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Influence of light spectrums on seedling emergence and growth of Lisianthus (*Eustoma grandiflorum)* cultivars

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ABSTRACT

This experiment was carried out at Horticulture Innovation Lab. BD, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka to study the effect of different LED light spectrums on seedling emergence, growth, and development of different Lisianthus cultivars. The study comprised of three different LED light spectrums: (i) White LED (W), (ii) Blue LED (B), (iii) Red LED (R), and four Lisianthus cultivars: (i) Arena Type 1 pure white (V_1), (ii) Double III pure white (V_2), (iii) Arena Type I Light pink (V_3), (iv) Super Magic Type Blue (V_4), following Completely Randomized Design (CRD) with three replications. Data on germination, vegetative growth, rosetting and survivability were taken. Among Lisianthus cultivars, Arena Type I Light Pink (V_3) showed the highest survival percentage, Seedling height, Leaf number, leaf length and root number. However, results indicated that variety had not any significant influence on days needed to 80% germination and rosetting percentage. Different light spectrum showed a significant impact on all parameters. The least days (11.2) required for 80 % seed germination, had great impact against rosette seedlings (7.4 %), the highest seedling height (4.5 cm) and seedling survival percentages (91.9) recorded in red light spectrum at two pair leaves condition. Seedlings under White LEDs found more number of leaves (10.2) and roots number (12.2). These findings may be a source of valuable information for the development of sustainable techniques of seedling production from true seeds of Lisianthus.

Key Words: *LED light spectrum, Nandini, Seedling, Cultivars and Rosetting.*

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I. Introduction

Light serves as a source of information for plants. Plants are capable of perceiving and processing information from Light for their optimal growth and development (Fankhauser and Chory, 1997). Different light spectra stimulate the plants to survive, flourish, and reproduce. Plants react to light in the range of 300 to 800 nm, which triggers them to develop. The light spectrum has a profound

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influence on plant development and physiological behavior, and it can also affect seedling morphology (McNellis and Deng, 1995). Different LED light spectrums have an impact on plant growth (Jamal Uddin et al., 2020), development and yield in strawberries (Jamal Uddin et al., 2018), seed production in broccoli (Jamal Uddin et al., 2017). Plants primarily utilize photosynthetically active sunlight with wavelengths in the blue (400-500 nanometers) and red (600-700 nanometers). Red light is important in controlling chloroplast, stem, and petiole growth, as well as reproductive system function, whereas blue light primarily regulates plant growth, leaf expansion, photomorphogenesis, stomatal opening, photosynthesis, and pigment accumulation (Naznin et al., 2019). For photosynthesis, red light is thought to be the most efficient (Wollaeger and Runkle, 2014).

In a controlled environment, in response to requirements for optimal light quality, quantity, and distribution, light-emitting diodes (LEDs) have been proposed as a promising light source for plants (Massa et al., 2008). Photosynthetic pigments absorb blue and red LED light more effectively than other wide-spectrum light (Pfündel et al., 1990). Furthermore, plants grown under white LED light alone have regular leaf morphology and a higher photosynthetic rate than plants grown under Red or Blue LED light (Hogewoning et al., 2010; Tran et al., 2017; Wang et al., 2009).

Eustoma grandiflorum is a prominent ornamental cut flower belonging to the family Gentianaceae. It is also known by its common name Lisianthus (Reid, 2009). Because of the small size seed (19,000 seeds per gram or 545,000 seeds per ounce), it is difficult to handle in field plantings (Rezaee et al., 2012). Under normal favorable conditions, Lisianthus repeatedly shows evidence of a slow germination rate, with germination percentages as low as zero (Ecker et al., 1994). The rosette formation of the seedling is another crucial problem for Lisianthus seedling production. Rosetted seedling does not produce flower. Using three types of LEDs and four varieties of Lisianthus, this study was designed to study the Influence of different Light spectrums on specific cultivars of Lisianthus and to find out the appropriate LED light for quality Lisianthus seedling production.

II. Materials and Methods

This experiment was conducted at Plant factory, Horticulture Innovation lab, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during October to January 2018 to evaluate different LED lights & variety for seedling emergence and seedling growth of Lisianthus following out Completely Randomized Design (CRD) with three replications.

