

Effect of Shade Levels on Leaf Area and Biomass Production of Three Varieties of *Dracaena sanderiana* L. in the Dry Zone of Sri Lanka

S. Srikrishnah¹, S.E. Peiris¹ and S. Sutharsan²

Postgraduate Institute of Agriculture
University of Peradeniya
Sri Lanka

ABSTRACT. An experiment was conducted in a shade house to determine the effects of three shade levels on leaf area and biomass production of three varieties of dracaena (*Dracaena sanderiana* L.) in the dry zone (Batticaloa district) of Sri Lanka. 'Gold', 'Victory' and 'White' varieties were arranged in 50%, 70% and 80% shade levels as a CRD. There was a significant interaction between varieties of dracaena and the shade levels on leaf area and biomass production. The plants grown at 50% and 70% shade levels produced the highest leaf area and biomass than plants subjected to 80% shade. Biomass production was in accordance with the trend of variances for leaf area. Varieties 'Gold' and 'Victory' performed better than 'White' in leaf area and biomass production under 50% and 70% shade level and there were no significant variations between them. Therefore, in this study it was concluded that, 70% shade level is suitable for growing dracaena varieties in the dry zone of Sri Lanka as the growth of dracaena varieties were higher than the other shade levels.

Key words: Biomass production, dracaena, dry zone, leaf area, shade levels

INTRODUCTION

Dracaena (*Dracaena sanderiana* L.) is a popular foliage plant (Beura *et al.*, 2007) that belongs to family Dracaenaceae. It is commonly known as Ribbon *Dracaena*, Lucky Bamboo, Belgian Evergreen or sometimes Ribbon Plant. It consists of several varieties including 'Gold', 'Victory' and 'White'. *Dracaena* is an evergreen foliage plant grown as a house or outdoor plant and it has a high demand in the export market. *Dracaena* varieties are commercially produced in export-oriented large scale plantations in Sri Lanka (Senevirathne *et al.*, 2007). In 2010, export earnings from cut flowers and foliage were US \$ 11.71 million (Anon, 2010). The potential exists for increased exports of cut foliages and rooted cuttings.

The agro-climatic diversity in Sri Lanka is very much advantageous for growing a wide range of foliage ornamentals and cut flowers. But commercial production facilities of floriculture products are mainly found in the central uplands and the lowlands in western and north-western regions (Weerakkody, 2004).

When expanding floriculture as an industry in Sri Lanka, it is essential to identify new niches for cultivation. Dry zone which comprises more than 2/3 of land area in Sri Lanka has

¹ Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka

² Department of Crop Science, Faculty of Agriculture, Eastern University, Vantharumoolai, Sri Lanka

Author for correspondence: shansri7@gmail.com

several potentials for future agricultural development. Climatic conditions prevailing in the dry zone are suitable for growing tropical flowers and foliage ornamentals under appropriate conditions. Introduction of floricultural crops in the dry zone could be an important intervention in this regard, where the farmers can earn more using available natural resources efficiently. These crops fetch better prices almost year round and there is no need to wait for a long time as in the case of conventional crops.

Batticaloa is a prominent agricultural district in the dry zone of Sri Lanka. The topography of the Batticaloa district is flat. The east coast of the district comprises of sandy soil and the west comprises of clay soil. The annual rainfall varies from 864 mm to 3081 mm distribution, which has slight variation throughout the district. The temperature ranges from 25 °C to 35.4 °C (Anon, 2004). Introduction of floricultural crops in Batticaloa district as a commercial venture would furnish several benefits to society. It could act as a livelihood activity for many women-headed households. Growth of this sector would contribute to the national economy through earning of foreign exchange.

