DOI: 10.17707/AgricultForest.62.1.32

Zeiynab SABAGHNIA,
Mansour MATLOOBI, Alirez MOTALLEBI-AZAR[1]

RESPONSE OF LEAF NUMBER AND PLANT HEIGHT OF POLKA DOT PLANT (*HYPOESTES PHYLLOSTACHYA*) UNDER VARIOUS INDOOR LIGHTS

SUMMARY

Variegated foliage plants such Polka Dot Plant (Hypoestes phyllostachya) as are often used in interiorscaping in low light environments. The changes in leaf number and plant height under various light types (blue, red and blue+red LED (light-emitting diode) and fluorescent) were investigated to elucidate their optimum indoor light environment. The changes in plant height (was different from leaf number. In general, plant height increased with increasing time. Leaf number showed no significant changes in first sampling decades under different light treatments. The analysis of variance results indicated significant differences for plant height in different light treatments for all sampling decades expect the first, second and third decades, but the results of analysis of variance for leaf numbers indicated non-significant differences among different light treatments. The comparison of means for plant height in the first, second and third decades indicated that there are no significant differences among light treatments while in next five decades, red light treatment showed the long plant height. Also, comparison of means for leaf numbers under various light treatments via Duncan's new multiple range test indicated that there is not any significant differences among different light treatments in first five decades and seventh decade while in the sixth decade, blue light treatment had the highest leaf numbers following to red and blue+red light treatments. In the eighth decade, blue and red light treatments had the highest leaf numbers following to blue+ red light treatment. This study revealed that the most suitable light treatment for obtaining short and high leaf numbers in Polka Dot Plant were blue or blue+red treatments.

Keywords: Blue light, Fluorescent, Red light, Polka Dot Plant.

INTRODUCTION

Polka Dot Plant (Hypoestes phyllostachya) is a lively and beautiful little plant with brightly spotted leaves that stand out especially well against other plants. It is a perennial herb, native to Madagascar, with ovate leaves marked with lavender-pink spots (Moronkola et al. 2009). Polka Dot Plant is common

[1] Zeiynab Sabaghnia, Mansour Matloobi, Alirez Motallebi-Azar, (corresponding author: zsabaghnia@yahoo.com), Department of Horticulture, Faculty of Agriculture, University of Tabriz, Tabriz, IRAN
Notes: The authors declare that they have no conflicts of interest. Authorship Form signed online.

houseplants with colourful foliar displays and it is highly hybridized to produce a variety of colours and types of leaf spotting. It is not especially difficult to grow, and their main drawback is their relatively short lifespan (Kim et al. 2012). Polka Dot Plant is also called freckle face plant; this houseplant can grow in any type of indirect light but has best colour in lower light situations. When it is grown as a potted plant, a growth regulator is normally used to control plant size or to give good height control (Armitage and Carlson, 1980). Control of plant height is one of important problems related with the production of Polka Dot Plant in many circumstances. In its common native habitat, the plant can get up to 3 feet in height, but pot grown specimens will usually be smaller.

Urbanization is associated with a substantial increase in impervious surface in world cities (Booth and Jackson 1997). Since many people spend most of their lives indoors, indoor air represents a major proportion of their exposure to air pollution and poor indoor air quality may pose serious health risks (Wood and Burchett, 1995). The importance of indoor air quality to human health has become of increasing interest where inhabitants often spend over 90% of their time indoors and indoor air has been reported to be as much as 12 times more polluted than that outdoors (Orwell et al. 2004; Zabiegała, 2006). Indoor air pollutants include volatile organic compounds, particulate matter, ozone, radon, lead, and biological contaminants (Destaillats et al. 2008) and exposure can cause acute illnesses and chronic diseases (Suh et al. 2000). Plants can effectively improve the indoor air quality by reducing volatile organic compounds (Thomsen et al. 2011), thus reducing the risk of sick building syndrome (Kim et al. 2011). Foliage plants are often used as house plants due to their attractive foliage as well as their ability to grow under limited indoor light (Chen and Henny, 2008).

The most limiting factor for plant growth is reduced light intensity regarding the environmental conditions for indoor plants because the typical indoor light intensity is less than 40 $\mu mol.m^{-2}.s^{-1}$ while the outdoor light intensity is higher than 1000 $\mu mol.m^{-2}.s^{-1}$ of photosynthetic photon flux (PPF) at sunny days (Manaker, 1997). Due to requirement of plant growth for light, plants need a particular light environment for suitable growth (Maloof et al. 2001). Plants can adjust to varying light circumstances through physiological and morphological changes, which is causing either in increased light capture or improvement of light utilization. Light acclimatization is the process needed to cause morphological changes enabling plants to withstand under low light conditions and foliage plants prior to placement indoors improves their survival and quality. Different responses of acclimation to low light consist on long plant height, higher shoot to root ratio, large leaf size increased, changes in leaf numbers, leaf dry weight, increased total chlorophyll content, and a decrease in the chlorophyll a:b ratio (Evans and Poorter, 2001; Nemali and van Iersel, 2004).

