DOI : https://doi.org/10.58993/ijh/2023.80.2.7

Indian J. Hortic. 80(2), June 2023: 171-176

Influence of shade levels on morpho-physiological characteristics of potted spathiphyllum

B. K. Tejukumar*[1], Parminder Singh, V. M. Hiremath, Shalini Jhanji, R. K. Dubey and Pooja A.
Department of Floriculture and Landscaping, Punjab Agricultural University, Ludhiana-141004, Punjab, India.

ABSTRACT

The intensity of the shade is a critical factor in the production of potted spathiphyllum. Plants were grown in various levels of green coloured shade net to assess the growth response regarding vegetative, flowering, and physiological characteristics. The results showed that under 75 % shade, spathiphyllum plants exhibited the most significant plant spread, petiole girth, leaf thickness, leaf number, and leaf length. Likewise, spathe characters such as length, width, diameter, and the number of blooms were recorded highest at 75 % shade level. Similarly, the fresh weight and dried weight of the leaves were also found to be significant. Foliage chlorophyll content and foliage longevity increased linearly with increasing shade. Shade levels improved the spathiphyllum's foliage colour, an essential characteristic of indoor plants. It is concluded that using shade nets with a shade intensity of 75% would result in better growth and production of potted spathiphyllum, allowing farmers to earn more income.

Keywords: *Spathiphyllum cochlearispathum,* Shade level, Spathe, Vase life, Indoor plant.

INTRODUCTION

Spathiphyllum cochlearispathum (Liebm.) Engl. is a herbaceous ornamental plant that belongs to the family *Araceae* and originated from the tropical region of Central America. It is characterized by dark green glossy foliage, hood-shaped white spathe, and cream or white spadix embedded with tiny hermaphrodite flowers. Due to its inflorescence characteristics, it is popularly known as the peace lily, white Anthurium, and snow flower. It has been widely used as an indoor plant and cut flower. Peace lilies are easy to grow, tolerate average household temperatures, grow under diffused light, and even achieve remarkable growth under fluorescent lights. Recently, NASA has recognized it as a popular phytoremediator for its ability to ameliorate the effect of harmful toxic gases such as formaldehyde, carbon monoxide, and benzene from the indoor environment (Chen *et al.,* 2). Indoor plants are recognized as specific in shade requirements for growth and flowering. When studying microclimate modification under different shade nets, Shao et al. (10) noticed crop-specific responses to different shade levels. In such plants, shade factor dramatically influences the full expression of the phenotypic characteristics and productivity. Spathiphyllum is a tropical indoor plant and requires low light intensity for plant growth. Excessive light level bleaches the foliage colour, whereas low light encourages better growth and quality foliage in indoor plants.

In regions facing high light intensity, the nurserymen and the farmers use shade nets to provide the required low light and temperature for light-sensitive plants. The spectral quality of light the plants receive can significantly affect their physiology, morphology, and growth rate. Shade nets in the market may vary in capacity (15 %, 35 %, 40 %, 50 %, 75 %, and 90 %) to transmit light inside the shade house. In this regard, it has become imperative to standardize the shade levels (or shade nets) before merely growing plants inside the shade houses from the commercial point of view. In this direction, optimum shade levels for different indoor foliage plants have been investigated in *Aspidistra elatior* (Stamps, 13), *Ficus benjamina* and *Codiaeum variegatum* (Scuderi *et al*., 9), *Dracaena sanderiana* (Srikrishnah *et al*., 12), *Cordyline terminalis* and *Dracaena fragrans* (Gaurav *et al*., 5). Studies on standardization of shade requirement for growing *Spathiphyllum* under different shade nets have been rarely investigated. Thus, the influence of shade levels on vegetative, flowering, and physiological characteristics in potted Spathiphyllum was investigated to understand their effect on growth patterns and to determine optimal shade levels for commercial use.

