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Effects of Different Levels of Shade on the Growth and Quality Characters of Coleus (*Plectranthus scutellarioides*) var. "Chocolate Covered Cherry"

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Abstract

Coleus is an ornamental foliage shrub with multicolored leaves. Light intensity greatly influences quality of the coleus. A study was conducted at the Crop Farm, Eastern University, Sri Lanka to assess the effects different shade levels on the quality of coleus (*Plectranthus scutellarioides*) var. chocolate covered cherry form of May to September 2020. Five treatments were defined in this experiment viz. 40% (T1), 50% (T2), 60% (T3), 70% (T4), 80% (T5) of shade levels. Shade houses were constructed using commercial nylon nets of different shade level. Experiment was arranged in a completely randomized design with ten replications. Agronomic practices were followed uniformly for all treatments. Plant height, leaf area, plant biomass was measured at monthly interval and quality evaluated at the end of experiment. Analysis of variance was performed to determine significant difference among treatments ($p< 0.05$). Plants provided with 60% shading showed significantly ($p<0.05$) better performance in measured growth parameters viz. plant height, leaf area, and total biomass, while the lowest performance was observed in a plant grown at 40% (T1) and 80% (T5) shade level. In quality assessment, plants grown at 60% shade level (T3) received significantly the highest score. Further plants grown at 60% shade level showed attractive marketable qualities. It could concluded that, plants grown at 60% shade level would have received optimum light as the growth and quality of the plant was higher, and this shade level suitable for commercial-oriented cultivation of Coleus (*Plectranthus scutellarioides*)var. "chocolate covered cherry" in the Batticaloa district of Sri Lanka.

Keywords: ***Coleus; Plant height; Total biomass; Leaf area; Shade level***

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1. Introduction

Foliage ornamentals and cut flowers play vital role in the floricultural industry of Sri Lanka. Floricultural development includes a broad variety of plant materials and plants. Floriculture industry of Sri Lanka has developed to provide consistent supply of quality floriculture products across the world [1].Floriculture products are widely used in decoration as a-filler in floral compositions and provide freshness, colour and variety to arrangements and bouquets [2]. In Sri Lanka, agro-climatic diversity is very beneficial for the development of cut flowers foliage, and ornamentals [3].

Common Names of the *Plectranthus scutellarioides* are Coleus, painted nettle, Flame nettle, plus over a thousand cultivar names and Coleus is native to tropical Asia, Australia, and Africa and is an associate of the Lamiaceae (Labiatae) family, which includes an additional than 500 Species. Original species used in the early 1800s for coleus cultivation and hybridization were fairly simple in terms of color pattern diversity, leaf shape, and habit of growth. Coleus is a versatile annual plant that has been popular for decades in the commercial bedding plant industry and is highly valued for its vibrant and colorful foliage. Climatic conditions of dry zone are suitable to growing tropic growing tropical flowers and foliage ornamentals under appropriate conditions [4].

Shading delays flowering and produces more leaves in plants. Canopy controlling is an essential part of foliage cultivation for rising a well-managed healthy plant. The levels of shade affect the development and quality of ornamentally leafy plants [5]. Light is one of the greatest essential environmental factors for rising and developing plants [6]. Different light intensities influence plant production, the exchange of leaf gas, and the efficiency of water usage. Plants with better morphological characters and foliage quality were provided by shade nets of 50% shading strength [2]. Different shade levels greatly affected the quality and growth of plants. Further dracaena foliage subjected to 70% of shadow level received a superior score in quality assessment while lesser (80% of shade level) and greater (open sunlight) light levels reduced the development and superiority of dracaena plants [7]. Shade not only affects the quantity of light that plants receive but also changes certain small environmental elements, like air and ground temperature, humidity, concentrations of carbon dioxide (CO_2), and so on, which are critical for plant growth. The quality and growth in coleus are comparatively low because of undesirable agro climatic conditions.

Improvement of floricultural industry in Batticaloa district would furnish several benefits to the farming society. It will lead improvement of famers “livelihood and women employment” as well as contribute to national economy. Since Coleus (*P. scutellarioides*) var. “chocolate covered cherry” is a tropical shade loving plant, it is essential to find the optimum shade level for maximum quality of the plant. Because irradiance level is one of the major environmental factors that influence the biomass, leaf area, quality, chlorophyll, and plant growth [8]. Providing required amount of shade condition will enhance the quality of ornamental plants [5].