However, researches on floricultural crops have not been conducted yet in an organized manner in the dry zone. An important ecological factor to be considered to any cultivated species is the best irradiance level (Mattana *et al.*, 2006). Shade levels influence the growth and quality of ornamentals plants and provision of shade is recommended for the cultivation of foliage plants in Sri Lanka. Netting is an effective solution for ornamentals, which enhance their quality (Shahak *et al.*, 2008). A better understanding of possible influence of different shade levels on the growth, development and quality of dracaena could lead to development of recommendation for the agronomic management of different cultivars of dracaena in the dry zone of Sri Lanka.

The leaf area of a crop is a determining factor in mechanisms such as radiation interception and water and energy exchange (Peksen, 2007). Plant biomass and productivity are interrelated (Guo, 2007), which influence the growth and development of a crop. The objectives of this research was to determine the effect of three shade levels on the leaf area and biomass production of three varieties of dracaena and to select the best shade level for their cultivation in the Batticaloa district.

MATERIALS AND METHODS

A shade house experiment was conducted from December 2010 to May 2011 at the Crop farm, Eastern University, Vantharumoolai, Batticaloa. Uniform, rooted and one month old cuttings of three varieties of dracaena 'Gold', 'Victory' and 'White' were obtained from conventional propagation techniques and planted in polybags (15 cm diameter and 20 cm height) filled with a potting medium consisting of loam soil, compost, cattle manure, sand in a ratio of 4:2:1:1 (volume basis). A basal fertilizer consisting of urea (87 kg), muriate of potash (67 kg) and super phosphate (89 kg) were mixed thoroughly and 9 g of mixture was applied per bag (Department of Agriculture, 2002). A liquid fertilizer (Crop Master[®]-Unipower) application was practiced once a month to all treatments equally. Plants were arranged at a spacing of 30 plants/m². Experimental plants were watered according to the shade levels. Plants at 50% and 70% shade levels were watered once in 3 days and plants at 80% shade were watered once in 5 days during dry periods. Other management practices were followed uniformly.

The treatments were arranged in a completely randomized design (CRD) with 3 replicates. Each replication contained 30 plants and an experimental unit consisted of one plant. The three varieties of dracaena ('Gold', 'Victory' and 'White') and additive series of shade levels (50%, 70% and 80%) were arranged in a two factor factorial design. The crop was grown for six months.

The leaf area (cm²) and biomass production (g) were taken as measurements. Analysis of variance was carried out using SAS package to determine significant differences among treatments ($p < 0.05$). Regression analysis was used to characterize the effects of shade levels on leaf area and biomass production of the three varieties.

RESULTS AND DISCUSSION

The study showed significant differences ($p < 0.05$) between treatments tested (Table 1).

Table 1. Effect of shade levels on leaf area and biomass production of three varieties of dracaena at 5th month after planting

Shade level (%)	Variety	Leaf area (cm ²)	Biomass production (g)
50	Gold	897.33 ^a	14.77 ^a
	Victory	911.67 ^a	14.83 ^a
	White	744.67 ^b	9.94 ^b
70	Gold	924.00 ^a	14.51 ^a
	Victory	901.00 ^b	14.22 ^a
	White	607.33 ^c	10.24 ^b
80	Gold	303.00 ^b	4.39 ^a
	Victory	344.67 ^a	4.17 ^a
	White	287.67 ^c	3.89 ^a
Probability	Shade levels	0.000	0.000
	Varieties	0.000	0.000
	Interaction	0.000	0.000
CV		4.365	4.747

Means followed by the same letter were not significant at $p = 0.05$

Leaf area

The varieties and shade levels had a significant effect ($p < 0.05$) on leaf area (LA) of dracaena. The interactive effect of the varieties and shade levels on LA of dracaena was also significant (Table 1). The plants grown at 50 and 70% shade levels produced the highest LA than the plants of 80% shade. The growth of crops was related to the amount of solar radiation received during the growing period (Cockshull *et al.*, 1992; Challa & Bakker, 1998). LA is also influenced by shade levels. Abdel-Mawgoud *et al.* (1996) reported that 30 % of shade has a significant effect on LA of tomato. At 80% shade, development of LA was significantly reduced in all three dracaena varieties as radiation received by the plants was below the requirement. This may have caused reduction in photosynthesis and subsequent growth. Ultimately, the growth and leaf development of the plants were suppressed irrespective of the variety at 80% shade. Under this shade level, variety 'Victory' had a

significantly ($p < 0.05$) higher LA followed by 'Gold'. Lowest LA was shown by variety 'White'.

