Light quality and duration on the germination of dragon fruit (*Hylocereus* spp.) grown out on different potting mixture

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ABSTRACT

Background and Objectives: Dragon fruit (*Hylocereus* spp.) is generally propagated by cuttings; however, its multiplication rate is slow. Dragon Fruit seeds are capable of self-pollinating and thus have a lower chance of contamination. Earlier investigations showed that the light spectrum plays a vital role in germination and seedling growth. This study determined the *in vitro* effect of light quality and lighting duration on dragon fruit seeds in terms of total germination (%) and plant height (mm). The other aim of this study was to know the effect of the light-exposed plant samples in terms of plant height (mm) using different potting mixtures.

Methodology: Each treatment was exposed to different lights which are red, blue, and white light as control and also the duration of 16 and 24 h light periods. Three potting mixtures were used to compare seedling growth; T1–50% coco peat: 25% vermicast: 25% compost; T2–25% coco peat: 25% vermicast: 50% compost, and T3–25% coco peat: 50% vermicast: 25% compost. The experiment was laid out in a two-factorial analysis arranged in a randomized complete block design (RCBD).

Main Results: Red light exposure for 24 h duration showed the highest germination percentage at 87.50 ± 1.00%. Moreover, the germination ($P < 0.01$) of dragon fruit seeds exposed to 24 h light duration, regardless of color, resulted in greater germination percentage (73.62 ± 0.02%) than when exposed only to 16 h light duration (44.41 ± 0.31%). The same red light at 24 h duration also produced the longest plant at 31.36 ± 1.77 mm. Furthermore, exposure to 24 h light duration, regardless of color, produced taller plants ($P < 0.01$) at 27.44 ± 0.29 mm when compared to those exposed to only 16 h light duration at 23.96 ± 0.31 mm.

Conclusions: Increased duration using red light enhanced the dragon fruit seed germination percentage and the average plant height. In addition, all potting mixtures utilized can support seedling growth of the dragon fruit resulting to 100% survival during grow-out.

Keywords: Dragon fruit, light spectrum, light duration, photoblastism, grow-out medium

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INTRODUCTION

Dragon fruit (*Hylocereus* spp.) is an introduced crop in the Philippines that was first grown on a modest scale in the early 1990s. It emerged throughout the period, with areas expanding and productivity increasing dramatically due to its resistance to arid settings, which has gained interest in many countries (Tran *et al*., 2015). Dragon fruit seeds are commonly used in research because it is capable of self-pollinating and thus have a lower chance of contamination from other varieties (Muniz *et al*., 2019). The fruits are high in fiber, and rich in vitamins C, B (B1, B2, and B3), calcium, iron, lycopene, and antioxidants that help in human health (Liaotrakoon, 2013). Its production contributes to poverty reduction efforts by providing a reliable source of income for rural communities that can be sold exclusively in the market (Pascua *et al*., 2015).

In vitro seed propagation of dragon fruit (*Hylocereus* spp.) is typically uncommon. Usually, it was done using vegetative cuttings from the mother plant, whose multiplication rate is low, and it is challenging to accumulate enough planting materials (Le Bellec *et al*., 2006). Furthermore, growth from seed is the preferred method for breeding programs because materials with different genetic information can be obtained and allow their various characteristics to be exploited. In brief, plants produced by sexual propagation exhibit wide variability, allowing the selection of offspring with desirable traits, such as productivity, external appearance, flesh color, and suitability for different climatic conditions (Andrade *et al*., 2008).