Therefore, scientific studies are needed to find the optimum shade condition for the cultivation of Coleus (*P. scutellarioides*) var. “chocolate covered cherry” in the Batticaloa district. Hence the objective of the study is to evaluate the effects of graded shade levels on the growth and quality of Coleus (*P. scutellarioides*) var. “chocolate covered cherry” in Batticaloa district of Sri Lanka.

2. Materials and Methods

Experimental Site: A shade house experiment was conducted form of May to September 2020 at the crop farm, Eastern University, Batticaloa (7.7944° N, 81.5790° E ecological zone DL2), Sri Lanka.

Treatments, Experimental Design and Plot Size: Experiment was arranged in a completely randomized design (CRD) and each treatment contained 10 replicates. Graded levels of shade were defined as treatments viz. 40% (T1), 50% (T2), 60% (T3), 70% (T4), and 80% (T5). Uniform, rooted and a month-old cuttings of Coleus (*P scutellarioides*) var. "chocolate covered cherry" were collected from a private nursery. The cutting were planted in black poly bags (1 feet diameter, 1 feet height) filled with a potting medium top soil and compost in a ratio of 1:1 (volume basis). Plants were arranged at a spacing of 10 plants per m^2.

Measurement and Data Gathering: Samples were collected randomly from each treatment. Plant height (cm), leaf area and plant biomass (g) were taken at monthly interval. Quality evaluation of experimental plants was done at Crop Science Laboratory by expert panellist. Criteria used for evaluation suggested by Conover and Poole [9].

Statistical Analysis: Treatment means were compared using Duncan Multiple Range Test (DMRT) at the 0.05 probability level. Scores obtained from the quality evaluation of plants were analyzed through Mood's Median Test at the 0.05 probability level.

3. Results and Discussion

3.1 Plant height

It was found that there were significant ($p<0.05$) differences in the plant height of coleus plants grown under different shade levels at 1 and 2 months after transplanting (MAT). The highest plant height was obtained in T3 (60% shade level) compared to other treatments at 1 and 2 MAT (FIG. 1).

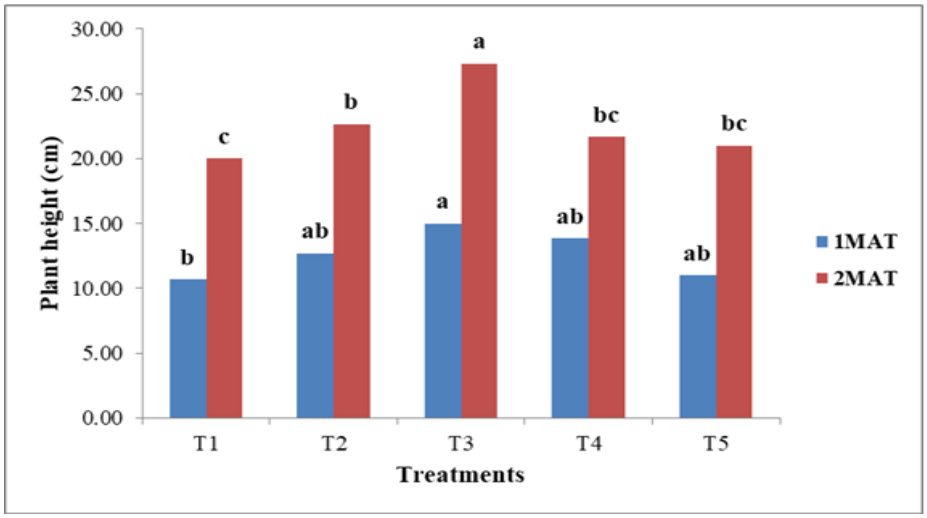

FIG. 1. **Plant height of *P. scutellarioides* var. "Chocolate covered cherry" under graded shade levels at 1 and 2 months after planting (MAT). Means followed by same letter within a month are not significantly different with the DMRT test at 5% level of probability (n=3).**

Several scientific studies reported that shading controls plant height. Light is an inevitable source for plant growth and development. Manaker [10] reported that optimum light level varies with different plants and both deficient and excessive light intensities are injurious. In this study, the influence of different shade levels on plant height was first noticed at one month after transplanting and difference among treatments persisted throughout the experimental period.

