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Effect of different coloured shade nets on growth and quality of ornamental plants

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ABSTRACT

The present investigation was conducted to study the effect of different colored shade nets on production and quality of different ornamental foliage plants. The experiment was carried out at Floriculture and Landscaping Block, College of Horticulture, Anantharajupeta during February-August, 2022. The experiment consists of 25 treatments with three replications which were laid out in Factorial Randomized Complete Block Design. The treatments were formed with two factors viz. Factor I (Colour shade nets, Green (C_1), White (C_2), Black (C_3), Red nets (C_4) and Open (C_5) condition and plants (Factor II, Pandanus veitchii (P_1),Epipremnum aureum (P_2), Sansevieria trifasciata (P_3), Aglaonema commutatum var. Red Gold (P_4), Rhoeo spathacea (P_5) were taken. The experiment revealed that the maximum mean plant height (35.33 cm and 52.08 cm) and highest mean plant spread (37.96 and 44.63 cm^2) was recorded at 90 and 180 DAP respectively under black shade net. The maximum mean total leaf area was recorded highest (1704.35 and 1981.34 cm^2) under red net in both 90 and 180 DAP respectively. Highest mean total chlorophyll (5.50 mg g^{-1}) was observed under black net and longest vase life (32.10 days) was reported under white shade net.

Keywords: Chlorophyll content, color shade nets, ornamental plants, plant height and vase life

Cut foliage and quality indoor plants have a great opportunity in the local as well as foreign markets and can play a valuable role in the economic upliftment of the farmers (El-Ghait *et al.*, 2012). The use of these bio-degradable decorative foliages as fillers in bouquet making has increased substantially from 5% to 20–25% (Bhattacharjee, 2006). In India, commercial production of cut foliage has flourished in recent years because of its huge demand, especially during festivals and annual events. The floricultural sector relies heavily on ornamental foliage plants, which are mostly used as fillers in flower arrangements for adornment. Indoor plants provide arrangements and exhibit a fresh, colourful, and varied feel. In recent years, India has begun the commercial manufacturing of cut foliage plants, which are in high demand on the market. The cut foliages may be produced all year round with little upkeep and expenditure. In general, plants with beautiful leaves thrive in partial shade and produce foliage all year round. Some decorative, vegetable, and even fruit crops have previously been tested using the coloured shade netting method of covered agriculture. Regardless of colour, providing shade nets will lower radiation that reaches the crops below and is directly correlated to the shade factor and change the micro-environment. Due to easy monitoring, consistent seedling growth, a lower incidence of pests and diseases, and a lower mortality rate, these nurseries are raised in protected structures (Patil *et al*., 2017).

Cordyline, *Pandanus*, *Chlorophytum*, *Ixora*, *Aglaonema*, *Sansevieria*, *Rhoeo*, *Pothos*, *Pedilanthus*, *Asparagus* and *Dracaena* are important ornamental plants in the world trade and used worldwide for their beautiful foliages. High grade quality foliage and healthy ornamental plants fetches more price and demand in the market. Today's lucrative business is ornamental plant nurseries, which include a wide variety of nurseries based on wholesale or retail, indoor/shade-loving plants, tissue culture plants, commercial flowering plants, shrub, climber, and tree seedlings for landscaping, annual plants, bulbous flowers, etc. Nurseries should be able to produce and deliver the needed quantity of seedlings at the appropriate time in the event of a sudden surge or drop in demand (Ashoka *et al*., 2019). These nurseries are doing well across the nation. Efficient and affordable shade structures facilitate the nurserymen in production of quality planting material so that they can get more profit. Use of different coloured shade nets improves the quality and production of cut greens and indoor plants. Taking into consideration of all the above studies the present investigation was carried out to study the 'Effect of different colored shade nets on growth and quality of various ornamental plants.

