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LIGHT COLOUR INFLUENCES THE MORPHOLOGICAL TRAITS OF THE *Cryptocoryne elliptica* Hook F., AN AQUATIC PLANT

AZI-AZEYANTY JAMALUDIN[1], AMIRRUDIN AHMAD[2,3] AND AZIZ AHMAD[3]*

[1]*Biology Department, Faculty of Science and Mathematics, Universiti Pendidikan Sultan Idris (UPSI), 35900 Proton City, Tanjung Malim, Perak.* [2]*Institute of Tropical Biodiversity and Sustainable Development, Universiti Malaysia Terengganu, 21030 Kuala Nerus Terengganu. Malaysia.* [3]*Faculty of Science and Marine Environment, Universiti Malaysia Terengganu, 21030 Kuala Nerus Terengganu. Malaysia.*

**Corresponding author: aaziz@umt.edu.my*
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Abstract: Light is crucial to enhance the appearance of fish and supports the survival of living ornamental aquatic plants in aquariums. The light required by the fresh aquatic plants varies depending on the species. The light absorption by plants is most significant in the red (R, 640 nm) and blue (B, 464 nm) regions of the electromagnetic spectrum. The present study investigates the impact of different light colours, specifically white (as a control), blue, red, and green, on the growth of tissue cultures derived from *Cryptocoryne elliptica* plants cultivated under submerged conditions. The morphological traits and chlorophyll content of the plantlets were measured for ten weeks. Results showed that plantlets' growth under blue light exhibited the longest petioles (4.9 ± 0.5 cm), leaf length (3.0 ± 0.2 cm), leaf width (1.3 ± 0.4 cm) and leaf number per plantlet ($p < 0.05$) compared with other treatments. The leaves of plantlets exposed to white light (control) exhibited the highest chlorophyll content, measuring 0.72 mg/g of its fresh weight. The number of newly produced shoot tips did not significantly differ between treatments ($p > 0.05$). This showed that in the current study, light source only alters the plant morphological traits, not the proliferation rate. In future studies, potential enhancements in the production of new plantlets can be explored through the investigation of various propagation methods, hormone treatments, and modifications to light intensity or duration.

Keywords: Aquarium, blue-light, chlorophyll, morphological traits, petioles, shoot tips.

Introduction

Light plays an important role in the photosynthetic activity and growth of both submerged marine and freshwater aquatic plants. Light consists of numerous localised packets of electromagnetic energy called photons. Each photon carries a linear and angular momentum with an associated wavelength and frequency. The energy of a photon is inversely proportional to its wavelength, where shorter wavelengths possess more energy than longer ones (Mascarenhas & Keck, 2018). The photons absorbed by submerged aquatic plants are largely determined by water quality. Due to water selectively scattering and absorbing specific wavelengths of visible light due to the presence of dissolved and particulate constituents (Mascarenhas & Keck, 2018).

Moreover, particulate matter in water will change the colour and underwater light available for the growth of plants and other underwater organisms. Angove *et al.* (2020) stated that yellow-green to brown water comprised a high concentrations of colour-dissolved organic matter such as tannins released from decaying detritus strongly scattered and absorbed the red or longer wavelength light. Meanwhile, shorter wavelengths of light (blue) penetrate deeper. The light wavelength received by submerged plants will influence various biochemical processes and changes in the morphological traits are an adaptation strategy of submerged aquatic plants (Wang *et al.,* 2022).