The objective of present research was to investigate the optimum light intensity for Polka Dot Plant foliage plant in an indoor light environment. These results will improve understanding of the light requirements for better performance of foliage Polka Dot Plant under limited indoor light environments.

MATERIAL AND METHODS

Rooted cuttings of Polka Dot Plant were obtained from a local garden center in Tabriz, Iran. All the seedlings were transplanted into 3-inch-diameter round plastic pots filled with vermiculite (30% by volume) and soilless substrate (70% by volume) and after acclimatization for 2 weeks in the greenhouse with shade at University of Tabriz, Iran. All the plants were moved to an indoor laboratory at a temperature of 25 °C and were hand-watered every other day. To obtain suitable indoor light treatments, two phosphor fluorescent lamps [Dulux L 36W (OSRAM GMBH, Germany) and FL40 EX-D (AEG, Germany)] were used as the light source at the 15 cm above canopy of the plants with light period was 12 h day and 12 h night. Four treatments including (i) blue light, (ii) red light, (iii) blue+red light and (iv) fluorescent light were applied and plant height and leaf numbers were measured every decade (each ten days). The datasets were first tested for normality by the Anderson and Darling normality test using Minitab version 14 (Minitab Institute, 2005) statistical software. Data from each trial were subjected to analysis of variance (ANOVA) using appropriate models. The experimental design was completely randomized design (CRD) with eight replications. Data were analyzed general linear models and regression in SAS version 9.1 (SAS Institute, 2004).

RESULTS AND DISCUSSION

The results of Anderson and Darling normality test indicated that dataset were normal and there is no need for transformation (data not shown). The analysis of variance results indicated highly significant differences for plant height in different light treatments for all sampling decades expect the first, second and third decades (Table 1)

Table 1. Analysis of variance for plant height of polka dot plant under various light treatments in eight decades of growt

SOV	DF	D1	D2	D3	D4	D5	D6	D7	D8
Treatment	3	15.08^{ns}	25.50^{ns}	52.13^{ns}	3226.42^{**}	7353.11^{**}	14140.21^{**}	32531.42^{**}	46018.78^{**}
Error	28	13.81	25.54	46.70	283.58	676.39	1414.97	2686.47	3830.95
CV (%)		27.0	27.2	27.3	36.9	40.7	45.6	45.4	40.7

**, * and ^{ns}; Significant 1% and 5% of probability level and non-significant.

Controlling of plant height trait is one of important problems in Polka Dot Plant and so applying different light treatments can be changed it. According to Table 2, the comparison of means for plant height of polka dot plant under various light treatments in the first, second and third decades of growth indicated that there are no significant differences among light treatments based on

Duncan's new multiple range test. In fourth decade, red light treatment with 75.4 mm had the most plant height and was not better than the other light treatments (Table 2) according to least significant differences (LSD) test. In other word, the low plant height was seen in the blue, red+blue and fluorescent light treatments and there are not any significant differences among these treatments. Similar trend was observed for plant height trait in the fifth decade and red light treatment with 108.8 mm had the long plant height in comparison to the other light treatments according to LSD test (Table 2). The plant height of the red light treatment in the sixth, seventh and eighth decades were 145.0, 208.8 and 264.6 mm, respectively, and were higher than the other light treatments based on LSD test (Table 2). Therefore, it seems that various light treatments did not affect height of Polka Dot Plant significantly till the first month of growth (three decades), but it can be reduced by applying blue, red+blue and fluorescent light treatments instead of only red light treatment from the fourth decade to last decade (about two months of growth).

Table 2. The comparison of means for plant height of polka dot plant under various light treatments in eight decades of growth.

Treatments	D1		D2		D3		D4		D5		D6		D7		D8	
Blue	13.3	A	17.9	A	24.1	A	32.3	B	44.0	B	54.8	B	70.4	B	100.4	B
Red	15.6	A	21.1	A	28.5	A	75.4	A	108.8	A	145.0	A	208.8	A	264.6	A
Red+Blue	13.8	A	18.6	A	25.1	A	35.0	B	47.3	B	62.4	B	84.4	B	117.0	B
Fluorescent	12.4	A	16.7	A	22.6	A	39.9	B	55.4	B	67.6	B	93.0	B	125.9	B

*Mean with the similar letters in each column have not significant differences at 0.05 probability level by least significant differences (LSD) test for F-test significant traits and Duncan's new multiple range test (MRT) significant traits

The results of analysis of variance for leaf numbers of polka dot plant indicated non-significant differences among different light treatments (Table 3). Regarding high magnitudes of coefficient of variations (CV), logarithmic and square root transformations were performed, but significant differences did not observed for leaf numbers in the eight decades (data not shown).