In the treatment of 50% shade, there were no significant ($p < 0.05$) differences between LA of varieties 'Gold' and 'Victory'. The variety 'White' produced a significantly lower LA than those of the other varieties. At 70% shade level, there was a significant difference between varieties in LA. The highest LA was produced by the variety 'Gold' followed by 'Victory'. The lowest LA was shown by the variety 'White'. In all three shade levels, the variety 'White' produced the lowest LA. These variations may be due to varietal effects on the LA. It was reported that the genotypic variations have significant effects on the LA (Sashidhar *et al.*, 1986; Rebetzke *et al.*, 2004). As such, varieties 'Gold' and 'Victory' performed better than the variety 'White' in leaf formation.

There were no significant differences in the LA of the varieties 'Gold' and 'Victory' at 50% and 70% shade levels. At higher irradiation levels, there may be chances for destruction of photosynthetic pigments in sensitive plant leaves. Mattana *et al.* (2006) also reported that, higher irradiance levels in esciophyte plants, such as *Pothomorphe umbellata*, can cause photodegradation of chromopigments, with a decrease in photosynthesis causing in a decrease in the biomass yield. The degradation of the photosynthetic pigments probably was responsible for the decrease of photosynthesis and growth. It is probably due to the destruction of the photosynthetic pigments and the structures of thylakoids in chloroplasts (photodestruction) (Lambers *et al.*, 1998). Leaves of dracaena might be sensitive to higher irradiation levels, which would have caused destruction of photosynthetic pigments and subsequent reduction of growth. This may be the reason for reduction of LA in dracaena under 50% shade level.

A 70% shade level seemed to be preferable for the optimum growth of LA of varieties 'Gold' and 'Victory'. Very high light intensity, which exceeds photosynthetic capability of the plants, results in photoinhibition and pale foliage (Stancato *et al.*, 2010). There were no symptoms of leaf burning or pale colouration in all three varieties under 70% shade level, which showed that 70% shade providing sufficient amount of light for optimum growth of the varieties 'Gold' and 'Victory'. This could be the possible reason for the approximately equal LA of dracaena varieties 'Gold' and 'Victory' under 50 and 70% shade levels.

Biomass production

Shade levels significantly ($p < 0.05$) influenced biomass production of the three varieties of dracaena (Table 1). At 80% shade, all varieties produced the lowest biomass and their differences became non-significant. Of all the climatic factors, light plays a major role in determining productivity. Shading by 31 to 67% reduced root yield of sweet potato (Mwanga & Zamora, 1989). LA of plants was also lower under 80 % shade. Dry matter production decreases with a decrease of leaf area index (Dalirie *et al.*, 2010). Hence, low irradiation and LA would have caused a reduction in photosynthesis and, thereby dry matter accumulation under 80% shade level.

At 50% shade, a significantly ($p < 0.05$) highest biomass was produced by varieties 'Victory' and 'Gold', while lowest was produced by the variety 'White'. The same phenomenon was observed at 70% shade. Under both 50 and 70% shade levels, there was no significant ($p < 0.05$) difference between biomass production of varieties 'Gold' and 'Victory'. Varieties 'Gold' and 'Victory' produced the highest LA and thereby would have captured more solar radiation under 50 and 70% shade levels which contribute to photosynthesis and biomass

production. Dalirie *et al.* (2010) stated that, increasing LA index as one of the ways of increasing the capture of solar radiation within the canopy and production of dry matter. In this experiment, it could be stated that, biomass production were in accordance with the trend of variances for LA. Varieties 'Gold' and 'Victory' performed better under 50 and 70% shade levels in terms of biomass production.