MATERIALS AND METHODS

A pot experiment was conducted at the Research Farm of the Department of Floriculture and Landscaping, Punjab Agricultural University,

*Corresponding author: tejukumar1995@gmail.com
[1]Division of Floriculture and Landscaping, ICAR-IARI, New Delhi- 110012, Delhi, India

Ludhiana, during 2018-19. Clean clay pots of 8-inch size (upper diameter - 20 cm, bottom diameter - 10 cm, perpendicular height - 20 cm, volume - 0.0035 cum) were selected for potting. One-month-old healthy and disease-free *Spathiphyllum* plants were potted with the media comprised of soil and farmyard manure in the 1:1 ratio. Potted *Spathiphyllum* plants were kept under four different green coloured shade nets with their respective shade levels *viz*., 35 % (T1), 50 % (T2), 75 % (T3), and 90 % (T4) as treatments (Fig. 2). The experiment was replicated thrice with twenty plants each. Plants were grown in pots with uniform cultivation practices and monitored for expression of characteristics during the growing period. The morphological data were recorded on vegetative characteristics viz, plant height (cm), plant spread (cm), petiole girth (mm), leaf thickness (mm), number of leaves, leaf length (cm), leaf breadth (cm) and petiole length (cm) and flowering characteristics *viz*, flower stalk length (cm), spathe length (cm), spathe width (cm), number of flowers per plant, spathe diameter (mm), number of days to flowering (days) and flower vase life (days). In addition, physiological parameters viz, chlorophyll content, fresh weight (g), dry weight (g), and foliage vase life (days) was also measured. All the above characteristics were recorded during the flowering stage. Foliage colour was recorded under full sunlight using RHS colour chart (Sixth revised edition, Royal Horticultural Society, UK). Leaf chlorophyll content was measured using a Minolta chlorophyll meter (Model SPAD 502) by taking an average of 10 plants. The experiment was laid out in a Completely Randomized Design (CRD), and significance at $P \leq 0.05$ was assessed by analysis of variance (ANOVA) using SPSS® v25. Software.

RESULTS AND DISCUSSION

The *Spathiphyllum* plants grown under different shade levels exhibited significant visual differences in the expression of vegetative characters (Table 1). Plant height was found to be highest (29.85 ± 1.16cm) under 90 % shade (T4), and it was at par with T2 (50% shade) and T3 (75% shade). At the same time, the lowest plant height (17.15 ± 0.66 cm) was observed in T1 (35 % shade). The plants grown under low light levels were found to show more apical dominance than those grown under high light intensities (Godi *et al*., 6). Increased auxin movement under low light increases cell elongation below the apical meristem. The results conform with the findings of Hlatshwayo and Wahome (7) in carnation, Khawlhring *et al.* (8) in Anthurium, and Singh *et al.* (11) in Boston fern.

Similarly, plant spread was recorded as the highest (35.37 ± 1.50 cm) in T3, and it was at par with T2 and T4 when compared to T1 (17.71 ± 0.60 cm). This result conforms to the report by Singh *et al.* (11) in *Nephrolepis exaltata* (L.). The lowest plant spread under 35 % shade was attributed to higher absorption of photosynthetically active radiations (PAR), which enhanced the photosynthetic rate compared to higher shade levels (Thakur and Kumar, 15). Leaf petioles were broad (3.33 ± 0.06 mm) in T3 and were at par with T2. In contrast, petioles were narrow in T1. Leaf petioles were longer (15.06 ± 0.40 cm) in T3 and differed significantly from other treatments. This result conforms to the study of Gaurav *et al*. (5), in which leaf petioles of cordyline were more prominent under 90 % shade. An increase in the petiole length of *Centella asiatica* under shade was also reported by Devkota and Jha (3). The ratio of R to FR light (R:FR) influences growth attributes of floriculture crops, including branching and elongation of stems and leaves. Plants show "shade avoidance response (SAR)" under shade, by which they position their leaves to capture more R light, consequently changing their growth. Thus, a low R:FR induces stems, leaves, and petioles to elongate while lateral branching is inhibited. It also increases petiole and leaf length, decreases the leaf mass per leaf area

Table 1. Influence of shade levels on vegetative characters of potted Spathiphyllum.

