestika, I. K., Nihayati, E., Sitawati, S. (2017). Simulasi Panjang Gelombang Cahaya Terhadap Kualitas Tanaman Krisan (*Chrysanthemum morifolium*) Potong. *Jurnal Produksi Tanaman*, *5*(7), 1187-1195.

Li, C., Xu, Z., Dong, R., Chang, S., Wang, L., Khalil-Ur-Rehman, M., and Tao, J. (2017). An RNA-Seq analysis of grape plantlets grown in vitro reveals different responses to blue, green, red LED light and white fluorescent light. *Frontiers in Plant Science*, *8*, 1-16.

Mustefa, G., Mohammed, W., Deschassa, N., and Gelmesa, D. (2017). Effects of different dormancy-breaking and storage methods on seed tuber sprouting and subsequent yield of two potato (*Solanum tuberosum* L.) varieties. *Open Agriculture*, *2*(1), 220-229.

Ouyang, F. Q., Mao J. F., Wang. J. H., Zhang. S. G., and Li, Y. (2015). Transcriptome analysis reveals that red and blue light regulate growth and phytohormone metabolism in Norway Spruce (*Picea ables* L.) *PLoS ONE*, *10*, 1-19.

Prahardini, P., Sudaryono, T., and Andri K. B. (2013). Pengembangan kentang varietas Granola Kembang di Jawa Timur. *Inovasi Hortikultura Pengungkit Peningkatan Pendapatan Rakyat*, 65-77.

Ruining, L., Wenwen, H., Wang, X., Liu, X., Xu, Z. (2018). Effects of Yellow, Green, and Different Blue SPectra on Growth of Potato Plantlets In Vitro. *HortScience*, *53*(4), 541-546.

Sahat, S., Sunarjono, H., and Soleh A.R. (1978). Pemecahan Masa Istirahat Umbi Bibit Kentang Varietas Rapan 106 dengan Beberapa Zat Kimia dan Pengaruh Pertunasan Awal Terhadap Hasil di Lapangan. *Buletin Penelitian Hortikultura*, *6*(2), 43-49.

Saputro, A. W., Rianto, H., and Suprapto, A. (2019). Hasil tanaman kentang (*Solanum tuberosum*, L.) var. granola L. (G1) Pada berbagai konsentrasi *Trichoderma sp.* dan media tanam. *VIGOR: Jurnal Ilmu Pertanian Tropika dan Subtropika*, *4*(1), 1-4.

Sihombing, P. and Sinaga, R.M. (1983). Penyimpanan umbi kentang di ruang terang. *Buletin Penelitian Hortikultura*. *10*(3), 7-11.

Susanti, I. (2009). Kandungan Klorofil dan Pertumbuhan Kacang Panjang (*Vigna sinensis*) pada Tingkat Penyediaan Air yang Berbeda. *Jurnal Sains dan Matematika*, *17*(3), 145-150.

Suttle, J. C. (2004). Physiological regulation of potato tuber dormancy. *American Journal of Potato Research*, *81*(4), 253-262.

Syafriyudin, S. and Ledhe, N. T. (2015). Analisis pertumbuhan tanaman krisan pada variabel warna cahaya lampu LED. *Jurnal Teknologi*, *8*(1), 83-87.