Rate of increase of leaf area versus time

With time, leaf area of dracaena increased linearly under the three shade levels (Figs. 1, 2 & 3), but there were prominent variations in the rate of development.

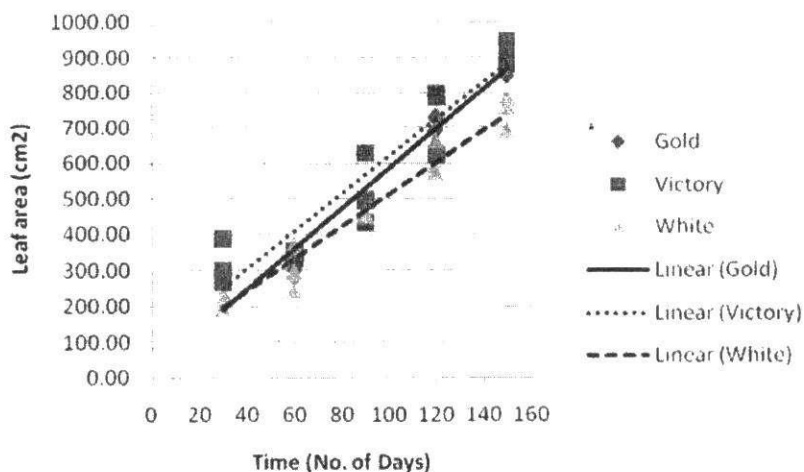


Fig. 1. Growth rate in leaf area at 50% shade level during experimental period

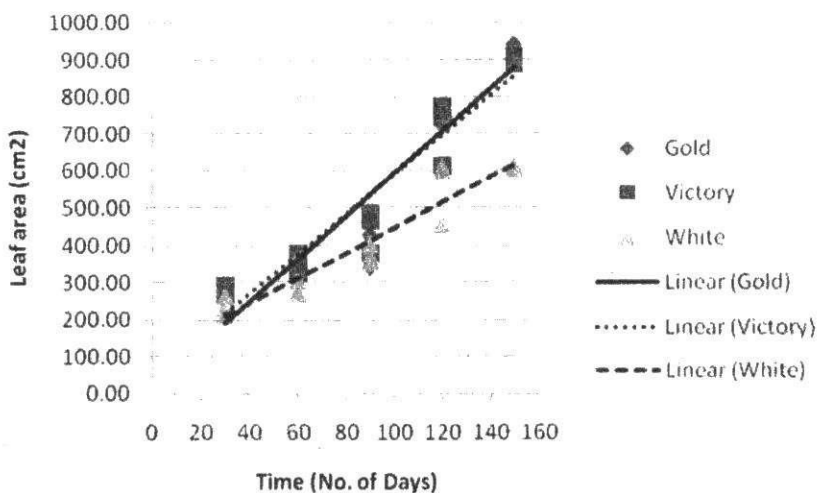


Fig. 2. Growth rate in leaf area at 70% shade level during experimental period

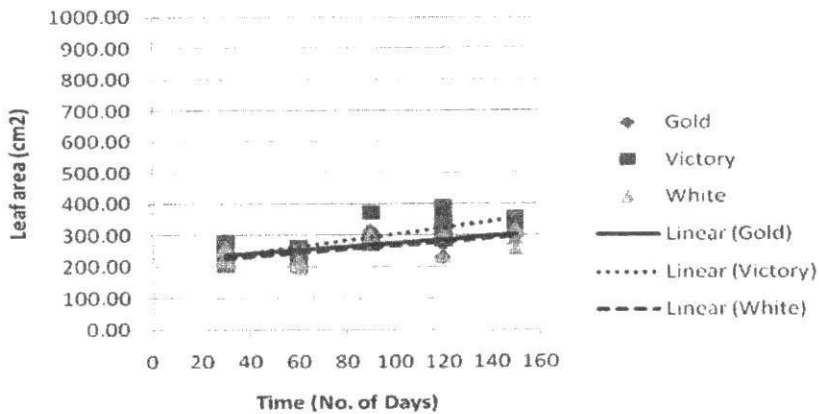


Fig. 3. Growth rate in leaf area at 80% shade level during experimental period

The LA development was higher at 50 and 70% shade levels than at 80% shade, as evidenced by higher gradients of the regression equations (Table 2). Higher shade levels could reduce the photosynthesis and growth of plants. Halva *et al.* (1992) reported that, the cultivation of *Anethum graveolens* under four levels of brightness, 100%, 70%, 50% and 30% showed that the decrease in levels of brightness resulted in a decrease of the number of leaves and specific LA. The same was observed in the present study that, LA development was lower under 80% shade level (Table 1).

Table 2. The relationship between shade and variety on LA

Shade Level (%)	Variety	Prediction equation	R ²	p value