Meanwhile, submerged aquatic plants attract ornamental fish keepers due to their interesting depictions of the aquarium scape. Moreover, aquatic plants release dissolved oxygen into the water, thereby increasing the oxygen content in the aquarium. It is also capable of absorbing dissolved organic carbon and ammonium released by fish (Szabo *et al.,* 2020). Nonetheless, the growth of aquatic plants is limited by nutrient availability and light penetration in the water (Angove *et al.,* 2020). Plant height is advantageous trait to submergence aquatic plants, where a leaf exposed to the water's surface has a high probability of capturing broad spectrums of light compared with the bottom. More importantly, the aquatic plant's ability to capture light intensity at different wavelengths is species-dependent (Angove *et al.,* 2020). Besides height, the leaf chlorophyll content also determined the health of plants. In most cases, plants with higher chlorophyll levels exhibit better growth characteristics (Szabo *et al.,* 2020; Muhammad *et al.,* 2022). Therefore, the selection of light colour needs to be considered for better morphophysio-phenological characteristics of each aquarium plant species.

Cryptocoryne is a popular plant genus in the aquarium industry. The genus consists of 50 described species including *C. elliptica* which has a restricted distribution in the northern part of Peninsular Malaysia (Nurul-Shakina *et al.,* 2022). To date, their studies on the effect of light on the growth performance of *C. elliptica* are limited. It was hypothesised that light colour will influence the growth characteristics of submerged *C. elliptica*. Consequently, the current study objective was to determine the effects of light colour on the tissue culture-derived plantlets of *C. elliptica.*

Materials and Methods

Plant Materials

The tissue culture-derived *Cryptocoryne elliptica* plantlets proliferated in the B5 culture medium as described by Norhanizan and Aziz (2018), was applied as the sample for this experiment. The plantlets that were approximately 5cm in height were taken from the culture vessels and rinsed with tap water to remove any excess medium. Subsequently, the plantlets were acclimatised in tap water in laboratory conditions for three days at room temperature (28˚C) for a 12 hour photoperiod. Similar-sized plantlets (5 cm in height) containing three leaves were then transferred into a small pot filled with river soil for the roots to take hold before experimentation.

Experimental Design and Treatment

A complete randomized design was used in the experiment. One plant for each pot was used, where eight pots were arranged in a plastic tray (0.3 m^2) and placed in a designed growth chamber (Figure 1). Three replicates were made for each light treatment (8 pots/replicate). The tray was filled with tap water until all plantlets were fully submerged and replenished evapotranspiration water losses. The temperature (27 ± 0.3˚C) and pH (6.5 ± 0.2) of water were maintained throughout the experiment. Hoagland's (1,950) nutrient solution was added to each tray at the bottom of the pots to supply nutrients to the plantlets.

Two fluorescent lamps were used as a source of light for each treatment. The treatments were red light, blue light, green light, and white light as a control. The coloured light was provided by wrapping a fluorescent light with blue, red, or green transparent plastic wraps. While white colour light was provided by a white, fluorescent lamp (Phillipe). All plantlets were continuously exposed to light treatment for 24 hours photoperiod for 10 weeks. The growth chamber was covered with black plastic wrappers and cardboard to create dark conditions and minimise interference from ambient light. Plants in the pots were systematically rotated at seven-day intervals during light treatments to minimise edge and position effects within the growth chamber.