Hence, Coleus plants grown at 60% shade level (T3) showed maximum plant height whereas, lowest plant height was recorded in 40% (T1) and 80% (T5) shade levels at 2 MAT. Coleus is a shade loving plant. Zhang et al. [11] opined that for shade-loving plants, the acclimation to lower light intensities is usually associated with some distinctive morphological and physiological changes.

Coleus plants grown at 40% shade level (T1) had the lowest plant height at 1 and 2 MAT. Light is the ultimate substrate for photosynthetic energy conversion, however, it can also harm plants if it exceeds the optimum level [12]. Coleus prefers partial sunlight for optimum growth.

In T1, plants would have received an excess amount of irradiation above their requirement. It would cause light stress on the plant. It could be the reason for the reduction of plant height at 40% shade level. Coleus plants grown at 70% (T4) and 80% (T5) shade levels also had the lowest plant height at 1 and 2 MAT. High shade level affects plant growth by reducing photosynthesis. Plants grown at this shade level would have received a sub-optimum level of irradiation. This might be the reason for the lowest plant height observed in this treatment.

The highest plant height was obtained in 60% shade level (T3). The plants grown at 60% shade would have received optimum light for better growth. Optimum light level is important for maximum photosynthesis. Therefore, the plant height was increased and there were no symptoms of etiolation. Chen and Setter [13] reported that shade significantly influenced cell division. Thus, the plants exhibited the highest growth rate and plant height at this shade level.

The optimum shade level for maximum growth and development varies with plants. Srikrishnah et al. [4] reported that a 70% shade level is suitable for growing dracaena varieties in the dry zone of Sri Lanka. Krishnakanth et al. [14] reported that, 50% shade level is suitable for growing *C. fruticosa* var. 'Purple Compacta' in the Batticaloa district as the growth and quality of plants were higher. Hence results of this experiment revealed that 60% of shade levels are suitable for growing coleus plants in the Batticaloa district of Sri Lanka.

3.2 Leaf area per plant (cm^2)

It was found that there were significant ($p<0.05$) differences in the leaf area (LA) of coleus plants grown under different shade levels at 1 and 2 months after transplanting (MAT). Significantly ($p<0.05$) highest plant leaf area was obtained in T2 (50%) and T3 (60% shade level) compared with other treatments at 2 MAT (FIG. 2).

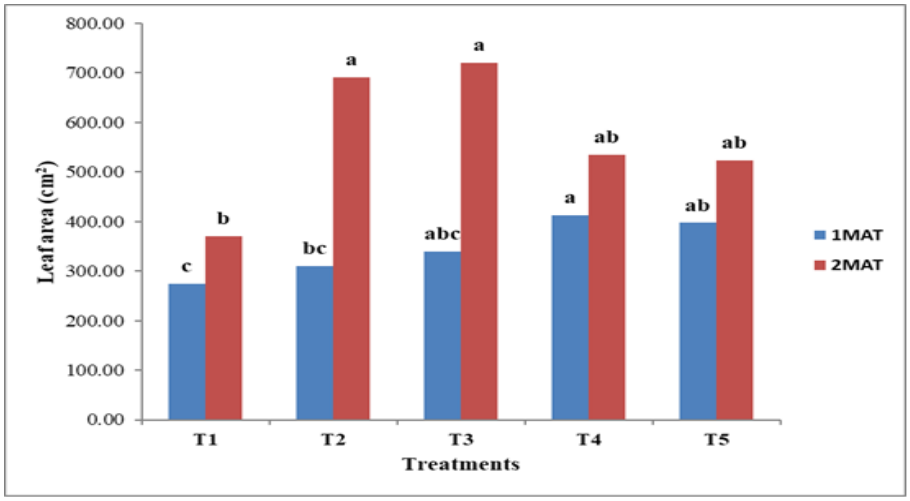

FIG. 2. **Leaf area of *P. scutellarioides* var. "Chocolate covered cherry" under graded shade levels at 1 and 2 months after planting (MAT). Means followed by the same letter within a month are not significantly different from the DMRT test at a 5% level of probability (n=3).**

Leaves are important organs for photosynthesis and play an important role in the growth of a plant. Leaf area is used to analyze the shade effect on plant growth as it associates directly with the photosynthetic surface area [15]. In this study, the influence of different shade levels on leaf area per plant was first noticed at one month after transplanting and difference among treatments persisted throughout the experimental period. Hence, Coleus plants grown at 60% shade level (T3) showed maximum leaf area whereas, lowest leaf area was recorded in 40% (T1) shade levels at 2 MAT.