Light and light duration play a vital role in seed germination and plant growth (Bian *et al*., 2015). Seed germination is a complex biological process determined by genetic, endogenous, and environmental factors. Light is necessary for seed germination in some species, which are identified as positively photoblastic (Stutte, 2009). Light induction of germination is exclusively mediated by phytochrome B and other phytochromes that perceive the red (600–700 nm) to far-red (700–800 nm) ratio, being maximally induced by a saturating pulse of monochromatic red light, in which the photoreceptor pigment is activated as a switch between 640 and 670 nm (Ibarra *et al*., 2013). Phytochrome receptors (PhyA, PhyB, etc.) sense red light in plants, presenting two inter-convertible Pr and Pfr forms. It generates responses related to germination, stem elongation, leaf expansion, and flowering induction (Lobiuc *et al*., 2017). Red light initiates seed germination and root development (Bewley and Black, 1994; Daud *et al*., 2013). It promotes the highest germination rates and the lowest mortality rates in *Adenium obesum* (Araújo *et al*., 2022). Blue light is sensed by cryptochromes and phototropin and regulates processes such as de-etiolation, phototropism, chloroplast movement, endogenous rhythms, and growth of roots (Ajdanian *et al*., 2019). This increased seed germination and affected the development of the largest number of leaves and roots in four-week-old stevia plantlets (Simlat *et al*., 2016). It is known that seeds and seedlings are able to respond not only to the intensity of light but also to its quality (Bewley and Black, 1994).

The success of all propagation techniques may boil down to how the seedlings are able to establish after they are successfully grown or germinated *in vitro*. The selection of growing media is essential for *in vitro* plantlets to provide optimal nutrients and physical and biological properties of the substrates used. The growing media should have various favorable characteristics such as being light-weight, good porosity, well-drained but with optimum water holding capacity, slightly acidic with optimum cation-exchange capacity and free from insects and diseases, and containing readily available nutrients are among the major considerations. Coco peat, vermicast, and compost are cheap since they are readily available. They are commonly used as organic soil amendments that enhance the soil's physical properties due to the organic compounds present (Bhagat *et al*., 2013). This study aimed to determine the effects of light quality and duration on the germination of dragon fruit seeds *in vitro* and grown out into different potting mixtures for seedling establishment.

MATERIALS AND METHODS

Collection, Treatments, and Light Supplementation

Dragon fruit seeds were collected manually from the fresh fruits using spoons and sieved in running water with the use of a strainer to remove the flesh and retain the seed, which was then placed on filter paper to dry. The experiment was conducted at the Center for Studies in Biotechnology, Cebu Technological University, Barili Campus. Each treatment was exposed to different light duration and quality, where light quality served as the main plot and duration as the sub-plot from August 2021 to September 2021. The main plot was red (0.43 $m^{-2}\ s^{-1}$), blue (2.21 $m^{-2}\ s^{-1}$), and white light (12.79 μmol $m^{-2}\ s^{-1}$). The subplot was 16 and 24 h under a light period. Supplementation of light undergoes after the inoculation, during which the samples were exposed to white, blue, and red lights under 16 and 24 h lighting duration and placed in the culture room at a temperature of 25 °C.

Surface Sterilization, Medium Preparation, and Inoculation

The dragon fruit seeds were exposed to surface sterilization using 50% bleach for 5 min, then rinsed with sterilized water and, right after, dipped into 70% alcohol solution and finally rinsed thoroughly with double-sterilized distilled water. In this experiment, two seeds were inoculated in each culture bottle which contained MS medium (Murashige and Skoog, 1962) supplemented with 30 g L^{-1} sucrose, 0.1 g L^{-1} myo-inositol, 2 mg L^{-1} 6-benzylaminopurine (BAP), 0.2 mg L^{-1} α-naphthalene acetic acid (NAA) and solidified with 0.8% agar (Figure 1A). The pH was adjusted to 5.8 with 1 N HCl or NaOH before dispensing into the culture vessels. Culture bottles with the medium were covered using autoclavable plastic and autoclaved at 121 °C for 2 h at 15 psi and kept to cool before the inoculation of seeds. Inoculation of 20 bottles/treatment/replication (Figure 1B) was done after cooling the culture media under the laminar flow hood with a sterilized scalpel and forceps. Before inoculation, the laminar flow was exposed to UV lights to sterilize the air surface from pathogens.