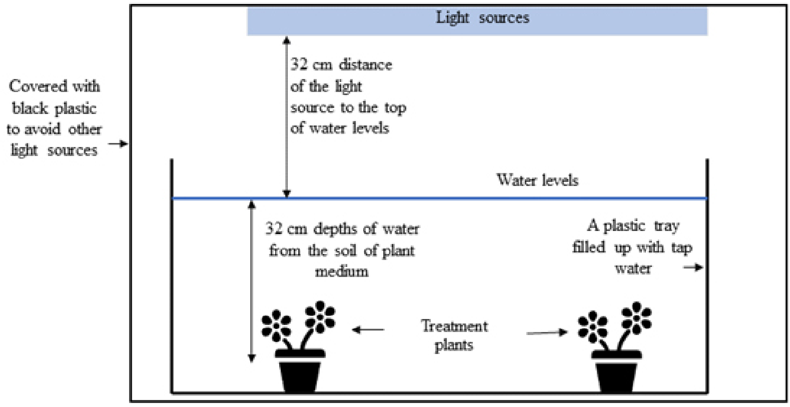

Figure 1: Experimental setup for the light treatment

Plant morphological traits, which were the petiole length, leaf length and leaf width were measured every two-week interval using a ruler. After 10 weeks of treatment, the number of leaves and newly produced shoot tips per plantlet was counted. Consequently, the chlorophyll content in the leaves was measured according to the methods described by Martin and Hine (2000). Fresh leaves (0.15 g) were homogenised in 80% (v/v) acetone with a mortar and pestle. The supernatant was obtained after centrifugation (5804R Eppendorf) at 10,000 rpm for 10 minutes. The absorbances were measured at 663 nm and 645 nm using a spectrophotometer (Shimadzu) and calculated for the total chlorophyll content.

Statistical Analysis

Data were analysed using one-way ANOVA and subjected to the Tukey test, where $p < 0.05$ was significantly different among the treatments.

Results and Discussion

Morphological Traits

Results in Figure 1 display the morphological traits of *C. elliptica* plantlets after 10 weeks of treatment. It showed that the number of leaves varied between light colour treatments [Figure 1(A)]. The highest mean value of leaves was observed with the blue light treatment (4.9 ± 0.5 cm). This indicated that blue light may promote the development of a higher number of leaves compared with other light colours. Similar results were observed on the leaf length [Figure 1(B)]. The highest mean leaf length in the blue light treatment was 3.0 ± 0.2 cm. The leaf width also showed variation among the light colour treatments [Figure 1(C)]. The widest leaves observed in the blue light treatment were 1.3 ± 0.4 cm. The petiole length was also highest in the blue light treatment [Figure 1(D)], which was 6.39 ± 0.5 cm. These results suggested that blue, which has the shortest wavelengths can penetrate deeper into water (Wang *et al*., 2022) and may have a positive effect on leaf areas and promote longer petioles compared with other colours. It was reported that the vertical pattern of the leaf's physiological traits was species-specific. Plant height and leaf area are closely related to the community productivity of the plants (Angove *et al.,* 2020).

Based on the results in [Figure 1(E)], no new plantlets were produced after 10 weeks of treatment, regardless of the type of light used. Instead, only single plantlets were observed until the end of the experiment in each treatment. This suggests that light colour did not have a significant effect on the proliferation of *C. elliptica* in the 10 weeks period of the experiment. Moreover, the molecular mechanism controlling plant cell proliferation and vascular differentiation in response to light remains elusive (Ghosh *et al.,* 2022). Most studies focus on the impact of the photoperiod, which is often equated with changes in light duration and changes in light time can relieve dormancy and trigger blooming in plants (Ream *et al.,* 2014; Qin *et al.,* 2019). It is common for certain plant species to have specific requirements or limitations when it comes to the production of new plantlets. Changing the light duration of plants suitably promotes the accumulation of photosynthetic products such as NADPH and sucrose, which in turn impacts plant growth and development. Factors such as genetic characteristics, environmental conditions (e.g., temperature, humidity, nutrient availability), and cultivation techniques (e.g., propagation methods) can all influence the ability of a plant to produce new plantlets (Liu *et al.,* 2023).