Characteristics	Treatments				C.D. (0.05)	CV (%)
	T_1 (35%)	T_2 (50%)	T_3 (75%)	T_4 (90%)		
Plant height (cm)	17.15^{b} ± 0.66	29.25^{a} ± 0.19	29.75^{a} ± 0.55	29.85^{a} ± 1.16	2.20	5.97
Plant spread (cm)	17.71^{b} ± 0.60	33.29^{a} ± 1.01	35.37^{a} ± 1.50	34.24^{a} ± 1.32	4.04	9.62
Petiole girth (mm)	1.98^{c} ± 0.18	3.19^{a} ± 0.15	3.33^{a} ± 0.06	2.74^{b} ± 0.12	0.37	9.53
Petiole length (cm)	6.38^{c} ± 0.41	12.84^{b} ± 0.30	13.12^{b} ± 0.31	15.06^{a} ± 0.40	1.05	6.40
Leaf thickness (mm)	0.22^{c} ± 0.01	0.25^{b} ± 0.01	0.29^{a} ± 0.01	0.24^{bc} ± 0.00	0.02	8.06
No. of leaves	18.30^{b} ± 0.71	23.80^{a} ± 1.33	27.20^{a} ± 2.89	17.05^{b} ± 1.73	5.41	7.99
Leaf length (cm)	9.82^{b} ± 0.51	15.99^{a} ± 0.66	17.12^{a} ± 0.32	17.01^{a} ± 0.76	1.72	8.26
Leaf breadth (cm)	3.12^{b} ± 0.23	6.75^{a} ± 0.24	6.76^{a} ± 0.24	6.89^{a} ± 0.45	0.67	8.27

(LMA), and reduces both the leaf chlorophyll content and the chlorophyll *a*:*b* ratio (Evans and Poorter, 4). Leaf thickness was maximum (0.29 ± 0.01mm) in T3 and significant from other treatments. In a similar line of study, Gaurav *et al.* (5) recorded the highest harvest index and leaf fresh weight under 75 % shade level. A specific leaf cell type, the palisade mesophyll, contributes to increased thickness in a desert-adapted wild species which might be the reason for increased leaf thickness in this shade-adapted crop. The highest number of leaves (27.20 ± 2.89) was recorded in T3, which was at par with T2. In a similar study, *Nephrolepis exaltata* (L.) Schott cv *bostoniensis* recorded the highest number of fronds under 75 % shade intensity (Singh *et al.,* 11). Light capturing ability and chlorophyll content of leaves are reported to be high in shade conditions. The most extended leaves (17.12 ± 0.32cm) were measured in T3, while the same was found at par with T2 and T4. Leaves were shortest (9.82 ± 0.51 cm) in T1. T4 had the widest (6.89 ± 0.45cm) leaves compared to T2 and T3, yet it was at par with T2 and T3. Leaf width was lowest (3.12 ± 0.23cm) in T1. Similar findings were recorded in Boston fern (Singh *et al*., 11) and Anthurium (Agasimani *et al.,* 1) under increased shade levels. Low light conditions persuade cell expansion to capture more light for photosynthesis. Hence, high shade levels influence changes in leaf characteristics.

The analysis of data (Table 2) revealed that shade levels substantially impact the flowering characteristics of the spathiphyllum. The blooms had the longest (25.40 ± 0.51 cm) stalks in T4 (90 % shade), which was at par with T3. At the same time, T1 had shorter (19.80 ± 0.86) flower stalks. Gibberellins (GA3), a potential growth hormone, plays a key role in cell division and elongation. GA3 could have increased stalk length due to the hydrolysis of stored food reserves in response to increased shade. Spathes were longest (7.50 ± 0.22 cm) in T3, which was found at par with T2 and T4. Shorter (7.50 ± 0.22 cm) spathes were recorded in T1. T3 had the widest (4.80 ± 0.20cm) spathes at par with T2 and T4. In T1, narrow (3.80 ± 0.12 cm) spathes were observed. T3 had the most flowers (1.60 ± 0.24), whereas T1 had the least (1.00 ± 0.00) blooms. T3 had the largest spathe diameter (3.67 ± 0.04cm), at par with T4. The spathe diameter of T1 was the smallest (2.69 ± 0.08cm). Several authors have come up with similar conclusions to support the abovementioned assertions. Under 75 % shade, Sudhakar and Kumar (14) noticed higher rachis length, number of blooms per plant, and stalk length in Heliconium compared to open environment conditions. Zohurul (16) reported increased spathe length, breadth, and maximum vase life in white Anthurium under enhanced shade. In the same study, the intensity of the response to shade varied slightly across Zantedeschia cultivars. It was recommended that they be given 55 % shade to improve scape length and spathe breadth. Further, the treatments had no significant differences in the number of days to flowering and the life of the flowers in the vase.