Acclimatization, Medium Preparation, and Transplanting

The month-old dragon fruit seedlings were acclimatized in 7 days at the normal room temperature ranging from 27–30 °C to adapt and survive the outside temperature during transplanting. Ten seedlings were randomly assigned to the different potting mixtures. Three potting mixtures were used to compare the growth of seedlings: T1–50% coco peat: 25% vermicast: 25% compost; T2–25% coco peat: 25% vermicast: 50% compost, and T3–25% coco peat: 50% vermicast: 25% compost. The culture media was mixed and sterilized by pouring hot boiled water into the surface and then placed into the potting bag. After acclimatization, the seedlings were transplanted to different potting mixtures from September 2021 to October 2021.

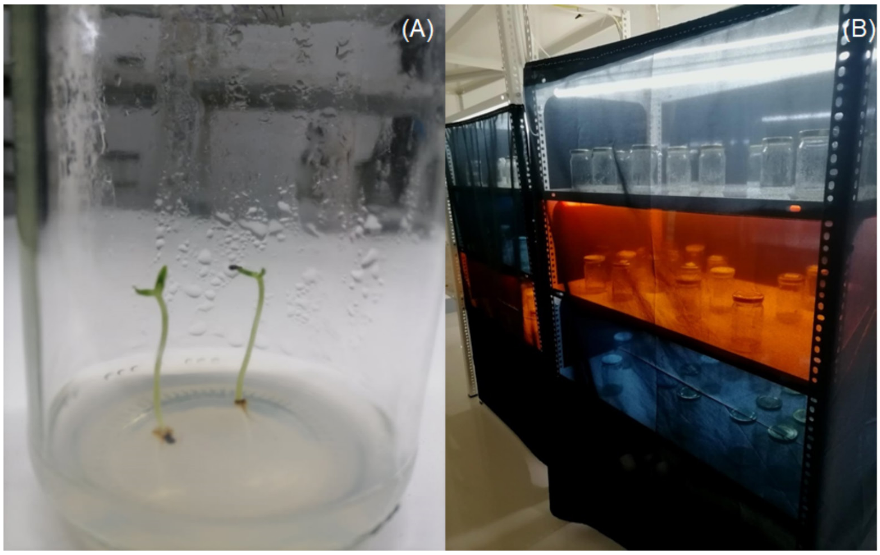

Figure 1 Seeds inoculated at two per bottle (A) and grown under different light quality and duration at 20 bottles per treatment (B) replicated three times

Data Gathering

Plants were observed weekly to monitor their development. The following data obtained in *in vitro* light and duration were 1) Germination (%) – this was calculated as germinated samples over the total samples per treatment multiplied by 100 and 2) plant height (mm) – this was done by measuring the height of the sample plants from the base to the tip of the plant. As for the different potting mixtures conducted on the field, the data gathered was plant height (mm) which was done by measuring the height of the sample plants from the ground to the tip of the plant.

Statistical Analysis

Data were recorded, tabulated, consolidated, and statistically analyzed through two-factorial analysis arranged in a randomized complete block design (RCBD). A comparison was done through Duncan's new multiple range test (DMRT) at 5% probability to determine the significant difference among treatment means.

RESULTS AND DISCUSSION

Light Quality and Duration

It is clearly indicated in Table 1 that prolonged light exposure across different spectra at 16 and 24 h showed significant differences in germination percentage with each other at an average of 44.41 ± 0.31 and 73.62 ± 0.02%, respectively. For the duration of the study, it can be seen that longer exposure to light leads to better germination percentage. Moreover, exposure to red light at 24 h duration resulted in 87.50 ± 1.00% on the third week. In comparison, 61.9 to 82.5% was achieved using the conventional shoot explant tissue culture (Dewir *et al*., 2023). Moreover, Kari *et al*. (2010), mentioned that germination greater than 70% can be considered fairly good. This result corresponded to the study of Ohadi *et al*. (2010) that the seed germination of weed species increased with the increase of exposure to light. It was also stated that both high light intensity and long exposure should be met to give high percent germination in seeds of *P. annua*.