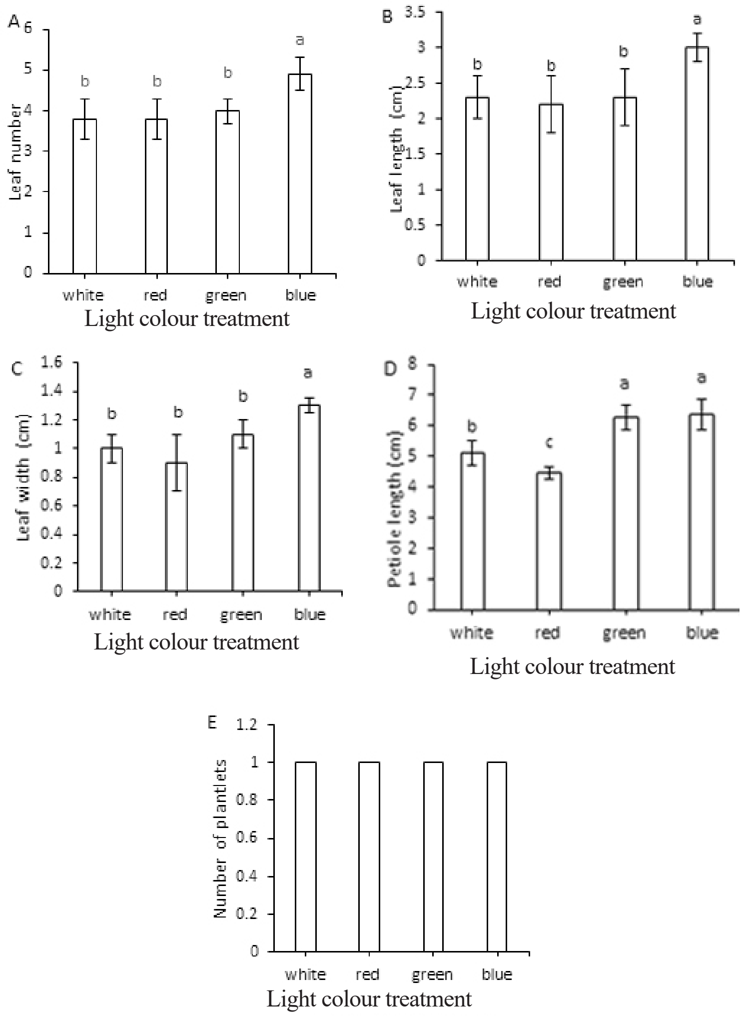

Figure 1: Effects of light colour on the morphological traits leaf number (A), leaf length (B), leaf width (C), petiole length (D), and the number of plantlets of *Cryptocoryne elliptica* after 10 weeks of treatments. Note: Bar with similar small letters did not significantly differ based on the Tukey test ($p > 0.05$)

Total Chlorophyll Content

Results in Figure 2 showed that the total chlorophyll content varied significantly between light colour treatments. The control plant (white light) contained the highest chlorophyll content (0.72 ± 0.01 mg/g fresh wt.), compared with other light treatments indicating that white light may result in higher chlorophyll content compared with other light colours. This finding recommended that the photosynthetic activity in the *C. elliptica* plants is light-dependent. Szabo *et al.* (2020) also reported that white-light conditions increased the chlorophyll content, apical elongation and root-shoot ratio of the *Elodea nutallii,* a type of aquatic plant. The *C. elliptica* plant might use the photosystem-1 (PSI) when growing under submergence conditions, where the PSI capture the photon of the light at a higher range than the PSII (Wang *et al.,* 2022).

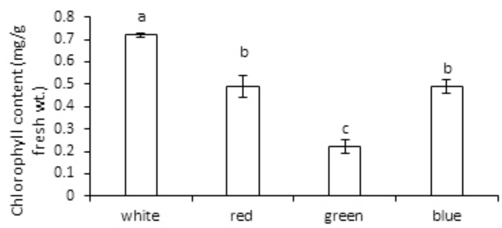

Figure 2: Effects of light colour on the chlorophyll content in the leaves of *Cryptocoryne elliptica* after 10 weeks of treatments. Note: Bar with similar small letters did not significantly differ based on the Tukey test ($p > 0.05$)

Conclusion

The influence of different light colours on the morphological characteristics and chlorophyll content of the C. elliptica plant is a subject of great interest. The application of blue light had a significant effect on the enhancement of various morphological characteristics of the plant, such as leaf number, leaf length, leaf width, and petiole length. The results indicate that white light demonstrated greater efficacy in enhancing chlorophyll content. The results mentioned above emphasise the significance of light colour in applying an influence on the growth and development of plants. A comprehensive comprehension of the optimal cultivation conditions and photoperiod is imperative for the prosperous cultivation and propagation of these aquatic plants.

