Effects of graded shade levels on the growth and quality of *Cordyline fruticosa* variety ‘Purple Compacta’ in the Batticaloa district

M. Krishnakanth, S.Srikrishnah* and S. Sutharsan

Department of Crop Science, Faculty of Agriculture, Eastern University, Sri Lanka, Chankalady

ABSTRACT

*Cordyline fruticosa* is a popular foliage plant and it has high demand in the export market. Shade influences the growth and quality of ornamental foliage plants. An experiment was conducted to determine the effects of different shade level on the growth and quality of *C. fruticosa* var. ‘Purple Compacta’ in the Crop Farm, Eastern University, Sri Lanka. Graded shade levels were defined as treatments viz. 0% (T1), 50% (T2), 60% (T3), 70% (T4), and 80% (T5). The experiment was arranged in a completely randomized design with three replications. Recommended agronomic practices were followed uniformly for all treatments. Plant height, leaf area, and plant biomass were measured at monthly interval and quality of cuttings was assessed at 3 months after transplanting. Analysis of Variance was performed to determine significant difference among treatments (p < 0.05). Results revealed that plants grown at 50% shade level (T2) obtained significantly (p < 0.05) higher plant height, leaf area, plant biomass and biomass partitioning. In quality assessment, plants grown at 50% shade level received significantly (p<0.05) highest scores. Plants performance was lower in other treatments. It could be concluded 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.

Key words: Biomass partitioning, Dryzone, Leaf area, plant biomass, shade levels.

Introduction

*Cordyline fruticosa* is a popular foliage plant belongs to family Asparagaceae. It is an evergreen foliage plant grown in houses or outdoors and it has high demand in the export markets as cut decorative foliage (Weerahewa and Somaratne, 2011). It is also popular as potted plant (Kobayashi *et al*., 2007). The agro-climatic diversity in Sri Lanka is very much beneficial for the production of foliar ornamentals and cut flowers. In Sri Lanka, *C. fruticosa* is commercially produced for export markets (Anon, 2012). However, commercial floriculture nurseries are mainly found in the central uplands and the lowlands in western and north-western regions (Weerakkody, 2004). Batticaloa is an important agricultural district in the dry zone of Sri Lanka. The climatic requirements of *C. fruticosa* are compatible to the prevailing climatic conditions in Batticaloa district and therefore this crop can be selected as a foreign income earner to this area. However, there is no information available regarding the optimal light intensity for *C. fruticosa* in the Batticaloa district. An important ecological factor to be considered to any cultivated species is the best irradiance level (Mattana *et al*., 2006). Shade levels affect growth and quality of ornamental foliage plants (Oren-Sharmir *et al*., 2001) and provision of shade is recommended for the cultivation of foliage plants. Therefore, proper shade level is necessary in nurseries where, *C. fruticosa* plants are being grown. As Sri Lanka has different climatic conditions across the island, regional specific researches are needed to...
cultivation of C. fruiticosa in a particular location. A better understanding of possible influence of different shade levels on the growth, development and quality of C. fruiticosa could lead to development of recommendation for the agronomic management of different varieties of C. fruiticosa in the dryzone of Sri Lanka. Hence objective of this experiment was to determine the effects of graded shade levels on growth and quality of C. fruiticosa var. ‘Purple Compacta’ and to select optimum shade level for the cultivation of C. fruiticosa var. ‘Purple Compacta’ in the Batticaloa district of Sri Lanka.

Materials and methods

A shade house experiment was conducted from October 2015 to March 2016 at the Crop Farm, Eastern University, Vantharumoolai, Batticaloa, located in low country dry zone of Sri Lanka. Experiment was arranged in a completely randomized design (CRD). Graded levels of shade were defined as treatments viz. 0% (T1), 50% (T2), 60% (T3), 70% (T4), 80% (T5). Each treatment contained 30 replications. An experimental unit consisted of one plant. Plants were arranged at a spacing of 30 plants per m². Uniform sized rooted cuttings of C. fruticosa variety ‘Purple Compacta’ were obtained from Tropical Abundance (Pvt) Ltd, Giriulla and treated with fungicide (Captan®) before planting. The cuttings were planted into polybags (diameter and height of the bags were 30 cm) filled with Potting media containloam soil, compost, cattle manure and sand in a in control plants (open air) as well. Plants in the control treatment would have received excess irradiation above their requirement may have caused light stress on plants. Fini et al., (2010) found that, lowest plant height was observed in open sunlight in the cultivation of Camellia japonica (Tea). Cordyline plants showed highest plant height at 50% of shade level (T2) at 1, 2 and 3 MAT. This may have been due to plants receiving optimum ratio of 4: 2: 1: 1 (volume basis) as per Department of Agriculture recommendation (2002). Other management practices were followed uniformly according to the recommendation. Plants were destructively sampled monthly in all treatments during the experiment. Plant height (cm), leaf area per plant (cm²), plant biomass (g), biomass partitioning (%) were taken as measurements. Analysis was carried out using Statistical Analysis System (SAS) to determine significant differences among treatments. Treatment means were compared using Tukey test 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.