Table 1 Germination percentage (± standard error; %) of dragon fruit seed exposed to different light quality and duration

Week	Light quality	Light duration		Mean
		16 h	24 h	
1	White	29.12 ± 0.76	45.87 ± 0.76	37.50 ± 0.76
	Red	33.33 ± 1.24	58.37 ± 1.44	45.85 ± 1.34
	Blue	25.00 ± 0.00	45.87 ± 1.24	35.44 ± 0.62
	Mean	29.15 ± 0.36^{b}	50.03 ± 0.20^{a}	
2	White	29.12 ± 0.76	58.37 ± 1.07	43.75 ± 0.92
	Red	50.00 ± 1.62	75.00 ± 1.32	62.50 ± 1.47
	Blue	29.12 ± 0.76	66.62 ± 1.07	47.87 ± 0.92
	Mean	36.08 ± 0.29^{b}	66.66 ± 0.08^{a}	
3	White	41.62 ± 0.76	62.50 ± 1.00	52.06 ± 0.88
	Red	50.00 ± 1.63	87.50 ± 1.00	68.75 ± 1.32
	Blue	41.62 ± 1.76	70.87 ± 1.07	56.23 ± 1.42
	Mean	44.41 ± 0.31^{b}	73.62 ± 0.02^{a}	

Note: Data is based on final germination percentage. Means followed by a common letter is not significantly different from each other at 5% level of significance using Duncan's new multiple range test.

Earlier investigations showed that the light spectrum plays an important role in germination and seedling growth. Many studies have revealed that different plant species had optimal growth and development in response to environmental factors according to the light they received (Li *et al*., 2012). Although light qualities are comparable with each other, red light showed a higher germination rate than the other color at 87.50 ± 1.00%. Farrokh-Tehrani *et al*. (2016) stated that red light affects the germination rate of oil seeds more than white and blue lights. Previous studies also reported that seed germination of some important weeds, *Chenopodium album* L. increased when treated with red light (Tang *et al*., 2010). Furthermore, According to Takaki *et al*. (1985), positively photoblastic seeds can be characterized as needing a high threshold of far-red phytochrome (Pfr) for germination to occur because they contain an insufficient quantity of Pfr to initiate the germination process. This means that a period of exposure to light is necessary to boost phytochrome to sufficient levels to initiate germination.

According to Goto (2003), light provides energy in photosynthesis to produce organic matter, and it is perceived as a morphogenetic stimulus. Photo morphogenetic responses include growth effects (such as seed germination, phototropism, and organ elongation). Several studies of growth morphologies *in vitro* plantlets are affected by light and showed that red light enhances stem elongation while blue inhibits shoot length (Rehman *et al*., 2020). In addition, it was stated in the study of Landi *et al*. (2020) that light affects not only plant photosynthetic performance but also the quality of plants by modulating the biosynthesis of photoprotective compounds. In a previous study, Simlat *et al*. (2016) reported that red light resulted in an increased germination rate, number of leaves and roots, higher stomatal frequency, and pigment contents of plants.

The result showed a significant difference in plant height between samples exposed to 16 and 24 h light duration at 23.96 ± 0.31 and 27.44 ± 0.29 mm, respectively (Table 2; Figure 2). Moreover, samples exposed to red light are significantly different from other light treatments. Red light exposed to 24 h light duration obtained the highest plant height at 31.36 ± 1.77 mm on the third week. This is because red light is sensed in plants by phytochrome receptors (PhyA, PhyB, etc.), presenting two inter-convertible Pr and Pfr forms that generate responses related to stem elongation, leaf expansion, and flowering induction (Lobiuc *et al*., 2017).