Shade levels considerably influenced the physiological parameters of potted spathiphyllum (Fig. 1). Under 75 % shade level (T3), maximum leaf fresh weight (2.66 ± 0.04 g) was measured, close to T2 and T4. T3 had the highest dry leaf weight (0.65 ± 0.03g) significantly higher than the other treatments. Our findings are supported by Gaurav *et al.* (5) in Cordyline and Singh *et al.* (11) in Boston Fern. On the other hand, Srikrishnah *et al*. (12), reported lower plant biomass under higher shade levels. Shading could have increased the amount of chlorophyll, increasing photosynthetic efficiency and, as a result, yield attributes. Plants grown in 75% shade received optimal light for development, resulting in increased growth and carbon assimilation rates

The highest SPAD value (53.22 ± 0.92) was found in 90 % shade (T4), showing increased chlorophyll

Table 2. Influence of shade levels on flowering characters of potted Spathiphyllum.

Characteristics	Shade levels				C.D. (0.05)	CV (%)
	T_1 (35%)	T_2 (50%)	T_3 (75%)	T_4 (90%)		
Flower stalk length (cm)	19.80^{c} ± 0.86	22.20^{b} ± 0.37	24.00^{a} ± 0.70	25.40^{a} ± 0.51	1.60	5.05
Spathe length (cm)	4.80^{b} ± 0.37	7.10^{a} ± 0.18	7.50^{a} ± 0.22	7.10^{a} ± 0.18	0.71	7.79
Spathe width (cm)	3.80^{b} ± 0.12	4.40^{a} ± 0.18	4.80^{a} ± 0.20	4.70^{a} ± 0.12	0.55	8.99
No. of flowers per plant	1.00^{b} ± 0.00	1.00^{b} ± 0.00	1.60^{a} ± 0.24	1.20^{ab} ± 0.20	0.45	17.42
Spathe diameter (cm)	2.69^{c} ± 0.08	3.48^{b} ± 0.01	3.67^{a} ± 0.04	3.65^{a} ± 0.05	0.16	3.55
No. days to flowering	76.20^{a} ± 0.49	76.40^{a} ± 0.92	75.20^{a} ± 0.80	76.40^{a} ± 0.67	NS	1.98
Flower vase life (days)	2.00^{a} ± 0.31	2.00^{a} ± 0.31	2.60^{a} ± 0.24	2.20^{a} ± 0.20	NS	20.21