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References

Angove, C., Norkko, A., & Gustafsson, C. (2020). The fight to capture light: Functional diversity is related to aquatic plant community productivity likely by enhancing light capture. *Frontier in Marine Science*, *7*(140). https://doi.org/10.3389/fmars.2020.00140

Ghosh, S., Nelson, J. F., Cobb, G. M. C., Etchells, P., & Lucas, M. (2022). Light regulates xylem cell differentiation via PIF in *Arabidopsis*. *Cell Reports*, *40*(3), 111075. http://doi.10.1016/j.celrep.2022.111075.

Lehtonen, S., & Falck, D. (2011). Watery varieties: Aquarium plant diversity from aesthetic, commercial and systematic perspectives. In J. C. Aquino. (Ed.) *Ornamental plants: Types, cultivation and nutrition*. New York: Nova Science Publishers Inc.

Liu, C., Liu, N., Ding, C., Liu, F., Su, X., & Huang, Q. (2023). Growth of *Populus* × *euramericana* plantlet under different light durations. *Forests, 14*, 579. https://doi.org/10.3390/f14030579

Mascarenhas, V., & Keck, T. (2018). Marine optics and ocean colour remote sensing. In Jungblut, S., Liebich, V., & Bode, M. (Eds.) *YOUMARES 8 – Oceans across boundaries: Learning from each other*. Springer, Cham. https://doi.org/10.1007/978-3-319-93284-2_4

Muhammad, I., Yang, L., Ahmad, S., Farooq, S., Al-Ghamdi, A. A., Khan, A., Zeeshan, M., Elshikh, M. S., Abbasi, A. M., & Zhou, X.B. (2022). Nitrogen fertilizer modulates plant growth, chlorophyll pigments and enzymatic activities under different irrigation regimes. *Agronomy, 12*, 845. https://doi.org/10.3390/agronomy12040845

Norhanizan, S., & Aziz, A. (2018). Thidiazuron amends the organ development of the endangered aquatic plant *Cryptocoryne elliptica* Hook. F. *IOP Conferences Series: Material Science and Engineering*, *440*, 012046 https://doi.org/10.1088/1757-899X/440/1/012046

Nurul-Shakina, M. T., Suwidji, W., & Ahmad-Sofiman, O. (2022). Complete chloroplast genome data for *Crptocoryne elliptica* (Araceae) from Peninsular Malaysia. *Data in Brief, 42*, 108075. http://doi.org/10.1016/j.dib.2022.108075

Qin, Z., Bai, Y., Muhammad, S., Wu, X., Deng, P., Wu, J., An, H., & Wu, L. (2019). Divergent roles of FT-like 9 in flowering transition under different day lengths in Brachypodium distachyon. *Nature Communications*, *10*, 812 (2019). https://doi.org/10.1038/s41467-019-08785-y

Ream, T. S., Woods, D. P., Schwartz, C. J., Sanabria, C. P., Mahoy, J. A., Walters, E. M., Kaeppler, H. F., & Amasino, R. M. (2014). The interaction of photoperiod and vernalization determines the flowering time of *Brachypodium distachyon*. *Plant Physiology*, *164*, 694–709.

Szabó S, Peeters, E. T. H. M., Borics, G., Veres, S., Nagy, P. T., & Lukács, B. A. (2020). The eco-physiological response of two invasive submerged plants to light and nitrogen. *Frontiers in Plant Science*, *10*, 1747. https://doi.org/10.3389/fpls.2019.01747

Wang, C. W., Wong, S. L. Liao T. S., Weng, J. H., Chen, M. N., Huang, M. Y. & Chen, C. (2022). Photosynthesis in response to salinity and submergence in two Rhizophoraceae mangroves adapted to different tidal elevations. *Tree Physiology*, *42*(5), 1016-1028. https://doi.org/10.1093/treephys/tpab167