Potting Mixture

The success of all propagation techniques may boil down to how the seedlings are able to establish after they are successfully germinated *in vitro*. All (100%) of the transplanted seedling from *in vitro* germination survived in different potting mixtures. The combination of 50% coco peat: 25% vermicast: 25% compost numerically enhanced the growth of dragon fruit seedlings in the second and the fourth week based on plant height at 16.72 ± 1.07 and 22.83 ± 1.28 mm, respectively (Figure 3). The results in Figures 3A–3B indicate that all potting mixtures are comparable with each other. This means that the seedlings have grown from the second to the fourth week from planting, but the effects of the treatments are comparable, implying similar benefits derived from various potting mixtures. Sinha *et al*. (2010) reported that the addition of vermicast and coco peat enhanced the growth of seedlings due to the improved soil physical properties. Vermicompost enhanced the formation of chlorophyll due to the presence of readily available nutrients such as N, P, K, Mg, Fe, and Cu, which are required for light harvesting and subsequent conversion into chemical energy via photo assimilation (Hussain and Abbasi, 2018). This was also supported by the study of Blouin *et al*. (2019), where it was stated that vermicompost applications have a positive effect on the growth of vegetables.

Table 2 Plant height (± standard error; mm) after three weeks from germination of dragon fruit seeds exposed to different light quality and duration

Week	Light quality	Light duration		Mean
		16 h	24 h	
1	White	14.58 ± 2.07	17.43 ± 1.79	16.01 ± 0.14
	Red	14.20 ± 1.39	13.63 ± 1.68	13.91 ± 0.15
	Blue	9.00 ± 1.97	14.57 ± 2.30	11.78 ± 0.17
	Mean	12.59 ± 0.21	15.21 ± 0.19	
2	White	17.14 ± 1.84	18.83 ± 1.42	17.98 ± 0.21^{ab}
	Red	19.80 ± 1.34	20.75 ± 1.35	19.81 ± 0.01^{a}
	Blue	11.89 ±1.13	18.65 ± 1.85	15.27 ± 0.36^{b}
	Mean	15.96 ± 0.21^{b}	19.41 ± 0.15^{a}	
3	White	24.68 ± 1.90	26.38 ± 2.63	25.53 ± 0.37^{ab}
	Red	29.53 ± 0.87	31.36 ± 1.77	30.45 ± 0.45^{a}
	Blue	17.67 ± 1.07	24.58 ± 1.76	21.12 ± 0.35^{b}
	Mean	23.96 ± 0.31^{b}	27.44 ± 0.29^{a}	

Note: Means followed by a common letter is not significantly different from each other at 5% level of significance using Duncan's new multiple range test.