NS – Non significant

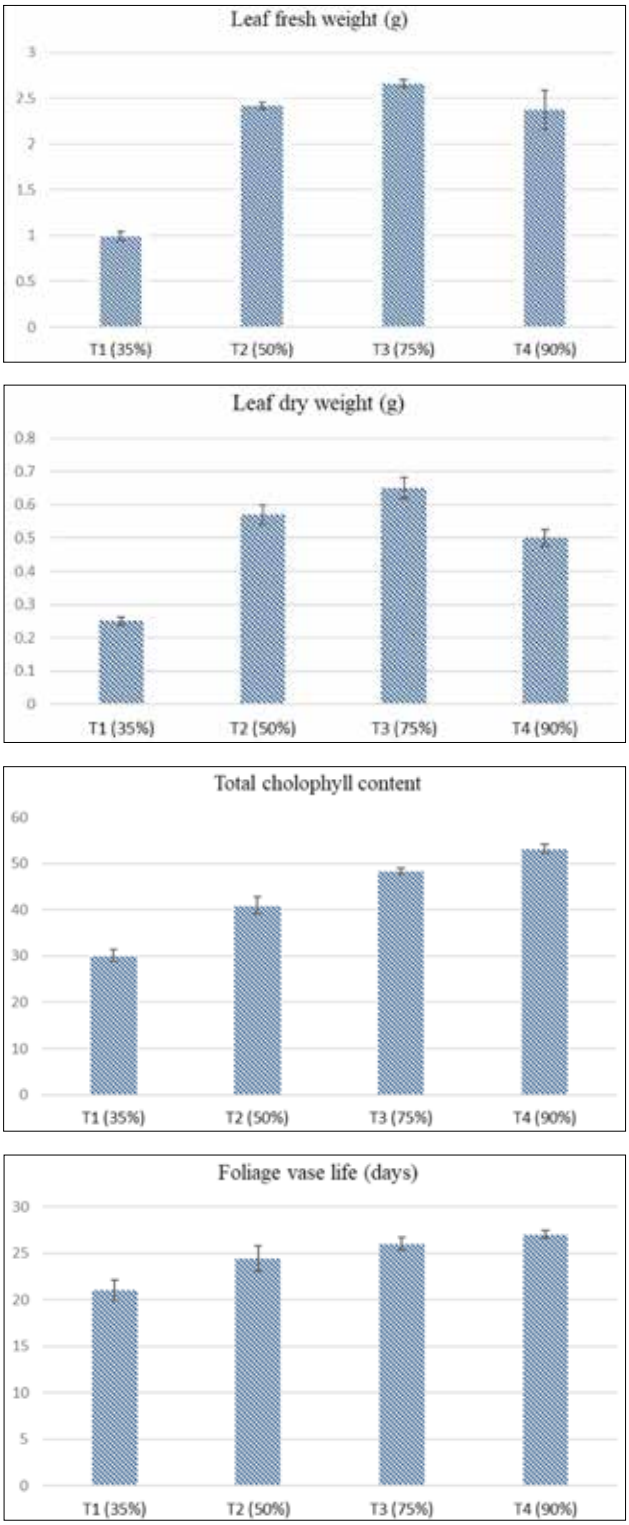

Fig. 1. Influence of shade levels on physiological characteristics of potted spathiphyllum.