Results and discussion

1. Plant height

It was found that there were significant (p<0.05) differences in the plant height of Cordyline plants under different shade levels at 1, 2 and 3 months after transplanting (MAT).

Cordyline plants grown at 50% shade level (T2) showed maximum plant height (38.33cm) and lowest plant height (19.66 cm) was recorded in 80% shade level (T5) at 3 MAT (Fig. 1). At 80% of shade level plant would have received sub optimum level of light. This might be the reason for treatment. Plants recorded lower height lowest plant height observed in this level of light intensity. Chen and Setter (2003) reported that shade significantly influenced cell division. Increased plant height could also be due to elongation of cells and increased number of cells due to higher rate of cell division under shade being a non-limited factor. These might be the reasons for highest plant height observed in this shade level throughout
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Moniruzzaman et al., (2009) reported the tallest plants were obtained from 50% shade level in the cultivation of Bangladhonia under different levels of shade (25%, 50%, 75, open sunlight).

2. Leaf area pre plant

In this experiment, there were significant (p<0.05) differences in the leaf area of Cordyline plants under different shade levels at 1, 2 and 3 months after transplanting (MAT). Cordyline plants grown at 80% shade level (T5) had lowest leaf area throughout the experiment. Plants grown under this shade level would have received lowest amount of light for photosynthesis. Thus development of vegetative growth was suppressed. Plants in the control treatment (open air) also produced lower leaf area. In this treatment, radiation might have been higher than the optimum requirement for Cordyline plants.

At higher irradiation levels, there may be chances for development of stress conditions in sensitive plants leaves. It was supported by Mattana et al., (2006).

Plants would have altered their morphological characters by reducing their leaf area to avoid stress conditions. Plants grown at 50% shade level (T2) showed highest leaf area.

This might be the fact that plant at this shade level would have received optimum amount of irradiation for their growth. This was evidenced by Marenco and Reis (1998), who found that leaf area was greater in wrinkled grass grown at 50% shade level than in those grown at control during the whole plant cycle.

3. Plant biomass

It was found that there were significant (p<0.05) differences in the plant biomass of Cordyline under different shade levels at 1, 2 and 3 months after transplanting (MAT).
Cordyline plants grown at 80% shade level (T5) had lowest biomass at 3 MAT. Limitation in availability of light can reduce photosynthesis and subsequently biomass production. Cordyline plants grown at this shade level would have obtained sub optimum level of light. Therefore, lower biomass was obtained due to reduced rate of photosynthesis.

Cordyline plants showed significantly highest plant biomass at 50% of shade level (T2) at 1, 2 and 3 MAT. Plants grown at these shade level would have received optimum amount of shade. Therefore, their growth and carbon assimilation were at highest level. Leaf area of the plants was also higher at this shade level.

Increased leaf area contributes to enhanced photosynthesis and subsequently increased plant biomass. Dalirie et al., (2010) stated that, increasing leaf area index is one of the ways of increasing the capture of solar radiation within the canopy and production of dry matter. Phonguodume et al., (2010) revealed that Xylium xylocarpa and Dipterocarpus alatus plants accumulated higher plant biomass under 50-70% light intensity compared to other lighting conditions.