Coleus plants grown at 40% shade level (T1) had the lowest leaf area at 1 and 2 MAT. In T1, plants would have received an excess amount of irradiation above their requirement. It would cause light stress on the plant. Coleus could be sensitive to higher irradiation levels. The energy cost for the plants to produce a given leaf area is high when shaded [16]. A leaf that was exposed to plenty of light had sufficient amounts of food and it does not need an excessive amount of chlorophyll. This enables the leaf to have a small surface area. The leaf area was found to be lowest in control, followed by 35% shade, 50% shade, 90% shade in the cordyline (*Cordyline terminalis*) [2]. Gunadasa and Dissanayake [17] pointed out that less leaf area has resulted in high light intensities in PBM (*Polyscias balfouriana* var. "Marginata"). The degradation of the photosynthetic pigments probably was responsible for the decrease of photosynthesis and subsequent growth. It could be the reason for the reduction of leaf area at 40% shade level. High irradiance levels induce suppression of photosynthetic productivity in many shade-loving plants [18].

Coleus plants grown at 70% (T4) and 80% (T5) shade levels also had the lowest leaf area at 2 MAT. High shade level affects plant growth by reducing photosynthesis. Plants grown at this shade level would have received a sub-optimum level of irradiation. This might be the reason for the lowest leaf area observed in this treatment. Xu et al. [19] reported that the leaf size became smaller with a short supply of light intensity. Zhang YJ, et al. [20] reported that irradiance less than that achieved in the 80% shade treatment limited carbon assimilation and led to decreased plant growth. Srikrishnah et al. [4] reported that Dracaena plants grown at 80% shade had reduced growth rate and leaf area as they were under light stress at this shade level.

Therefore plants grown at 80% and 70% shade had reduced growth rate and leaf area as they were under light stress at this shade level.

The highest leaf area was obtained in 60% shade level (T3). The plants grown at 60% shade would have received optimum light for better growth. Optimum light level is important for maximum photosynthesis. Devkota and kumer [21] conducted experiments on Centella asiatica under different light levels and found that the highest leaf area was under 70% shade level (optimum shade level). The shade level of 50% seemed to be preferable for optimum growth of the leaf area of turmeric in the Batticaloa district of Sri Lanka as the leaf area increased with time [22]. These findings showed that different plants have different levels of optimum shade levels for their maximum growth and development. Hence the results of this experiment revealed that 60% of shade levels are suitable for growing coleus plants in the Batticaloa district of Sri Lanka as the growth of leaf area was higher.

3.3 Total biomass (g)

It was found that there were significant ($p<0.05$) differences in the total biomass of coleus plants grown under different shade levels at 1 and 2 months after transplanting (MAT). Significantly ($p<0.05$) highest biomass was obtained in T2 (50%) and T3 (60% shade level) compared with other treatments at 2 MAT (FIG. 3).

