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Studies on growth and quality of *Philodendron xanadu* plants under different coloured shade nets

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Abstract
The present investigation was carried out to study the influence of different coloured shade nets on *Philodendron xanadu* (Cut foliage plant). The plants were grown under four different coloured shade nets *viz*., red, white, green, black and control as natural tree shade. Environmental parameters *viz*., light intensity, temperature and relative humidity recorded during the entire study period indicated that highest light intensity was recorded under red net and control conditions. Plant height and plant spread were superior in the plants grown under red shade net during sixth month after planting. Unlike the significant influence of certain morphological parameters under red net condition, the physiological parameters like total chlorophyll content was highest under black net conditions while epicuticular wax content in the leaves was found to be higher under green net conditions. In contrast to the above, photosynthetic rate was highest in the plants grown under natural shade conditions (control). Foliage quality parameters like days taken for leaf senescence in plants and vase life in distilled water was found to be superior in the foliage harvested from the plants grown under green net.

Keywords: *Philodendron xanadu*, coloured nets, total chlorophyll content, foliage quality, red shade net

Introduction
Cut foliage plants are important component in floricultural industry and are largely used for decoration as fillers in floral arrangements. Cut foliage provides freshness, colour and variety to arrangements and bouquets. The commercial production of the cut foliage plants has started in India in recent years and these plants have huge demand in the market. The cut foliages are suited for year round production with low investment and maintenance. *Philodendron xanadu* (Philodendron) is an important cut foliage plant used commonly in bouquet making and stage decorations. It is widely cultivated as a landscape plant in tropical, subtropical and warm temperate climates. It is a shade loving crop and recommended in interiorscaping. Generally cut foliage plants perform well under partial shade and produces foliage round the year. Coloured shade nets approach has already been experimented in certain ornamentals, vegetable and even fruit crops. Providing shade nets regardless of colour reduce radiation that reaches the crops underneath and is directly proportional to the shade factor and modify microenvironment. Hence the present study was carried out with the objective of evaluating the growth, performance and quality of cut foliage plants under different coloured shade nets and to find the suitable colour for growing.

Materials and methods
This study was conducted at the Department of Floriculture and Landscaping, TNAU, Coimbatore located at 11 ^{0} 02' N latitude and 76 ^{0} 57' E longitude at an altitude of 426.76 m above MSL. The plants were grown and evaluated under different coloured shade nets (50%) *viz*., red, white, green, black and in natural tree shade as control. Uniform sized plants were selected and planted in pots of 20 cm diameter. The growing media used for planting consisted of sand, garden soil, red soil in the ratio 1:1:1. The experiment was laid out in FCRD (Factorial Completely Randomized Design) with two factors and three replications. Coloured shade net and months after planting were the two factors. First factor consist of 5 levels S_1 (Red), S_2 (White), S_3 (Green), S_4 (Black) and S_5 (Control). Second factor consists of 3 levels namely M_1 (2 months after planting), M_2 (4 months after planting) and M_3 (6 months after planting). Environmental parameters were recorded regularly @ 9.00 AM, 12.00 Noon and 3.00 PM in a day. Temperature, relative humidity and light intensity were recorded using thermometer, hygrometer and lux meter respectively.

Morphological and physiological parameters were recorded @ 2 months interval (2nd, 4th and 6th month after planting), root and foliage quality parameters were recorded once after harvesting. Physiological parameters like Photosynthetic rate, transpiration rate and leaf temperature were measured using PPS (Portable Photosynthesis System) whereas chlorophyll content estimated by DMSO (Di-methyl sulphoxide) method (Hiscox, 1979) [4], Epicuticular wax determined by petroleum ether method (Ebercon *et al*., 1977) [1].

Results and Discussion

Environmental parameters

In the present study, highest temperature (28.97 and 27.58ºC) was experienced under white and red shade net while least temperature (26.33ºC) was recorded under black shade net (Table 1). The present study was in agreement with earlier studies that temperature reduced under black shade net and this in turn affects plant processes (Smith *et al.*, 1984) [10]. Among the different growing conditions, light intensity was highest (5616 lux) under control, followed by white shade net (5422 lux) and the least light intensity (4948 lux) was recorded under greens shade net conditions. Tree shade (without shade net) ensure the maximum sunlight utilization or light fall in control (Table 3). High light intensity combined with high temperature recorded under red net conditions might in turn have registered lesser relative humidity levels. However, no significant difference was observed among the interaction of shade nets and months. Relative humidities (Table 2) are often higher under netting than outside as a result of water vapour being transpired by the crop and reduced mixing with drier air outside the netted area (Elad *et al*., 2007) [2], even when temperatures under the netting are higher than outside (Stamps, 1994) [11].