**Biomass partitioning**

It was found that there were significant (p<0.05) differences in the biomass partitioning of Cordyline plants under different shade levels at 3 months after transplanting(MAT). (Table 1)

Plants grown at 50% shade level had significantly highest biomass for root, shoot and leaf. At this shade level plants may have received optimum amount of light for their growth. This might be the reason for significantly highest biomass observed at 50% of shade. This coincided with findings of Sesma et al., (2009). They stated that Jatropha curcas plants subjected to 50% shading showed greater growth than plants grown in full sun. Plants grown at 80% of shade obtained significantly lowest biomass for root, shoot and leaf.
Table 1. Effect of different shade levels on biomass partitioning of *Cordyline fruticosa* var. ‘Purple Compacta’ at 3 months after transplanting

| Shade level | Root       | Shoot      | Leaves     |
|-------------|------------|------------|------------|
| Control     | 9.37b (51%)| 4.43c (24%)| 4.73b (25%)|
| 50%         | 11.86a (36%)| 10.31a (31%)| 10.567a (33%)|
| 60%         | 3.07c (22%)| 6.45b (42%)| 5.16b (36%)|
| 70%         | 1.57d (14%)| 4.65c (44%)| 4.51b (42%)|
| 80%         | 0.59e (10%)| 3.86c (67%)| 1.28c (23%)|

Means (n=3) within the same column followed by the same letter are not significant at p < 0.05 value in parentheses are percentage value for biomass partitioning.

Plants grown at this shade level would have received lowest radiation. It subsequently reduced the photosynthesis process. It revealed that plants in 80% shade were subjected to low light stress. Plants competing for light will shift biomass partitioning toward more leaf and shoot production and less root production.
Allocation of biomass for root was highest (56%) in control (T1). Plants grown at open field condition were subjected to water stress as they allocated more resources for root development. Plants allocate biomass to the organ that acquires the most limiting resource (Bloom et al., 1985). According to the optimal partitioning theory plants will respond to changes in the environment by shifting biomass partitioning patterns to obtain the most limiting resource (Hilbert, 1990). Highest (67%) shoot biomass partitioning was observed in plants grown at 80% shade level. Plants grown at 80% of shade level would have received low amount of irradiation. According to the optimum partitioning theory, allocation of biomass for shoot was higher to receive more amount of radiation at 80% shade level. Allocation of biomass for leaf was highest (42%) in 70% of shade level. Plants at this shade level would have received sub optimum level of light. It revealed that plants in 70% shade level were subjected to low light stress. As per optimal partitioning theory, plants competing for light will shift more biomass towards leaf production. Cordyline plants grown at 50% of shade level would have received optimum light for better growth. At this shade level, the biomass allocation for different organs was higher and almost equal.

5. Quality of plant

Highest colouration of foliage was observed in the plants belong to shade treatment while lowest was detected in open field condition (Fig. 4). Chlorophyll is the major component that influences colour of the foliage. Amount of chlorophyll in the plants is influenced by amount of light received by the plants. Plants under control condition would have received a higher amount of light than their requirement. Therefore, low amount of chlorophyll was produced by plants in this treatment. However, in shade treatments there might have been limitations of irradiation for photosynthesis. The amount of chlorophyll could be increased in foliage to trap available light as much possible. This may have caused increased colour of foliage in plants belong to shade treatments. This may be the possible reason for the increased colouration of plants in shade treatments. Prasad and Kumar, (2003) stated that light level is a very important factor, because it influences the chloroplast development in leaves during the growth thereby influence leaf colour and variegation.

Plants in the control treatment had highest chlorosis and necrosis while lowest was observed in shade conditions. It may be due to highest amount of light received by the plants at outdoors under full sun light (open field). High light levels caused damage to chlorophyll and resulted in burned appearance of plants. Solar radiation could be beneficial to plant growth, but the extreme could be harmful (Teremura, 1983).

Plant grown under 50% of shade level (T2) obtained remarkable confirmation and greatest overall appearance than plants belong to other treatments. Plants under this shad level would have received optimum amount of light for better quality characters. These results are in agreement with Gaurav et al., (2015). They revealed that when Cordyline was cultivated under different shade level (35%, 50, 75%, 90% and control), 50% shading intensity produced plants with
better morphological characters and foliage quality.

Conclusions

In this experiment, Cordyline fruticosa variety ‘Purple Compacta’ plants performed better under 50% of shade level. Plants attained higher plant height, leaf area, plant biomass and biomass partitioning at 50% shade level. Quality assessment indicated that plants grown at 50% shade had highest mean score. Higher (open field) and lower irradiation (80% of shade level) negatively influenced on Cordyline plant growth and quality. C. fruticosa variety ‘Purple Compacta’ plants would have received optimum amount of light at 50% shade level for better performance. It could be the reason for highest performance of these plants at this shade level. From this study, it may be concluded that, 50% shade level is suitable for growing Cordyline in the Batticaloa district of Sri Lanka.