The seeds were collected from Takii seed, Japan. In this experiment, four Lisianthus Lines (Arena Type I Pure White, Double III Pure White, Arena Type I Light Pink, Super Magic Type Blue) and 3 wavelengths of LED Lights - Red LED (around 620 to 750 nm), Blue LED (around 400 to 525 nm), White LED (390 nm to 700 nm) were used to understand how the seedling emergence and seedling growth and development are influenced by different LED Light Spectrums and distinct variety/ to find out the appropriate LED light and variety for quality seedling production of Lisianthus in Bangladesh.

In this experiment coco pellets were used as growing media, its EC is 0.5 (s/m) ≤ and pH is 6.5. Coco pellet and seedling trays were collected from Agrosal ltd, Urmi group. Each tray has 104 chambers. Coco pellets were placed in the chamber of the seedling tray. Coco pellets were soaked well by spraying water before sowing seeds. Each seed was placed in the middle of each coco pellet carefully. As the Seeds were coated, so after sowing seeds must be soaked by gently spraying water to dissolve the thin coat outside the seeds. Then the seed tray was covered by a transparent polyethene which retain the related humidity for better seedling growth and always kept the coco pelletes evenly moist but not saturated and did not allow the pellets to dry out during germination.

Seed trays were kept in the Plant factory where optimum temperature was 68-71 degrees Fahrenheit/20 degrees Celsius and 16 hours of light was ensured. Three types of LED light were used in this experiment, Red LED (around 620 to 750 nm), Blue LED (around 400 to 525 nm), and White LED (390 nm to 700 nm). The LED lights were placed above the seed tray at such a distance that 2500 foot-candle/2700 lux light intensity was ensured and The LED lights were designed such a way that the chambers were individually illuminated by red (R), blue (B), White (W). Lisianthus Seedlings are growing slowly at first and it is necessary to avoid exposure to stress. After emergence plastic cover

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kept open sometimes for good air circulation and to prevent algae growth and avoid excessive humidity. Excessive moisture invites disease. Plugs can take up to 85 days to be ready for transplanting.

Data were collected on Days needed to 80% Germination, Days needed to 80% 4 leaves, Seedling height (cm), Root length (cm), Leaf length (cm), Numbers of Leaves, Numbers of roots, Leaf width (cm), Resetting and Survival % were recorded and analyzed for all the treatments considered. All seedling growth parameters were measured at the time of transplanting (85 days after sowing; DAS) in ten randomly-selected seedlings. Root samples were washed with water to measure no. of roots, root length (cm).

We calculated Survival % like this:

$$\text{Survival \%} = \frac{\text{Number of seedling survived}}{\text{Number of seed sown}} \times 100$$

Statistical analysis

The data recorded for different parameters were statistically analyzed using Statistics-10 computer software to find out the significance of variation among the treatments and treatment means were compared by Tukey HSD Test at 5% level of probability.

III. Results and Discussion

Days to 80% Germination

The findings revealed that Lisianthus seeds under Red LED resulted significantly enhanced germination time compared to Blue and White LED in case of days to 80% germination. In Red LED, seeds need the minimum time (11.2 days) for 80% germination than Blue (14.8 days) and White LED (15.4 days) (Table 01). These findings are in accord with Behnaz Akbarian et al., (2016) who reported that the emergence parameters were highest under Red light and the second highest ones were observed under Blue light in zinnia, petunia, and impatiens. Results showed that Lisianthus varieties have no significant influence on days to 80% germination (Table 01).

Table 01. Light spectrum impact and performance of lisianthus cultivars; on days to seed germination, days to two pair leaves, survive rate, rosett rate and height of lisianthus seedling

Treatment	80% germination (Days)	Two pair leaves (Days)	Survive rate (%)	Rosetting rate (%)	Seedling height (cm)
LED light spectrum					
W	15.4 a	34.2 c	89.7 b	9.5 b	4.4 a
B	14.8 a	39.6 a	86.6 c	10.1 a	3.9 b
R	11.2 b	35.8 b	91.9 a	7.4 c	4.5 a
LSD	0.63	1.09	1.22	0.56	0.27
Lisianthus cultivars					
V_1	13.9 a	36.6 ab	89.1 ab	9.2 a	4.2 b
V_2	13.8 a	36.7 ab	88.9 b	9.3 a	4.1 bc
V_3	13.6 a	35.8 b	90.6 a	8.7 a	5.0 a
V_4	14.1 a	37.2 a	89.1 ab	8.8 a	3.8 c
LSD	0.79	1.09	1.56	0.72	0.34
CV%	4.40	2.28	1.33	6.12	6.07