Table 1: Effect of different coloured shade nets on temperature of shade net house

Temperature (ºC)							
Months	**November**	**December**	**January**	**February**	**March**	**April**	**Mean**
S_1 (Red)	26.50	25.00	26.00	26.50	29.00	32.50	27.58
S_2 (White)	27.50	26.00	27.80	28.00	30.00	34.50	28.97
S_3 (Green)	27.25	25.50	25.50	26.50	29.00	33.50	27.88
S_4 (Black)	25.30	24.50	24.70	24.50	27.30	31.70	26.33
S_5 (Control)	26.45	25.00	25.32	26.00	28.60	33.50	27.48
Mean	26.60	25.20	25.86	26.30	28.78	33.14	27.65
	S		M		S x M		
S. Ed.	1.20		3.20		2.95		
CD (0.05)	NS		2.64		NS		

Table 2: Effect of different coloured shade nets on relative humidity of shade net house

Relative humidity (%)							
Months	**November**	**December**	**January**	**February**	**March**	**April**	**Mean**
S_1 (Red)	68.50	71.50	66.00	55.67	64.00	63.00	64.78
S_2 (White)	67.95	72.50	67.50	59.50	67.00	66.00	66.74
S_3 (Green)	68.00	72.00	67.00	59.50	66.50	65.00	66.33
S_4 (Black)	70.50	73.50	68.00	60.00	68.00	68.00	68.00
S_5 (Control)	67.95	71.50	66.00	58.50	66.00	65.00	65.83
Mean	72.20	72.20	66.90	58.63	66.30	65.40	66.34
	S		M		S x M		
S. Ed.	2.85		2.13		7.00		
CD (0.05)	NS		6.26		NS		

Table 3: Effect of different coloured shade nets on light intensity of shade net house

Light intensity (lux)							
Months	**November**	**December**	**January**	**February**	**March**	**April**	**Mean**
S_1 (Red)	4946	5024	4546	6877	5357	6932	5616
S_2(White)	5378	5442	6826	4008	4532	6348	5422
S_3 (Green)	4341	4783	3980	5722	4938	5922	4948
S_4 (Black)	4330	4570	3890	5357	6860	5940	5158
S_5 (Control)	5391	5499	5237	5689	5578	6837	5705
Mean	4877	5064	4899	5531	5453	6396	5370
	S		M		S x M		
S. Ed.	234.91		257.34		575.43		
CD (0.05)	470.00		514.76		1151.04		

S- Shade net colour, M- Month, S x M- Interaction

Morphological parameters

Plants grown under red shade net exhibited the highest plant height (39.50 cm), plant spread (38.52 cm (N-S) and 35.11 cm (E-W)), leaf length (13.68 cm), leaf breadth (5.80 cm), leaf area (32.77 cm^2), Petiole girth (1.20 cm) (Table 4). Most of the morphological parameters were significantly highest under red shade net conditions followed by white, green and natural shade conditions (Control). This results supports the result of Mythrong and Sudhadevi (2016) [7], in which they concluded that increased plant height, plant spread and number of leaves of *Nephrolepis exaltata* and *Asparagus densiflorus* observed under red net. Increased total leaf area exhibited by plants maintained under red shading has been reported due to the expansion of individual leaves, probably influenced by the smaller R:B (Red:Blue) light ratio. A similar finding was reported for *O. basilicum* specimens,

which produced greater leaf area and higher fresh biomass yields when cultivated in soil covered with red plastic mulches (Kasperbauer, 1994) [6]. The favourable micro-climate and spectral quality of red shade net conditions might have proved beneficial in improving the leaf traits.

Table 4: Effect of coloured shade net on morphological parameters of *Philodendron xanadu* @ 6 months after planting

Shade net colour	Plant height (cm)	Plant spread (cm)		Number of leaves/ plant	Leaf length (cm)	Leaf breadth (cm)	Leaf area (cm^2)	Petiole girth (cm)
		E-W	N-S					
S_1 (Red)	39.50	35.11	38.52	30.15	13.68	5.80	32.77	1.20
S_2 (White)	37.12	31.78	36.83	25.81	11.37	4.50	26.73	1.18
S_3 (Green)	36.50	28.74	32.52	16.83	10.50	4.60	25.00	0.42
S_4 (Black)	30.70	30.76	35.87	19.80	8.80	3.40	23.25	0.50
S_5 (Control)	35.67	29.66	36.73	26.70	9.80	4.50	27.64	0.50
Mean	35.90	29.94	35.82	23.85	10.83	4.54	26.88	0.74
S. Ed.	1.51	3.18	3.65	2.25	1.12	0.49	2.82	0.07
CD (0.05)	3.08	6.51	7.46	NS	2.30	1.01	5.77	0.15