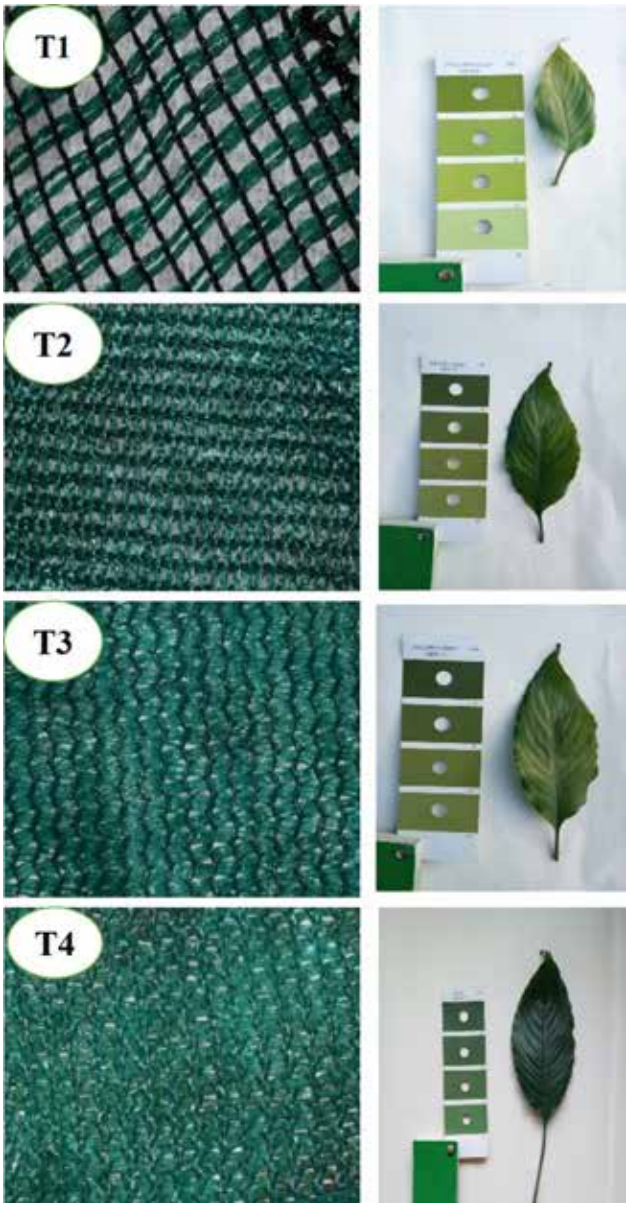

Fig. 2. Shade nets representing various shade levels (T1-35%, T2-50%, T3-75%, and T4-90%) and foliage colour were observed using RHS colour chart.

concentration concerning increased shade levels, indicating that as shade levels increased, so did chlorophyll concentration. The leaf chlorophyll content controls the photosynthetic rate and dry matter production. Plants growing in 90 % shade had dark green leaves compared to other treatments. Foliage colour was recorded for each treatment using RHS colour chart *viz*., T1– Yellow-Green Group 144A, T2– Yellow-Green Group 146A, T3– Yellow-Green Group 146B, T4– Green Group 137A (Fig. 2). Higher light intensities cause the degradation of chlorophyll.

As a result, the leaves become pale. Our results were consistent with reports of Gaurav *et al.* (5) in cordyline. Foliage colour is an essential characteristic of indoor plants. The amount of chlorophyll in the leaves could be directly proportional to the colour of the foliage. The significant increase in leaf chlorophyll content under 90 % shade demonstrated the plant's ability to maximize light harvesting capacity in low-light growth conditions. Foliage longevity increased in tandem with higher shade levels. The vase life of T4 foliage was 27.0 ± 0.44 days, which was at par with T2 and T3. Increased foliage longevity under higher shade levels is due to higher chlorophyll content, photosynthesis rate, fresh weight, and relatively low transpiration rate in plants grown under shade conditions. Stamps (13) reported that *Aspidistra elatior* and *Ruscus* plants have a linear increase in vase life with increasing shade level. The vase life determines the commercial use of cut foliage, and higher vase life is always preferred in commerce.

The right amount of shade is crucial for the growth and development of potted plants. *Spathiphyllum cochlearispathum*, is a shade-tolerant, low light-requiring plant. Shade nets provide an ideal growing environment for the successful cultivation of *Spathiphyllum* plants. Optimum shade levels determine yield and productivity, which help the farmers to earn more income. In this study, plants performed best under 75% shade level for most of the vegetative (plant spread, petiole girth, leaf thickness, leaf number, leaf length), flowering (spathe length, spathe width, spathe diameter, number of flowers per plant) and physiological (leaf fresh weight and leaf dry weight) characteristics. Plant height, petiole length, leaf breadth, flower stalk length, chlorophyll content, and foliage vase life were all significant in 90 % shade. It was, however, comparable to a shadow level of 75%. Shade intensity greater than 75 % may affect the net photosynthesis rate and cause plant growth to decline. Thus, 75 % shade intensity is optimal for producing container-grown spathiphyllum plants.

AUTHORS' CONTRIBUTION

Conceptualization of research (PS, RKD); Designing of the experiments (PS, SJ, TBK); Contribution of experimental materials (PS, SJ, RKD); Execution of field/lab experiments and data collection (TBK); Analysis of data and interpretation (TBK, VMH, PA); Preparation of the manuscript (TBK, VMH, PS). All the authors read the manuscript and approved the final draft of it.

DECLARATION

The authors declare that they have no conflict of interest.

ACKNOWLEDGEMENT

The first author gratefully acknowledges ICAR, New Delhi, for providing Junior Research Fellowship for postgraduate study. The first author also expresses sincere gratitude to the Department of Floriculture and Landscaping, Punjab Agricultural University, Ludhiana, for providing research facilities for his research work.