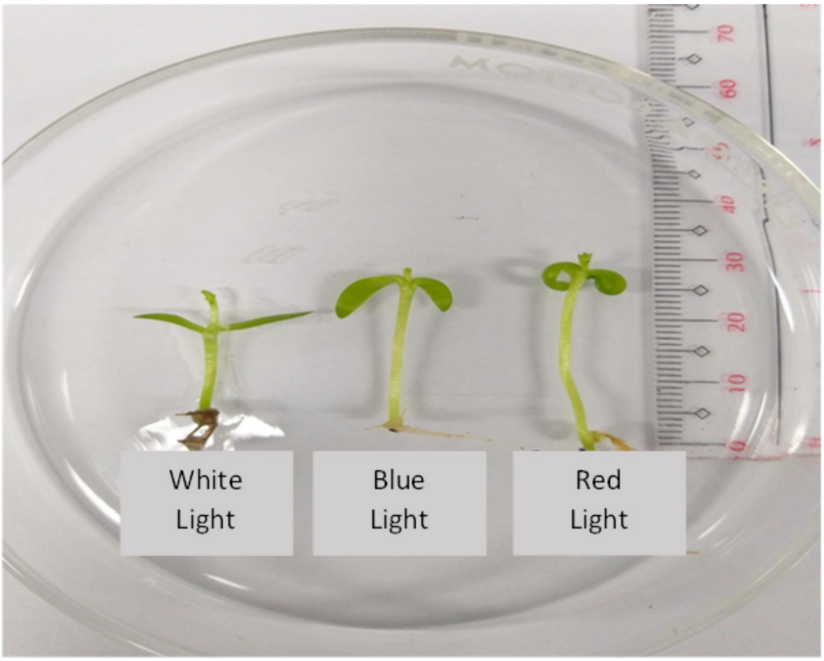

Figure 2 Appearance of dragon fruit seedlings as exposed to 24 h light duration using white, blue, and red light

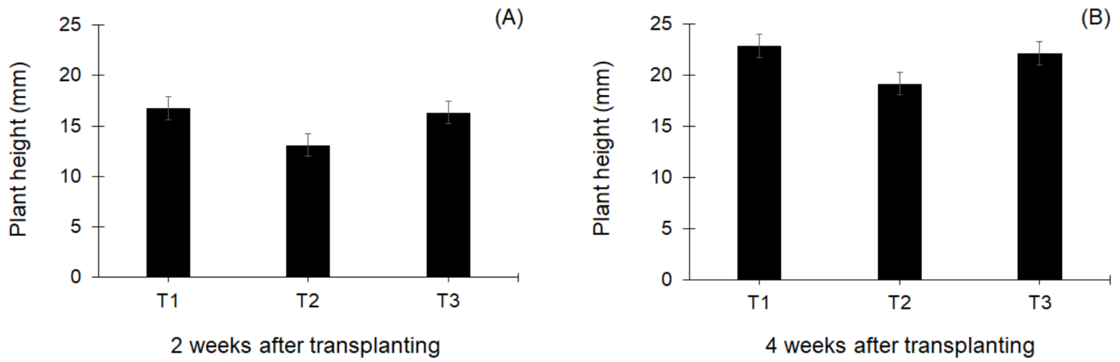

Figure 3 Plant height of dragon fruit seedlings grown in different potting mixtures after 2 weeks (A) and 4 weeks (B) from transplanting. T1 = 50% coco peat: 25% vermicast: 25% compost, T2 = 25% coco peat: 25% vermicast: 50% compost, and T3 = 25% coco peat: 50% vermicast: 25% compost.

There are various ways like vermicast, coco peat, compost, and plant juice extracts which showed essential effects on plant growth (Atiyeh *et al*., 2002; Pascual, 2013; Ceritoğlu *et al*., 2018). In this study, coco peat, vermicast, and compost showed promising results. Coco peat serves as a soil conditioner that significantly provides a reservoir of soil water available to plants on demand in the upper layers of the soil where the root systems normally develop. Apart from improving the soil's physical properties, it also serves as a buffer against temporary drought stress and reduces the risk of plant failure during establishment. Vermicompost, whether used as a soil additive or as a component of greenhouse bedding plant container media, has been reported to improve seed germination, enhance seedling growth and increase overall plant productivity (Atiyeh *et al*., 2002). Lazcano *et al*. (2010) reported that changes in the physical properties of the germination media after the incorporation of vermicompost influenced the moisture retention and aeration of the substrate, which have an impact on seed germination. Further, water-soluble bioactive substances, humic acids, water-soluble plant growth regulators, or micro-organisms present in vermicompost may also be responsible for the increased germination with vermicompost as reported by Lazcano *et al*. (2010) for pine seeds. On the aspect of availability and cost, the medium containing 50% cocopeat is hereby recommended as a grow-out mixture.

CONCLUSION

The increased time duration under light supplementation greatly enhanced the percentage of dragon fruit seed germination and the average growth development. Moreover, red light promotes plant height. In addition to this, the combination of coco peat, vermicast, and compost has shown improvement in the growth and development of dragon fruit seedlings.

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