Here, W: While LED, B: Blue LED, R: Red LED; and V_1: Arena Type 1 pure white, V_2: Double III pure white, V_3: Arena Type I Light pink, V_4: Super Magic Type Blue

Days to 80% seedlings of 2 paired leaves stage

Different light spectrums had significant impact on emerging 80% 2 paired leaves of Lisianthus seedling. It was observed that the lowest days (34.2) were required in White LED light than Red LED light (35.8 days) and highest days (39.6) needed in Blue LED light (Table 01). Varieties used in this experiment differ significantly on days to 80% seedlings of 2 paired leaves stage. The data indicated that the least days (35.8) required in V_3, while the maximum days (37.2) required in V_4 (Table 01). In the case of days to 80% 2 paired leaves stage, the data indicated that there was significant variation

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observed influenced of Treatment combination. Maximum days (40.3) required to 80% 2 paired leaves in V_4B, which is statistically similar with V_1B and V_3B, while the minimum days (33.3) required in V_3W (Table 02).

LED light spectrums on Rosetting (%)

The Rosetting percentage of Lisianthus seedlings varied in response to the type of LED light used. The highest number of rosetted seedlings (10.1) was found in Blue light, followed by a slight decrease (9.5) in White light, and the lowest (7.4) in Red light (Table 01). Statistical analysis showed that variety has not showed any significant influence on Rosetting percentage (Table 01).

LED light spectrums on Survival (%)

Under different LED lights, there was a significant difference in the survival percentage of Lisianthus seedlings. The findings showed the highest survival % (91.9) found under Red LED and lowest survival % (86.6) found in Blue LED (Table 01). The statistical analysis of the data observed from performance of variety on survival % revealed that the highest survival % was in V_3 (90.6), the second highest was in V_1 and V_4 (89.1), and the lowest survival % was in V_2 (88.9) (Table 02). Because of the interaction effect, V_3R had the maximum (93.0) survival %, while V_2B had the minimum (85.3) (Table 02).

LED light spectrums on Seedling height

In the case of seedling height under Red LED (4.5 cm) and White LED (4.4 cm) recorded statistically similar results and minimum showed in Blue LED (3.9 cm) (Table 01). Our results were correlated with those of Behnaz Akbarian et al., (2016). They stated that Zinnia and impatiens both showed a significant increase in stem elongation when exposed to Red light. A large number of studies have reported that Blue light has an inhibitory effect on stem elongation. Randall and Lopez, on the other hand, carried out their experiment in a greenhouse with natural light. The Blue light reduces stem elongation, limiting photon capture and biomass accumulation while increasing leaf thickness and chlorophyll concentration (Wollaeger and Runkle, 2014). Among the varieties used in the experiment showed significant performance on the Seedling height. The highest value (5.0 cm) was recorded in V_3, V_1 and V_2 have pretty similar results 4.2 cm and 4.1 cm. Among four varieties V_4 attained the lowest height (3.8 cm) (Table 02). The findings showed that there was significant variation in seedling height due to the interaction effect. Maximum height (5.3 cm) was found in V_3R, while the minimum height (3.4) was observed in V_2B which is statistically similar in V_4W (Table 02).

Table 02. Interaction effect of Light spectrums and performance of lisianthus cultivars on days to seed germination, days to two pair leaves, survive rate, rosette rate and seedling height

Treatment	80% germination (Days)		Two pair leaves (Days)		Survive rate (%)		Rosetting rate (%)		Seedling height (cm)	
V_1W	15.7	a	34.3	cd	89.7	a-d	9.7	a	4.6	a-c
V_1B	14.7	a	39.7	a	86.7	de	10.3	a	3.7	de
V_1R	11.3	b	35.7	cd	91.0	a-c	7.7	b	4.5	bc
V_2W	15.3	a	34.7	cd	89.0	b-d	9.7	a	4.5	bc
V_2B	14.7	a	39.7	a	85.3	e	10.7	a	3.4	e
V_2R	11.3	b	35.7	cd	92.3	ab	7.7	b	4.4	b-d
V_3W	15.0	a	33.3	d	91.0	a-c	9.3	a	5.1	ab
V_3B	14.7	a	38.7	ab	87.7	c-e	9.7	a	4.7	a-c
V_3R	11.0	b	35.3	cd	93.0	a	7.0	b	5.3	a
V_4W	15.7	a	34.7	cd	89.3	b-d	9.3	a	3.6	e
V_4B	15.3	a	40.3	a	86.7	de	9.7	a	3.9	c-e
V_4R	11.3	b	36.7	bc	91.3	ab	7.3	b	3.9	c-e
LSD	1.81		2.47		3.53		1.63		0.27	
CV %	4.40		2.28		1.33		6.12		6.07	