Table 3. Analysis of variance for leaf numbers of polka dot plant under various light treatments in eight decades of growth

SOV	DF	D1	D2	D3	D4	D5	D6	D7	D8
Treatment	3	21.28^{ns}	31.03^{ns}	42.08^{ns}	121.83^{ns}	303.79^{ns}	705.58^{ns}	763.78^{ns}	1629.21^{ns}
Error	28	12.08	17.33	24.62	112.21	169.09	363.10	434.09	617.12
CV (%)	21.1	21.1	20.9	42.6	49.9	60.3	57.0	56.7	21.1

However, comparison of means for leaf numbers of polka dot plant under various light treatments via Duncan's new multiple range test (MRT) indicated that there is not any significant differences among different light treatments in first five decades (D1, D2, D3, D4 and D5) and seventh decade (Table 4). In the sixth decade, blue light treatment had the highest leaf numbers (41.5) following to red and blue+ red light treatments (32.6 and 33.5, respectively) while fluorescent light treatment had the lowest (18.9) leaf numbers (Table 4). In the eighth decade, blue and red light treatments had the highest leaf numbers (54.6 and 53.4, respectively) following to blue+ red light treatment (43.5) while fluorescent light treatment had the lowest (23.8) leaf numbers (Table 4). Therefore, it seems that various light treatments did not affect leaf numbers of Polka Dot Plant significantly till the sixth decade of growth, but it can be increased by applying blue, red and red+blue light treatments instead of only fluorescent light treatment in the sixth and eighth decades.

Table 4. The comparison of means for leaf numbers of polka dot plant under various light treatments in eight decades of growth.

Treatments	D1		D2		D3		D4		D5		D6		D7		D8	
Blue	15.9	A	19.1	A	22.9	A	27.5	A	29.9	A	41.5	A	45.9	A	54.6	A
Red	18.9	A	22.7	A	27.2	A	28.0	A	31.6	A	32.6	AB	41.5	A	53.4	A
Red+Blue	15.3	A	18.3	A	22.0	A	24.5	A	24.9	A	33.5	AB	35.4	A	43.5	AB
Fluorescent	15.9	A	19.1	A	22.9	A	19.5	A	17.9	A	18.9	B	23.4	A	23.8	B

*Mean with the similar letters in each column have not significant differences at 0.05 probability level by duncan's new multiple range test (mrt) for non f-test significant

According to Fig. 1, plant height of Polka Dot Plant under various light treatments did not changed until the third decade, but from the third to the eighth decade, blue light treatment increased plant height significantly while the other three light treatments have not any significant differences with each other and did not increased plant height. The trend of leaf number over eight decades was relatively complicated (Fig. 2); fluorescent light treatment had the low leaf number over eight decades, but the other light treatments had incensement trend and increase over time. Artificial lighting is gaining relevance in horticulture, since it allows cultivation wherever natural light is not sufficient (indoor cultivation). Although, various plants need various light treatments, it has been confirmed that the optimal ratio between blue and red light is of great relevance in determining yield performance (Tarakanov et al. 2012). Moreover, increased crop growth is also related to improved light interception rather than increased photosynthetic rates (Hogewoning et al. 2012). A great opportunity for the financial sustainability of artificial lighting is provided by the chance of quality improvement and light is one of the most important variables affecting physiological processes in plants (Kopsell and Kopsell, 2008). Different light regimes may help to optimize growth and a control developmental transition makes the implementation of light type especially to design the controlled circumstance targeted to production (Samuoliene et al. 2010). Among different light treatments considered in the present study, plant height was increased to a greater extent in plants grown under red light while the other light treatments (blue, red+blue and fluorescent) (Table 2), confirming that the proper balancing of red and blue components of the light spectrum would be beneficial to plants' production (Hogewoning et al. 2012). The present work confirmed the efficiency superiority of LED compared to the traditional fluorescent lamps, enabling an increase of about two folds leaf number productivity (Table 4).