50	Gold	$y = 5.6133x + 23.667$	0.9431	<0.05
	Victory	$y = 5.2622x + 92.2$	0.8983	<0.05
	White	$y = 4.5178x + 60.4$	0.9602	<0.05
70	Gold	$y = 5.7367x + 18.833$	0.9071	<0.05
	Victory	$y = 5.3467x + 55.4$	0.9200	<0.05
	White	$y = 3.3778x + 108.07$	0.9091	<0.05
80	Gold	$y = 0.5567x + 219.43$	0.4609	<0.05
	Victory	$y = 1.0022x + 203.07$	0.5560	<0.05
	White	$y = 0.5711x + 209.27$	0.4123	<0.05

The growth rate of LA of varieties 'Gold' and 'Victory' was higher than that of variety 'White' at 50 and 70% shade levels. This may be due to varietal effects on LA. The rate of development of LA of varieties 'Gold' and 'Victory' were approximately similar at shade levels 50 and 70%. The treatments 50 and 70% of shade levels were better than 80% level for growth of dracaena varieties in the dry zone of Sri Lanka in terms of LA development.

Rate of increase of biomass production versus time

Biomass of dracaena varieties increased with the time under different shade levels. A linear relationship clearly represents the differences of varieties on biomass production under different shade levels (Figs. 4, 5, & 6). However, the rate of biomass production of different varieties differed notably with shade levels.

