Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

J P P Journal of Pharmacognosy and Phytochemistry

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(4): 1141-1144
Received: 28-05-2019
Accepted: 30-06-2019

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Effect of coloured shade nets on physiology and quality of cut foliage plants

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Abstract
The present study was carried out to evaluate cut foliage plants namely *Asparagus sprengeri* and *Nephrolepis exaltata* under four different coloured shade nets *viz*., red, white, green, black and control as natural tree shade. Total chlorophyll content in the foliages found to be highest under black net conditions. In contrast, photosynthetic rate was highest in the plants grown under natural shade conditions. Root parameters and foliage quality parameters were found to best in the cut foliage harvested from green shade nets.

Keywords: *Asparagus sprengeri*, *Nephrolepis exaltata*, foliage quality, green shade net, chlorophyll content

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 less care and maintenance. *Asparagus sprengeri* (Asparagus fern) is one of the familiar cut foliage seen everywhere in floral arrangements. It is a rounded herbaceous perennial that is used in the landscape for its attractive, fine-textured foliage. *Nephrolepis exaltata* (Sword fern) is a very popular house plant, often grown in hanging baskets or similar conditions. This fern thrives best in humid conditions and in outdoors this plant prefers partial shade or full shade, in case of indoors it grows best in bright filtered light. Generally cut foliage plants perform well under partial shade and produces foliage round the year. Coloured shade nets approach in protected cultivation 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 physiological performance and quality of cut foliage plants grown under different coloured shade nets.

Materials and methods
This study was conducted at the Department of Floriculture and Landscaping 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). Two different cut foliage plants used namely *Asparagus sprengeri* and *Nephrolepis exaltata* were used in this experiment. Physiological parameters were recorded at two months interval and documented whereas root parameters and foliage quality parameters were observed once after harvesting. Photosynthetic rate and Transpiration rate were measured using PPS (Portable Photosynthesis System) whereas chlorophyll content estimated by DMSO (Di-methyl sulphoxide) method (Hiscox, 1979) [3], Epicuticular wax determined by petroleum ether method (Ebercon *et al*., 1977) [11].

Results and Discussion

Physiological parameters

Differential stimulation of desirable physiological responses can be achieved with coloured shade nets (Shahak, 1999) [6]. Highest total chlorophyll content was observed in the cut foliage plants grown under black shade net. *Asparagus sprengeri* and *Nephrolepis exaltata* leaves contain 1.58 mg g^{-1} and 2.15 mg g^{-1} of total chlorophyll content respectively (Table 1 & 2). The total chlorophyll was higher under black net which corroborates the findings of Stamp and Chandler (2008) [8] who found greater chlorophyll content in *Pittosporum tobira* 'Variegata' under black and blue coloured nets. This is associated with the low levels of PAR (Photosynthetically Active Radiation) and light intensity recorded under black net. 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). Photosynthetic rate found to be increased in outside conditions (Control) with the values of 6.31 µmol $m^{-2}s^{-1}$ (*Asparagus sprengeri*) and 4.20 µmol $m^{-2}s^{-1}$ (*Nephrolepis exaltata*) (Table 1 & 2). 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 was recorded in black net and control conditions for *Asparagus sprengeri* with the rate of 0.73 mmol $m^{-2}s^{-1}$ whereas in *Nephrolepis exaltata*, plants exhibited least transpiration rate of 0.28 mmol $m^{-2}s^{-1}$ in control conditions alone. Higher photosynthetic rate and lower transpiration rate prevailed under control conditions 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 1 & 2). Among the different treatments (coloured shade nets), leaves of plants grown under green shade net recorded the highest epicuticular wax content (6.87 µg cm^{-2} & 3.80 µg cm^{-2}) in *Asparagus sprengeri* and *Nephrolepis exaltata* respectively (Table 1 & 2) but the least epicuticular wax content was observed in control. Lowest epicuticular wax content in control condition causes highest photosynthetic rate in foliages, this shows the interaction activity of physiological characters in cut foliage plants. The deposition rate of wax in leaf cuticle depends directly on temperature and light, being inversely proportional to water content in the plant (Skoss, 1955) [7].

Table 1: Effect of coloured shade net on physiological parameters of *Asparagus sprengeri* @ 6 months after planting

Shade net colour	Chlorophyll content (mg g^{-1})			Photosynthetic rate (µmol $m^{-2}s^{-1}$)	Transpiration rate (mmol $m^{-2}s^{-1}$)	Epicuticular wax (µg cm^{-2})
	Total Chlorophyll	Chlorophyll 'a'	Chlorophyll 'b'			
Red	0.42	0.32	0.10	3.31	0.61	3.93
White	0.30	0.19	0.11	2.65	0.75	3.43
Green	1.25	0.95	0.30	2.51	1.02	6.87
Black	1.58	1.50	0.08	2.66	0.73	4.52
Control	0.55	0.40	0.15	6.31	0.73	2.73
Mean	0.81	0.64	0.12	3.48	0.76	4.29
S. Ed.	0.08	0.06	0.02	0.30	0.07	0.47
CD (0.05)	0.17	0.13	0.02	0.62	0.15	0.97

Table 2: Effect of coloured shade net on physiological parameters of *Nephrolepis exaltata* @ 6 months after planting