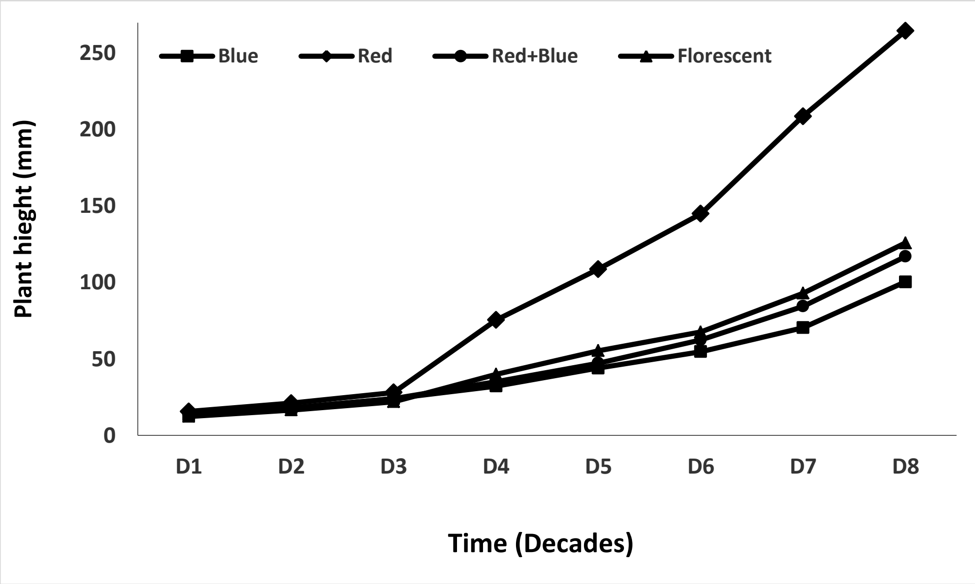

Figure. 1. Effect of various light treatments on plant height in polka dot plant

According to Samuoliene et al. (2010), a species-specific mixture of red and blue spectral components is necessary for proper plant development and the effect of the blue light in promoting leaf number has been addressed in a range of recent reports, although often with controversial results (Tarakanov et al. 2012). Furthermore, the improvement on the biomass of Welsh onion (*Allium fistulosum* L.) shoot with blue, rather than red and green, overnight supplemental lighting was reported by Sase et al. (2012). Different activities of plants consist on physiological and biochemical processes are strictly related with the quality of the incident light (Horton, 2000), and identification of the optimal spectral composition shall take into account how plant functions varied across light treatments. The increased crop growth (more leaf numbers in sixth and eighth decades) under LED lighting (blue, red and red+blue) should be related to improved light interception rather than increased photosynthetic rates (Hogewoning et al. 2012).

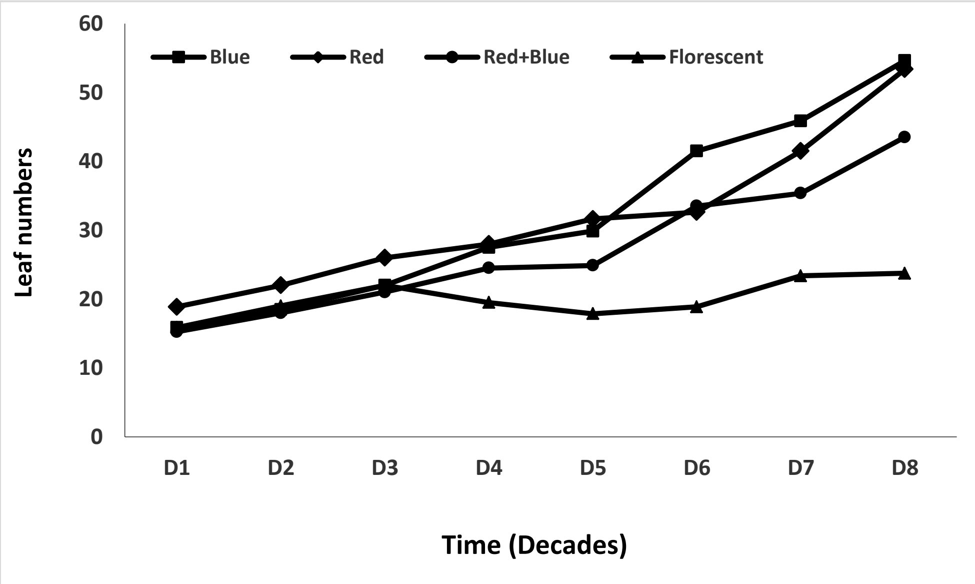

Figure 2. Effect of various light treatments on plant leaf numbers in polka dot plant.

CONCLUSIONS

This study addressed the applicability of blue, red and blue+red LED lights and fluorescent light for indoor production of Polka Dot Plant. Through of analyses (addressing plant height and leaf number), it was possible to determine the most suitable light blue or blue+red treatments. Consistently, LED lights (blue and blue+red) improved plant leaf number and reduced unwanted traits (e.g. long plant height).

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