References

Anonymous (2004) District Profile: Batticaloa. Consortium of Humanitarian Agencies. Online at: https://www.yumpu.com/en/document/view/29775409/district-profile-batticaloa-consortium-of-humanitarian-agencies. (Accessed on 25 December 2010).

Anonymous (2012) Exporters Association of Sri Lanka, Annual Reports and Accounts 2011/2012. Online at: http://www.exporterssrilanka.net/. (Accessed on 25 January 2012).

Bloom, A. J., F.S. Chapin and H.A. Mooney (1985) Resource limitation in plants--an economic analogy. Annual review of Ecology and Systematics 16(1): 363-392.

Chen, C. T. and T. L. Setter (2003) Response of potato tuber cell division and growth to shade and elevated CO2. Annals of Botany 91(3): 373-381.

Dalirie, M. S., R.S. Sharifi and S. Farzaneh (2010) Evaluation of yield, dry matter accumulation and leaf area index in wheat genotypes as affected by terminal drought stress. Notulae Botanicae Horti Agrobotanici Cluj-Napoca 38(1): 182 - 186.

Fini, A., F. Ferrini, P. Frangi, G. Amoroso and C. Giordano (2010) Growth, leaf gas exchange and leaf anatomy of three ornamental shrubs grown under different light intensities. European Journal of Horticultural Science 75(3):111-117.

Gaurav, A. K., D. Raju, B.S. Janakiram, R. Jain and S.G. Krishnan (2015) Effect of shade levels on production and quality of cordyline (Cordyline terminalis). Indian Journal of Agricultural Sciences 85(7): 931-5.

Hilbert, D. W. (1990). Optimization of plant root: shoot ratios and internal nitrogen concentration. Annals of Botany 66(1): 91-99.

Kobayashi, K., J. Griffis, A. Kawabata, A. and G. Sako (2007) Hawaiian Ti. Cooperative Extension Services. University of Hawaii. Online at: https://www.ctahr.hawaii.edu/oc/freepubs/pdf/of-33.pdf. (Accessed on 06 December 2015)

Marenco, R. A. and A. C. Reis. (1998) Shading as an environmental factor affecting the growth of Ischaemum rugosum. Revista Brasileira de Fisiologia Vegetal 10(2): 107-112.

Mattana, R. S., L. C. Ming, J. A. Marchese and M. O. M. Marques (2006) Biomass production in plants of Pothomorphe umbellata (L.) Miq. Submitted to different shade levels. Brazilian Journal of Medical and Biological Research 8: 83-85.
Moniruzzaman, M., M. S. Islam, M. M. Hossain, T. Hossain and M. G. Miah (2009) Effects of shade and nitrogen levels on quality Bangladhonia production. *Bangladesh Journal of Agricultural Research* **34(2)**: 205-213.

Oren-Sharmir, M., E. E. Gussakovskey, E. Shpiegel, A. Nissim-Levi, K. Ratner, R. Ovadia, Y. E. Giller and Y. Shahak (2001). Coloured shade nets can improve the yield yield and quality of green decorative branches of Pittosporum variegatum. *Journal of Horticultural Science and Biotechnology, 76*(3):353-361.

Phonguodume, C., Y. D. Park, D. K. Lee, S. Savathvong, W. M. Ho, and E. A. Combalicer (2012) Effects of light intensities on growth performance, biomass allocation and chlorophyll content of five tropical deciduous seedlings in Lao PDR. *Journal of Environmental Science and Management* **1**: 60-67.

Prasad, S. and U. Kumar (2003) *Principles of Horticulture*. Agrobios, Jodhpur.

Sesma, R. B., V. G. Demuner and S. A. Hebling (2009) Effect of different shading levels on initial growth of Jatropha curcas L. plants in green house. *Natureza online* **7**(1): 31-36.

Teremura, A. H (1983) Effect of Ultraviolet β-radiation on the growth and yield of crop plants. *Physiology* **58**: 415-417.

Weerahewa, H. L. D and S. Somaratne (2011) Effect of some selected vase water additives on vase life of Cordyline terminalis ‘red’ foliage. Proceeding of Annual Academic Session, Open University, Sri Lanka. pp. 257-261.

Weerakkody, W.A.P. (2004). Horticulture in Sri Lanka. *Chronica Horticulturae* **44**: 23-27.