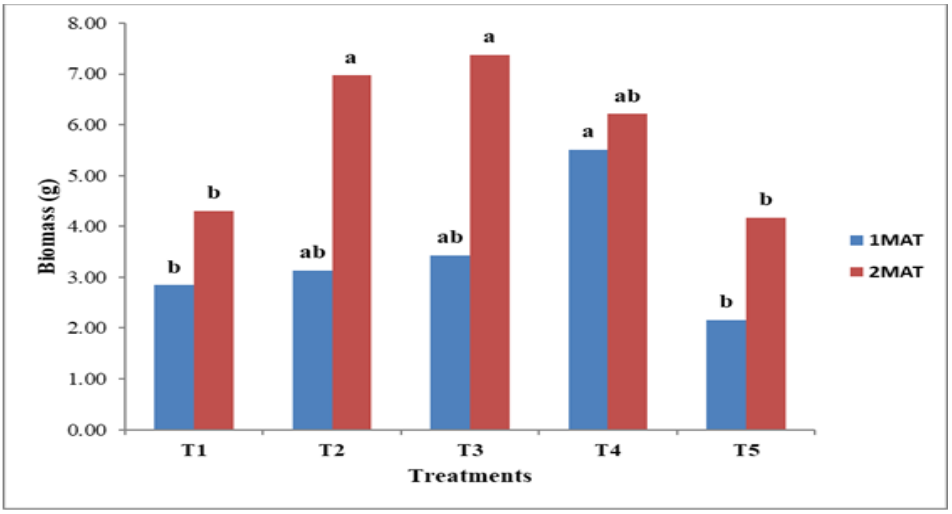

FIG. 3. **Total biomass of *P. scutellarioides* var. "Chocolate covered cherry" under graded shade levels at 1 and 2 months after planting (MAT). Means followed by the same letter within a month are not significantly different from the DMRT test at a 5% level of probability (n=3).**

Shading affects the plant biomass of the plant. Biomass is a measure of plant productivity. Pearcy [23] revealed that most of the plants can adjust their morphological and physiological characteristics in response to exposure to the different light environment. Light is the most important determinant of variance in total biomass. In this study, the influence of different shade levels on total biomass was first noticed at one month after transplanting and difference among treatments persisted throughout the experimental period. Coleus plants grown at 70% shade level (T4) showed maximum total biomass whereas, the lowest total biomass was recorded in 80% (T5) shade levels at 1 MAT. However, at 2 MAT, the highest biomass was recorded in plants grown at 60% shade level (T3), and the lowest total biomass was recorded in 80% (T5) shade levels.

Coleus plants grown at 80% shade level (T5) had the lowest total biomass at 1 and 2 MAT. Coleus prefers partial sunlight for optimum growth. Dry matter accumulation was significantly reduced by higher levels of shading. In higher shade levels, photosynthesis slows down significantly while respiration continues. These might be the reasons for the lowest biomass was obtained in T5 (80% shade level). Several findings revealed that plants produced the lowest biomass at higher shade levels. Dracaena plants belong to 80% of the shade level produced significantly lowest plant biomass [7]. The highest total biomass was obtained in 60% shade level (T3). The plants grown at 60% shade would have received optimum light for better growth. Therefore, their growth rate and carbon assimilation were at the highest level. Krishnakanth et al. [14] reported that 50% shade level is suitable for growing Cordyline fruticosa var. 'Purple Compacta' in the Batticaloa district as the growth and quality of plants were higher. These findings showed that different plants have different levels of optimum shade levels for their maximum growth and development. Hence results of this experiment revealed that 60% of shade levels are suitable for growing coleus plants in the Batticaloa district of Sri Lanka as the total plant biomass was higher.

3.3.1 Determination of optimum shade level for coleus in the dry zone using a polynomial regression model

Biomass is a measure of plant productivity. The relationship between plant biomass of coleus and shade levels is shown in FIG. 4. The results of regression analysis indicate that polynomial models gave the best fit for regression of plant biomass of coleus and shade levels.

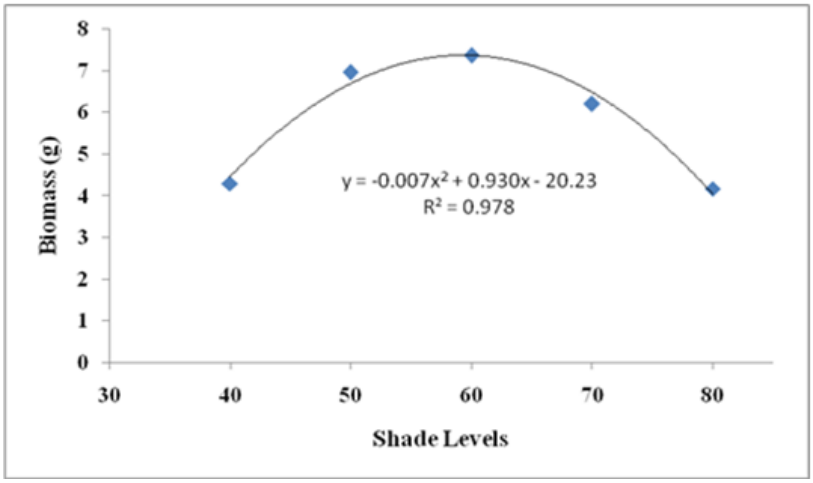

FIG. 4. **The relationship between plant biomass of coleus and different levels of shade at 2 MAT. Each data point is the mean of three replicates.**