Here, W: While LED, B: Blue LED, R: Red LED; and V_1: Arena Type 1 pure white, V_2: Double III pure white, V_3: Arena Type I Light pink, V_4: Super Magic Type Blue

LED light spectrums on Leaf Number

The statistical analysis of the data acquired from the influence of LED light on the leaf no. of Lisianthus seedlings revealed that the White LED and Red LED produced the highest leaf no. (10.2), however, the

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Blue LED produced the lowest leaf number (8.3) (Table 03). These results are in close agreement with studies by Yanagi et al., (1996) who showed that lettuce plants grown under R LEDs had more leaves. Studies by Behnaz Akbarian et al., (2016) observed a similar result for Petunia but they found reverse results for impatiens and verbena, this could be because different cultivars were used. Consequently, the effect of light quality on leaf number may vary based on the species and cultivars. Our results are also correlated with those of Ryu et al., (2012). They observed that the Number of leaves was significantly increased by LED treatment, and red LED treatment was most effective in promotion of number of leaves. The number of leaves on Lisianthus varied depending on the variety. The highest number of leaves was found in V_3 (10.2) and the second highest number was found in V_2 (10.0). V_4 had the lowest score (8.4), while V_3 had the highest (Table 03). When Furthermore, a combination of them, the highest number (11.3) of leaves was observed in V_3W and the lowest number (8.0) was observed in V_4B (Table 04).

LED light spectrums on Leaf length

Leaf length of Lisianthus seedling varied with different LED lights. The longest leaf (2.2 cm) was recorded in W, which was statistically similar with R and the shortest (1.9 cm) in B (Table 03). Variation of Leaf length among the four Lisianthus varieties was observed. The highest (2.4) leaf length was found in V_3 which is statistically similar to V_1 and the lowest leaf length was found in V_4 (1.9) which was statistically similar to V_2 (Table 03). Statistically, significant variation was found in the combined effect of LED light and Varieties on Leaf length of Lisianthus. The highest (2.6 cm) leaf length was observed by the treatment combination of V_3R and the lowest (1.8 cm) was obtained from V_4B which is statistically similar to V_1B (Table 04).

LED light spectrums on Leaf width

The leaf width of Lisianthus seedlings varied in response to the type of LED light used. The largest leaf (1.0 cm) was found in R, while the smallest leaf (0.9 cm) was found in B (Table 03). This result is correlated with Kim et al., (2013) where they observed that red light increased leaf width. Leaf width varied significantly among the four Lisianthus varieties. The largest leaf width (1.1 cm) was observed in V_4, while the smallest leaf width was noticed in V_3 (0.87) (Table 03). The combined effect of LED light and Varieties on the leaf width of Lisianthus revealed statistically significant variation. The treatment combination of V_4R resulted in the largest leaf width (1.14 cm), while V_3B resulted in the smallest leaf width (0.9 cm) (Table 04).

Table 03. Light spectrum impact and performance of lisianthus cultivars; on leaf number, leaf length, leaf width, root number and root length of lisianthus seedling

Treatment	Leaf number		Leaf length (cm)		Leaf width (cm)		Root number		Root length (cm)	
LED light spectrum										
W	10.2	a	2.2	a	0.9	b	12.2	a	3.8	a
B	8.3	b	1.9	b	0.9	b	9.7	c	3.5	b
R	10.2	a	2.2	a	1.0	a	11.3	b	3.9	a
LSD	1.04		0.19		0.06		0.68		0.12	
Lisianthus cultivars										
V_1	9.6	ab	2.0	a	1.0	b	10.2	b	3.6	b
V_2	10.0	a	2.1	b	0.9	bc	11.6	a	3.6	b
V_3	10.2	a	2.4	a	0.8	c	12.1	a	3.9	a
V_4	8.4	a	1.9	b	1.1	a	10.3	b	3.8	a
LSD	1.32		0.24		0.08		0.87		0.16	
CV%	10.57		8.8		5.96		5.98		3.18	

Here, W: While LED, B: Blue LED, R: Red LED; and V_1: Arena Type 1 pure white, V_2: Double III pure white, V_3: Arena Type I Light pink, V_4: Super Magic Type Blue