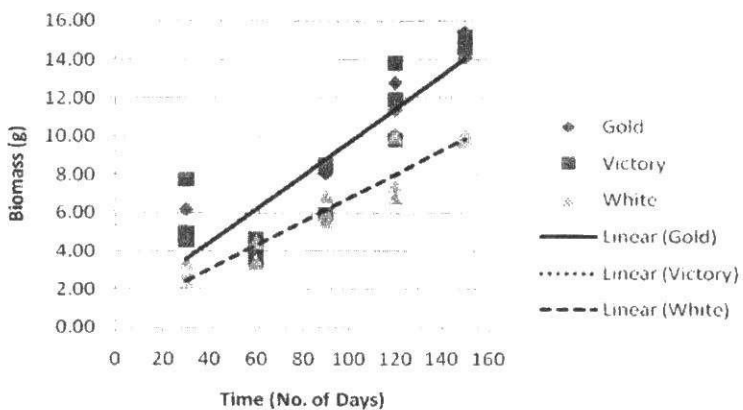


Fig. 4. Growth rate in biomass at 50% shade level during experimental period

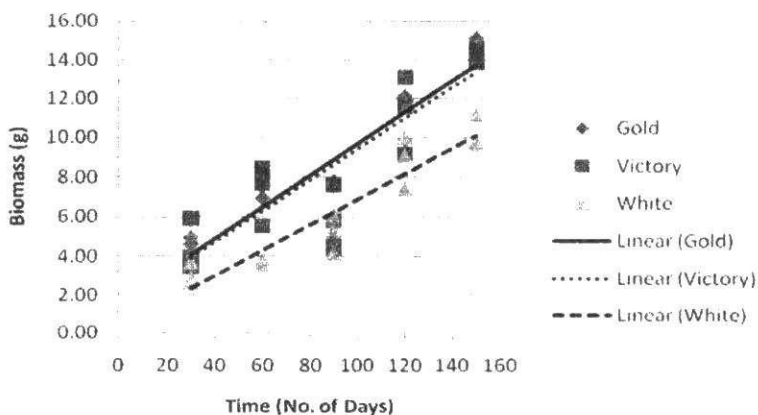


Fig. 5. Growth rate in biomass at 70% shade level during experimental period

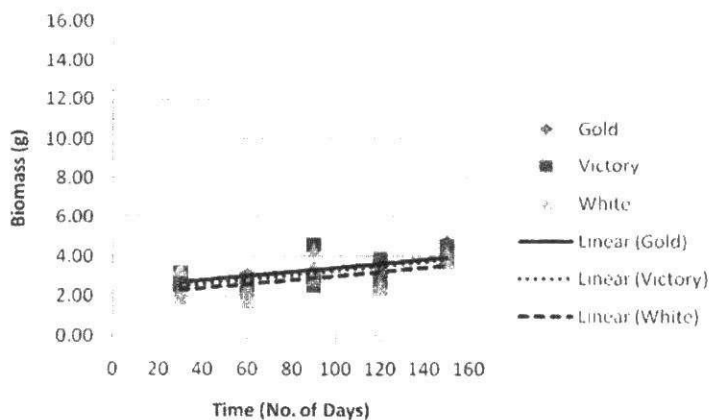


Fig. 6. Growth rate in biomass at 80% shade level during experimental period

Biomass production of dracaena varieties was higher at 50 and 70% shade levels than 80% shade (Table 3). At high radiation levels, the rate of biomass production was higher. Shade reduces plant biomass production, and at 30% shade, total dry matter production was significantly reduced in tomato (Abdel-Mawgoud *et al.*, 1996). As such, biomass production was lower under 80% shade level.

Table 3. Relationship between shade and varieties on biomass production at $p < 0.05$

Shade Level %	Variety	Prediction equation	R ²
50	Gold	$y = 0.0874x + 0.9303$	0.8815
	Victory	$y = 0.0865x + 1.0433$	0.7909
	White	$y = 0.0616x + 0.621$	0.9134
70	Gold	$y = 0.0802x + 1.689$	0.8456
	Victory	$y = 0.0788x + 1.5337$	0.7744
	White	$y = 0.065x + 0.371$	0.8845
80	Gold	$y = 0.0103x + 2.3957$	0.373
	Victory	$y = 0.0106x + 2.2147$	0.3439
	White	$y = 0.0103x + 1.986$	0.3026

The biomass production rate of varieties 'Gold' and 'Victory' were higher than that of variety 'White' at 50 and 70% shade level. Variety 'White' had low leaf area development rate (Table 2). The decrease of the photosynthesis activity may have related to the decrease in dry matter accumulation. Guttieri *et al.* (2001) reported that dry matter accumulation decreased due to decrease in leaf number, leaf area index and acceleration in leaf senescence. The biomass production rate of varieties 'Gold' and 'Victory' were approximately similar at shade levels of 50 and 70%. There is a high positive correlation between LA and biomass production and the biomass production followed to a similar pattern to that LA development (Table 2). Fifty percent and 70% shades were better than 80% shade for the growth of dracaena varieties in the dry zone of Sri Lanka with regard to biomass production.

CONCLUSIONS

The dracaena varieties used in this study performed better under 50 and 70% shade levels. The varieties 'Gold' and 'Victory', with little differences, attained a high LA and dry matter levels. Further, growth rates of varieties were higher at 50 and 70% shade levels than at 80% shade level. It could be concluded that, 70% shade level is suitable for growing dracaena varieties in the Batticaloa district of Sri Lanka and the varieties 'Gold' and 'Victory' are most suitable than the variety 'White'.

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