Significant ($p<0.05$) relationship was observed between plant biomass of coleus and shade levels at 2 MAT. The response of biomass of coleus at 2 MAT to shade levels described by the following equations:

$$y = -0.007x^2 + 0.930x - 20.23 \ldots\ldots\ldots\ldots\ldots \text{EQUATION (1)}$$

Where y = plant biomass (g) at 2 MAT and x = shade levels

The optimum shade level of coleus for maximum biomass production obtained from this study from quadratic equations is 66% shade level. This was calculated by equalizing the first derivative of the curve to zero (FIG. 4 and EQUATION 1). An optimum

amount of shade level is important for maximum growth. Excess or deficit levels of shade may hinder plant growth. This result could be used when making a recommendation for coleus cultivation dracaena when the conditions are the same or very close to those in this experiment. However, extensive field trials are needed to confirm this result and for recommendations to growers.

3.4 Quality evaluation of experimental plants

The quality of plants was ($p<0.05$) significantly influenced by different shade levels. Coleus (*Plectranthus scutellarioides*) var. 'Chocolate-covered cherry' plants grown at 60% shade level (T3) obtained a significantly highest median while the significantly lowest median was received by control (T1) 40% shade level plants (FIG. 5).

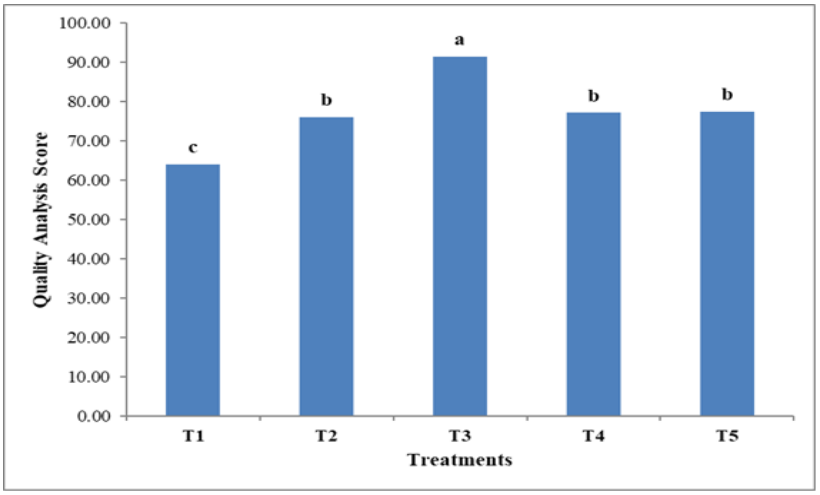

FIG. 5. **Effect of graded shade levels on the quality of *P. scutellarioides* var. "Chocolate covered cherry" cuttings at 2 MAT. Means followed by the same letter within a month are not significantly different with the DMRT test at 5% level of probability (n=3).**

Coleus is used as an ornamental plant and planted as a pot or bed plant in many gardens and herbaria around the world [24]. It is available in a variety of bright colors that are adapted to different amounts of light from shade to full sun. Coleus has long been prized for their colorful foliage which may combine shades of green, yellow, pink, red, and maroon. Noordegraaf [25] stated that the colour of leaves, leaf expansion, shoot elongation, number of leaves in cuttings are the main quality parameters of foliage plants. Light intensity greatly influences the amount of variegation in the plant [9]. Therefore, an appropriate light level is necessary for nurseries. Coleus is a shade-loving plant and the quality of foliage is influenced by light levels. In quality evaluation coleus plants grown at 60% shade level (T3) obtained a significantly highest score while the significantly lowest score was received by 40% (T1) plant. Plants react to changing light conditions in terms of quantity and composition of pigments in the chloroplasts.