Shade net colour	Chlorophyll content (mg g^{-1})			Photosynthetic rate (µmol $m^{-2}s^{-1}$)	Transpiration rate (mmol $m^{-2}s^{-1}$)	Epicuticular wax (µg cm^{-2})
	Total Chlorophyll	Chlorophyll 'a'	Chlorophyll 'b'			
Red	1.53	1.13	0.40	2.96	0.64	3.21
White	1.49	1.10	0.37	1.75	0.79	1.77
Green	1.50	1.12	0.38	3.10	0.32	3.80
Black	2.15	1.20	0.95	2.86	0.43	2.24
Control	1.50	1.50	0.32	4.20	0.28	2.73
Mean	1.62	1.13	0.48	2.97	0.49	2.33
S. Ed.	0.14	0.10	0.05	0.29	0.04	0.25
CD (0.05)	0.29	0.20	0.10	0.60	0.08	0.53

Root parameters

In *Asparagus sprengeri*, increased root length (32.50 cm), root spread of 20.13 cm (N-S), 19.22 cm (E-W) and primary roots (23.50) were observed under green net conditions (Table 3). In contrast to the above, *Nephrolepis exaltata* plants showed increased root length (25.20 cm), root spread of 19.47 cm (N-S), 17.46 cm (E-W) and primary roots (26.80) under red shade (Table 4). The distribution and accumulation of photosynthetic products in the roots is significantly enhanced by light. 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)

Table 3: Effect of coloured shade net on root growth of *Asparagus sprengeri*

Shade net colour	Root length (cm)	Root spread (cm)		Number of primary roots
		N-S	E-W	
Red	26.50	15.28	14.32	19.50
White	26.50	15.25	14.11	17.50
Green	32.50	20.13	19.22	23.50
Black	20.50	15.29	13.14	9.50
Control	18.50	13.42	13.27	10.00
Mean	24.90	15.87	14.81	15.87
S. Ed.	3.52	1.89	1.80	2.14
CD (0.05)	7.84	4.21	4.02	4.77

Table 4: Effect of coloured shade net on root growth of *Nephrolepis exaltata*

Shade net colour	Root length (cm)	Root spread (cm)		Number of primary roots
		N-S	E-W	
Red	25.20	19.47	17.46	26.80
White	22.50	16.78	14.73	21.30
Green	14.50	7.55	5.83	11.50
Black	19.20	12.91	10.11	19.80
Control	12.50	6.34	5.71	12.00
Mean	18.78	12.61	10.77	18.28
S. Ed.	2.09	1.45	1.28	2.02
CD (0.05)	4.66	3.10	2.85	4.50

Foliage quality parameters

Leaf colour intensity was measured using RHS (Royal Horticultural Society) colour chart which showed that foliages from all the treatments belonged to green group. The leaves (cladophylls) of *A. springeri* grown under black shade net conditions registered Green group 139 Dark yellowish green and Leaves (Pinnae) of *N. exaltata* belonged to the Green Group 143 Strong Yellow Green A under black shade net conditions (Table 5 & 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) [5]. Days taken for leaf senescence in plants was highest in the foliages grown under green shade nets. *A. sprengeri* plants took maximum of 29.50 days and *N. exaltata* took 29.52 days respectively for leaf senescence (Table 5 & 6). Likewise positive results were exhibited in the vase life of foliage harvested from the plants grown under green shade net. Maximum vase life of 5.50 and 6.50 days reported in *A. sprengeri* and *N. exaltata* foliages kept in distilled water respectively at ambient conditions (Table 5 & 6). This results shows that higher epicuticular wax content paves way for improved foliage quality in the plants grown under green shade net. Highest epicuticular wax content prevents transpiration and thereby water loss from plant tissues. Leaf longevity is a favourable trait particularly in case of plants which is used as an indoor plant.

Table 5: Effect of coloured shade net on foliage quality of *Asparagus sprengeri*

Shade net colour	Leaf colour intensity (RHS Chart)	Vase life in distilled water (days)	Days taken for leaf senescence (days)
Red	Green group 141 Deep Yellowish Green A	4.00	26.80
White	Green group 143 Strong yellow green A	4.50	25.30
Green	Green group 137 Strong Yellow Green A	5.50	29.50
Black	Green group 139 Dark yellowish green	4.50	25.32
Control	Green group 143 Strong Yellow Green A	4.50	24.47
Mean	--	4.60	26.28
S. Ed.	--	3.01	0.53
CD (0.05)	--	6.70	1.18

Table 6: Effect of coloured shade net on foliage quality of *Nephrolepis exaltata*

Shade net colour	Leaf colour intensity (RHS Chart)	Vase life in distilled water (days)	Days taken for leaf senescence (days)
Red	Yellow Green Group 144 Strong Yellow Green A	4.50	25.34
White	Yellow Green Group N144 Strong Yellow Green C	4.50	25.26
Green	Yellow Green Group 144 Strong Yellow Green A	6.50	29.52
Black	Green Group 143 Strong Yellow Green A	5.00	24.32
Control	Green Group 143 Strong Yellow Green A	4.75	22.70
Mean	--	5.05	25.43
S. Ed.	--	0.59	1.37
CD (0.05)	--	1.33	3.06

Conclusion

Thus the study regarding physiological activity and foliage quality was much needed in coloured shade net approach. Since foliage quality seems to be very important trait in cut foliage industry, effect of varied coloured shade net gave significant results. Green shade net enhanced the root and foliage quality of both the cut foliage plants. Moreover physiological parameters also gave supporting results with the foliage quality.

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