REFERENCES

1. Agasimani, A. D., Harish, D. K. and Imamsaheb, S. J. 2011. Anthurium varieties performance and economics under greenhouse. *Res. J. Agril. Sci*. **2**: 226-29.

2. Chen, J., McConnell, D. B., Henny, R. J. and Everitt, K. C. 2003. Cultural guidelines for Commercial production of interiorscape Spathiphyllum. EDIS, **18**: 1-6.

3. Devkota, A. and Jha, P. K. 2010. Effects of different light levels on the growth traits and yield of *Centella asiatica. Middle-East J. Sci. Res.* **5**: 226-310.

4. Evans, J. and Poorter, H. 2001. Photosynthetic acclimation of plants to growth irradiance: the relative importance of specific leaf area and nitrogen partitioning in maximizing carbon gain. *Plant Cell Environ.* **24**: 755-67.

5. Gaurav, A. K., Raju, D. V. S., Janakiram, T., Singh, B., Jain, R. and Gopala Krishnan, S. 2015. Effect of shade levels on production and quality of *Cordyline terminalis. Indian J. Agric. Sci.* **85**: 931-35.

6. Godi, V., Manohar, K. R. and Kumari, V. R. 2018. Effect of different coloured shade nets with varying shade intensities on growth parameters of Tomato (*Solanum lycopersicum* L.) var. Arka Rakshak. *Int. J. Pure. App. Biosci.* **6**:142-46.

7. Hlatshwayo, M. S. and Wahome, P. 2010. Effects of shading on growth, flowering and cut flower quality in carnation (*Dianthus caryophyllus*). *J. Agric. Soc. Sci.* **6**: 34-38.

8. Khawlhring, N., Thanga, J. L. T. and Lalnunmawia, F. 2012. Plant performance of *Anthurium andreanum* as affected by shade conditions and different conventional nutrient sources. *J. Hortic. For.* **4**: 22-26.

9. Scuderi, D., Li Rosi, A., Cassaniti, C., Paratore, A. and Romano, D. 2007. The influence of shading

levels on foliage plant growth and quality. *Acta Hortic.* **801**: 1191-96.

10. Shao, Q., Wang, H., Guo, H., Zhou, A., Huang, Y., Sun, Y. and Li, M. 2014. Effects of shade treatments on photosynthetic characteristics, chloroplast ultrastructure, and physiology of *Anoectochilus roxburghii*. *PloS one*, **9**:e85996.

11. Singh, P., Dubey, R. K. and Singh, K. 2014. Effect of shade levels on growth and frond production in Boston fern (*Nephrolepis exaltata* (L.) Schott). *Asian J. Hortic.* **9**:377-81.

12. Srikrishnah, S., Sutharsan, S., Thanusha, R. and Paskaran, A. 2017. Effect of graded shade levels on the growth and qualities of *Dracaena sanderiana var. '*Celes'. *Res. J. Agric. For. Sci.* **5**: 1-4.

13. Stamps, R. H. 1995. Effects of shade level and fertilizer rate on yield and vase life of *Aspidistra elatior* 'Variegata' leaves. *J. Env. Hortic.* **13**: 137-39.

14. Sudhakar, M., and Ramesh Kumar, S. 2012. Effect of different shading conditions on growth, flowering and yield of heliconium (*Heliconia* sp) cv. Golden torch. *The Asian J. Hortic.* **7**: 512-14.

15. Thakur, M., Bhatt, V. and Kumar, R. 2019. Effect of shade level and mulch type on growth, yield and essential oil composition of damask rose (*Rosa damascena* Mill.) under mid hill conditions of Western Himalayas. *PLoS. One*, **14**, e0214672.

16. Zohurul, K. R. 2014. Influence of partial shades on morpho-physiological characteristics of potted Anthurium. *M.Sc. Thesis*, Sher-e-Bangla Agricultural University, Dhaka.

Received : April, 2022; Revised : May, 2023;
Accepted : May, 2023