Coleus plants grown at 40% and 50% shade levels obtained the lowest score in quality evaluation at 2 MAT. Plants were grown at 40% shade level produced less variegated foliage when compared to other treatments. Light is the ultimate substrate for photosynthetic energy conversion, however, it can also harm plants if it exceeds the optimum level [26]. Coleus prefers partial sunlight for optimum growth. In T1 (40%), plants would have received an excess amount of irradiation above their requirement. It would cause light stress on the plant. Coleus could be sensitive to higher irradiation levels. Higher irradiance levels in shade

obligate plants can cause photodegradation of chromo pigments [27]. At high light levels, plants have lower chlorophyll content [28]. These might be the reason for the lowest score obtained at T1 and T2.

Coleus plants grown at 70% (T4) and 80% (T5) shade levels also had the lowest quality evaluation of experimental plants at 2 MAT. High shade level affects plant growth by reducing photosynthesis. Plants grown at this shade level would have received a sub-optimum level of irradiation. This might be the reason for the lowest quality evaluation of experimental plants observed in this treatment. Walters, and Reich [29] stated that lower light levels limit plant growth. Dracaena plants grown at 80% shade level developed dark green color foliage [7]. These might be the reasons for the low quality of plants in 70% and 80% shade levels.

The highest quality score was obtained in 60% shade level (T3). The plants grown at 60% shade would have received optimum light for better growth. Further plants grown at 60% shade level showed compactness, better leaf size, and increased leaf thickness. Compactness and leaf thickness is the main exported quality parameters of foliage plants [30]. The compactness of plants is directly correlated with lateral branches formation. Optimum light level is important for maximum photosynthesis. Light is a prime factor affecting both the growth and distribution of tissues in the whole plant [31]. Hence results of this experiment revealed that a 60% shade level is suitable for growing coleus plants in the Batticaloa district of Sri Lanka as the quality of cuttings is higher at this shade level.

PLATE 1. **Coleus (*P. scutellarioides* var. "chocolate covered cherry") under different shade levels at 2 MAT.**

4. Conclusion

Coleus (*P. scutellarioides* var. "chocolate covered cherry") plants grown at 60% shade level showed better performance in growth parameters such as plant height, leaf area and biomass. Further, plants subjected to 60% of shade level received highest score in quality assessment. Lower (80% of shade level) and higher (40% of shade level) light levels reduced the growth and quality of Coleus (*P. scutellarioides* var. "chocolate covered cherry") plants. From this study, it could be concluded that 60% shade level is optimum for growing *P. scutellarioides* var. "chocolate covered cherry" in the Batticaloa district of Sri Lanka.