Physiological parameters

Highest total chlorophyll content (2.78 mg g^{-1}) was observed in the plants grown under black shade nets. These results were similar to those of work conducted by Rekha Meena *et al*. (2012) [9] in *Spinacia olearecae*. Although the plants were not directly exposed to sun, they produced additional chlorophyll to capture the diffuse radiation in order to produce carbohydrates required for their growth and development (Ilic *et al*., 2015) [5]. At natural tree shade condition, highest photosynthetic rate of (8.97 µmol $m^{-2}s^{-1}$) was observed (Table 5). The highest photosynthetic rate might be due to high CO_2 prevailing in outer environment when compared to shade net conditions, which might have increased the photosynthetic efficiency. Least transpiration rate (0.71 m mol $m^{-2}s^{-1}$) was also exhibited under control conditions which are explained by the fact that, photosynthetic rate and transpiration rate are negatively correlated and this is evidently observed in the plants grown in control (Table 5). Epicuticular wax content (18.25 µg cm^{-2}) found to be highest in the leaves collected from the plants grown under green shade net. This ensures the occurrence of limited transpiration in leaves eventually increases foliage quality.

Table 5: Effect of coloured shade net on physiological parameters of *Philodendron xanadu* @ 6 months after planting

Shade net colour	Total chlorophyll content (mg g^{-1})	Photosynthetic rate (µmol $m^{-2}s^{-1}$)	Transpiration rate (mmol $m^{-2}s^{-1}$)	Epicuticular wax (µg cm^{-2})
S_1 (Red)	2.52	3.68	1.20	12.42
S_2 (White)	2.35	3.23	0.72	13.23
S_3(Green)	2.43	5.95	1.48	18.25
S_4 (Black)	2.78	3.55	0.84	12.69
S_5 (Control)	1.93	8.97	0.71	11.26
Mean	2.38	0.47	0.11	1.39
S. Ed.	0.22	0.97	0.22	2.85
CD (0.05)	0.46	0.47	0.11	1.39

Root parameters

Highest root length (32.50 cm) and root spread of 17.53 cm (N-S), 16.84 cm (E-W), was observed under green net conditions (Table 6). Shading treatments diminish the storage of photosynthetic products in the roots and any environmental variation will modify the root growth by altering the distribution of photosynthetic assimilates within the plant (Ferreira *et al*., 2004) [3]. Red and far red radiation may control the plant phytochromes and influence the partition between roots and aerial tissues under controlled conditions but the alteration in the root growth is attributed to the variation in light intensity experienced under different shade nets.

Foliage quality parameters

Leaves of the plants grown under black shade net conditions registered Green group 139 Dark yellowish green (Table 6). The darker green colour and higher chlorophyll content may be due to the heavier PAR shading under black netting compared to red (Poorter *et al*., 1995) [8]. (Table 6). With regard to leaf senescence in plants, days taken for leaf senescence was highest (38.52) in leaves of green net grown plants and the other treatments were on par with each other. This may be due to better protection of the leaves by these nets from high light intensity and thereby improved quality of cut foliage. Vase life of leaves was highest (28.92 days) in the plants under green net followed by control and black shade net which were on par with a vase life of 24.67 and 22.83 days respectively. This parameter will improve the post harvest quality of cut foliages commonly used in floral arrangements.

Table 6: Effect of coloured shade net on root parameters and foliage quality of *Philodendron xanadu*

Shade net colour	Root length (cm)	Root spread (cm)		Colour intensity of leaf (RHS chart)	Days taken for leaf senescence (days)	Vase life in distilled water(days)
		N-S	E-W			
S_1 (Red)	23.50	15.22	13.18	Green group 141 Deep Yellowish Green A	32.57	17.38
S_2 (White)	24.30	15.35	13.28	Green group 143 Strong yellow green A	31.67	16.38
S_3 (Green)	32.50	17.53	16.84	Green group 137 Strong Yellow Green A	38.52	28.92
S_4 (Black)	15.00	8.68	6.35	Green group 139 Dark yellowish green	32.49	22.83
S_5 (Control)	15.00	9.51	6.88	Green group 143 Strong Yellow Green A	29.87	24.67
Mean	22.06	13.26	11.31		33.02	22.04
S. Ed.	2.90	1.68	1.45		3.58	2.62
CD (0.05)	6.47	3.75	3.24		7.99	5.83

Conclusion

Thus red shade net improved the morphological parameters whereas the green shade net enhanced the root characters and foliage quality. Hence use of red shade net with frequent harvesting is recommended for growing *Philodendron xanadu*.

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