LED light on spectrums Number of root/plant

Under different LED lights, there was a significant difference in the number of roots. The highest number of roots (12.2) was found in W, followed by a slight decrease (11.3) in R, and the lowest (9.7) in B (Table 03). The statistical analysis of the data obtained from the performance of variety on root number revealed that V_3 (12.1) had the highest number of roots, V_2 (11.6) had the second highest

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number, and V_1 (10.2) and V_4 (10.3) had the lowest number (Table 03). As a result of the interaction effect V_3W (13.7) has the most roots, while V_1B has the fewest (9.3) V_1R (9.7) and V_4B (9.3) have statistically similar results (Table 04).

LED light spectrums on Root Length

The root length of a Lisianthus seedling varied with the intensity of the LED light. Red light had the longest root length (3.9 cm) which is statistically similar to White, and Blue had the shortest (3.5 cm) (Table 03). In the study of Effects of LED Light on Seed Emergence and Seedling Quality of Four Bedding Flowers, Behnaz Akbarian et al., (2016) stated that the root length of Zinnia in Red light was larger than Blue light. In zinnia and verbena the BR light produced longer roots than Fl light. In petunia, the B, R and BR light remarkably increased the root length compared to Fl light. Our findings are also consistent with those of Ryu et al., (2012). During the entire growth period, they reported a significant increase in root length with red LED treatment. The statistical analysis of the data observed from performance of variety on root length revealed that the longest root length was in V_3 (3.9 cm), the second longest was in V_4 (3.8 cm), and the shortest length of root was in V_1 (3.6), which is statistically similar to V_2 (3.6) (Table 03). Because of the interaction effect V_1R and V_3W had the longest root lengths (4 cm), while V_1B had the shortest (3.2 cm) (Table 04).

Table 04. Interaction effect of Light spectrums and performance of lisianthus cultivars on leaf number, leaf length, leaf width, root number and root length of lisianthus seedling

Treatment	Leaf Number		Leaf length (cm)		Leaf width (cm)		Root Number		Root length (cm)	
V_1W	10.0	ab	2.1	a-c	0.96	b-e	11.7	b-d	3.6	bc
V_1B	8.0	b	1.8	c	0.91	c-e	9.3	e	3.2	d
V_1R	10.7	ab	2.1	a-c	1.02	a-d	9.7	e	4.0	a
V_2W	10.7	ab	2.2	a-c	0.94	c-e	12.7	ab	3.7	a-c
V_2B	8.7	ab	1.9	bc	0.9	c-e	9.7	e	3.4	cd
V_2R	10.7	ab	2.1	a-c	0.99	a-e	12.3	a-c	3.7	a-c
V_3W	11.3	a	2.4	ab	0.88	de	13.7	a	4.0	a
V_3B	8.7	ab	2.1	a-c	0.84	e	10.3	de	3.7	a-c
V_3R	10.7	ab	2.6	a	0.88	de	12.3	bc	3.9	ab
V_4W	8.7	ab	2.1	a-c	1.11	ab	10.7	de	3.8	ab
V_4B	8.0	b	1.8	c	1.06	a-c	9.3	e	3.7	a-c
V_4R	8.7	ab	1.9	c	1.14	a	11.0	c-e	3.9	ab
LSD	2.99		0.55		0.17		1.96		0.35	
CV %	10.57		8.8		5.96		5.98		3.18	

Here, W: While LED, B: Blue LED, R: Red LED; and V_1: Arena Type 1 pure white, V_2: Double III pure white, V_3: Arena Type I Light pink, V_4: Super Magic Type Blue; *Within line, means followed by the same letter are not significantly different according to Tukey's honestly (0.05)

IV. Conclusion

According to this research, the morphological characteristics of different Lisianthus cultivars may be affected differently depending on light spectrum. The quality of seedlings grown with Red LED light spectrum was generally better (Seedling height, Leaf number, Leaf length, root number and survival percentage). Under Red light, Arena Type Pure I Light pink (V_3) seedlings displayed the best quality. The emergence of seedlings was improved by Red light spectrum. Plant growth inhibitors and other height-suppressing strategies can be eliminated with the development of LED lighting systems with effective spectra. Furthermore, seedling morphology does not always indicate whether or not a seedling will survive transplantation. Combining morphological measurements with a suitable measure of physiological quality could lead to improved transplanting performance. So, using LED light to improve plant growth in controlled environments is a viable option.

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