REFERENCES

1. Senevirathne GASS, Kumari DLC, Disanayake L. Productivity improvement of foliage plant Dracaena sanderiana (Ribbon Dracaena) variety "White". Proceedings of the Sri Lanka Association of Advancement of Science. 2007;63(1):186.
2. Gaurav AK, Raju DT, Janakiram BS, et al. Effect of shade levels on production and quality of Cordyline (Cordyline terminalis). Ind J Agric Sci. 2015;85(7):931-5.
3. Weerakkody WAP. Horticulture in Sri Lanka. Chronica Hort. 2004;44(4):23-7.
4. Srikrishnah S, Peiris SE, Sutharsan S. Effect of Shade Levels on Leaf Area and Biomass Production of Three Varieties of Dracaena sanderiana L. in the Dry Zone of Sri Lanka. Trop Agric Res. 2012;23(2):142-51.
5. Oren-Shamir M, Gussakovsky E, Shpiegel E, et al. Coloured shade nets can improve the yield and quality of green decorative branches of Pittosporum variegatum. J Hortic Sci Biotechnol. 2001;76(3):353-61.
6. Hatamian M, Arab M, Roozban MR. Stomatal behavior of two rose cultivar under different light intensities. J Crops Improv. 2015;17(1):1-11.
7. Srikrishnah S, Sutharsan S. Effect of graded shade levels on the growth and qualities of Dracaena sanderiana var. 'Celes'. Res J Agric For Sci. 2017;5(3):1-4.
8. Vilela AE, Ravetta DA. The effect of radiation on seedling growth and physiology in four species of Prosopis L. (Mimosaceae). J Arid Environ. 2000;44(4):415-23.
9. Conover CA, Poole RT. Nitrogen source effects on growth and tissue content of selected foliage plants. Hort Sci.1986;21(4):1008-9.
10. Manaker GH. Interior plantscapes: Installation, maintenance, and management. Prentice Hall.1986 Online at: http://agris.fao.org/agris-search/search.do?recordID=US9738500. (Accessed on: 20/12/2015).
11. Zhang X, Hao L, Hong K, et al. Growth, dendrobine content and photosynthetic characteristics of Dendrobium nobile under different solar irradiances. Plant Omics. 2014;7(6):461-7.
12. Barber J, Andersson B. Too much of a good thing: light can be bad for photosynthesis. Trends Biochem Sci. 1992;17(2):61-6.
13. Chen CT, Setter TL. Response of potato tuber cell division and growth to shade and elevated CO_2. Ann Bot. 2003;91(3):373-81.
14. Krishnakanth M, Srikrishnah S, Sutharsan S. Effects of graded shade levels on the growth and quality of Cordyline fruticosavar. 'Purple compacta' in the Batticaloa district. AGRIEAST J Agric Sci. 2017;11(1): 17-24.
15. Farias VC, Silva DE, Almeida AJ. Analise de crescimento de mudas de cedrorana (Cendrelinga catenaeformis (Ducke) Ducke) cultivadas em condicoes de viveiro. Revista Brasileira de sementes. 1997;19(2):193-200.
16. Larcher W. Physiological plant ecology. 4th edn. Berlin: Springer, Germany; 1995.
17. Gunadasa HKSG, Dissanayake PK. Optimization of quality in exported Polyscias balfouriana "marginata" by using different shade levels. J Agric Sci. 2012;7(2):58-65.
18. Kitao M, Lei TT, Koike T, et al. Susceptibility to photo inhibition of three deciduous broadleaf tree species with different successional traits raised under various light regimes. Plant Cell Environ. 2000;23(1):81-9.
19. Xu F, Guo W, Wei Y, et al. Leaf morphology correlates with water and light availability: What consequences for simple and compound leaves. Prog Nat Sci. 2009;19(12):1789-98.

20. Zhang YJ, Yan F, Gao H, et al. Chlorophyll content, leaf gas exchange and growth of oriental lily as affected by shading. Russ J Plant Physiol. 2015;62:334-9.
21. Devkota A, Jha PK. Effect of different light levels on the growth traits and yield of Centella asiatica. Middle-East J Sci Res. 2010;5(4):226-30.
22. Srikrishnah S, Sutharsan S. Effects of different shade levels on Growth and Tuber yield of Tumeric (Curcuma longa L.) in the Batticaloa district of Sri Lanka. Am-Eur J Agric Environ Sci. 2015;15(5):813-6.
23. Pearcy RW. Acclimation to sun and shade. In: Raghavendra AA, editor. "Photosynthesis: A Comprehensive Treatise". Cambridge: Cambridge Unversity Press, England; 1998. 250-63 p.
24. Duke JA, Godwin MJ, Cellier DUJ, et al. Handbook of Medicinal Herbs. Boca Raton, Florida: CRC Press, USA; 2002. 210-5 p.
25. Noordegraaf CV. Production and marketing of high-quality plants. Acta Hortic. 1994;353:134-48.
26. Barber J, Andersson B. Too much of a good thing: light can be bad for photosynthesis. Trends Biochem Sci. 1992;17(2):61-6.
27. Mattana RS, Ming LC, Marchese JA, et al. Biomass production in plants of Pothomorphe umbellata (L.) Miq. submitted to different shade levels. Rev Bras Pl Med. 2006;8:83-5.
28. Ballantine JEM, Forde BJ. The effect of light intensity and temperature on plant growth and chloroplast ultrastructure in soybean. Amer J Bot. 1970;57(10):1150-9.
29. Walters MB, Reich PB. Low light carbon balance and shade tolerance in the seedlings of woody plants: do winter deciduous and broadleaved evergreen species differ? New Phytol. 1999;143(1):143-54.
30. Alvarez S, Sanchez-Blanco MJ. Changes in growth rate, root morphology and water use efficiency of potted Callistemon citrinus plants in response to different levels of water deficit. Sci Hortic. 2013;156:54-62.
31. Fahn A. Plant Anatomy. 2nd edn. Oxford: Butterworth Heinemann, England; 1990.