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MATERIALS AND METHODS

The present investigation was carried out during the year 2022 for 6 months at Dr. YSRHU-College of Horticulture, Anantharajupeta with 5 types of ornamental foliage plants under five types of color shade (50%) treatments *viz*, Green (C_1), White (C_2), Black (C_3), Red nets (C_4) and Open (C_5). The details of materials used, methods adopted and experimental techniques employed during the study are outlined here. The five plant species *Pandanus veitchii* (P_1), *Epipremnum aureum* (P_2), *Sansevieria trifasciata* (P_3), *Aglaonema commutatum var.* Redgold (P_4), *Rhoeo spathacea* (P_5) of same height and aged plants were taken and prepared in 12/15-inch black polybags. There were 12 poly bags in each treatment and among them 6 plants were selected randomly for recording the observations. The data on morphological parameters (plant height, plant spread and total leaf area per plant with WinDAS conveyer belt leaf area meter) were recorded at three-month interval, whereas physiological and quality parameters (Total chlorophyll content and vase life) were taken at the end of the season. Total chlorophyll analysis was done with DMSO method and then estimated by spectro-photometric observation (Sadasivam and Manicham, 1992). Vase life was recorded till the leaves began to show yellowing or atleast 5% or more of the leaves were desiccated. The data of 6 months were analyzed statistically at 0.05 level of significance with the help of OPSTAT software (O. P. Sheoran,)

RESULTS AND DISCUSSION

The various observations pertaining to the vegetative and biochemical attributes are presented in Table 1-7. Among multiple shade colors, plants grown under C_3 (Black) had highest plant height (35.33 cm) which was found significantly superior and was followed by C_1 (28.28 cm) and this was on par with C_4 (28.09 cm). While plant height recorded was minimum under white shade net (C_2) (26.49 cm). Findings for means of ornamental plant heights indicated a significant difference among them. P_2 (*Epipremnum aureum*) (recorded the greatest plant height (33.03 cm) followed by *Pandanus veitchii* (P_1) (32.03 cm), *Sansevieria trifasciata* (P_3) (28.47 cm), *Rhoeo spathacea* (P_5) (26.56 cm). Plant height recorded was minimum (25.11 cm) in *Aglaonema commutatum* var. Red gold (P_4) and all the treatments found significantly independent with each other. Plant height varied significantly among interactions. Maximum plant height of 50.53 cm was recorded in the interaction of (P_2 x C_3). Lowest plant height of 20.03 cm was recorded in (P_1 x C_5).

Among multiple shade colors, plants grown under C_3 had maximum plant height (52.08 cm) which was found significantly superior and followed by C_1 (42.81 cm) and C_4 (41.09 cm). Lowest plant height was reported under open (C_5) (38.36 cm). Amongst the ornamental plants grown under different colored shade nets there was a significant difference in plant heights. The P_2 showed the significantly superior plant height (54.84 cm) which is followed by P_1 (43.69 cm), P_3 (40.14 cm) and P_5 (38.22 cm) and lower plant height was recorded in P_4 (36.78 cm). In respect to the interaction among shade color nets and plants the combinations showed the significant difference. The maximum plant height (87.60 cm) was recorded in (P_2 C_3) and the lowest plant height (30.12 cm) was recorded in P_2 which was grown under C_5.

These variations might be due to optimum temperature inside the shade net and also genetic makeup of plants. Under a black shade net, Stamps and Chandler (2008) noted a similar kind of plant height in *Aspidistra elatior*. Nesi *et al*. (2013) also found highest plant height in *Hydrangea macrophylla* var. Dienemann and Tricolor under black shade net. Kurepin *et al*. in 2015, studies have shown that shade reduces leaf area while increasing the development of the stem and petiole.

Among multiple shade colors, plants grown under C_3 had maximum plant spread (37.96 cm) which was found significantly better and followed by C_4 (33.97 cm) and C_5 (29.78 cm). While the C_1 (28.70 cm) and C_2 (28.85 cm) had shown minimum plant spread and was statistically on par with each other.

Table 1: Effect of different colored shade net and ornamental plants on plant height (cm) at 90 DAP

	Name of ornamental foliage plant (P)					
Shade color (C)	***Pandanus veitchii* (P_1)**	***Epipremnum aureum* (P_2)**	***Sansevieria trifasciata* (P_3)**	***Aglaonema commutatum* var. Red gold (P_4)**	***Rhoeo spathacea* (P_5)**	**Mean**
Green (C_1)	26.67	36.67	26.00	22.33	29.73	**28.28**
White (C_2)	24.43	27.53	32.20	21.77	26.50	**26.49**
Black (C_3)	35.70	50.53	31.07	31.50	27.87	**35.33**
Red (C_4)	35.37	30.29	24.03	27.10	23.67	**28.09**
Open (C_5)	38.00	20.03	29.07	22.90	25.03	**27.00**
Mean	**32.03**	**33.03**	**28.47**	**25.11**	**26.56**	
Source	**Shade colour (C)**		**Ornamental plants (P)**		**C x P**	
SEm(±)	**0.19**		**0.19**		**0.42**	
LSD(0.05)	**0.53**		**0.53**		**1.19**	

Table 2: Effect of different shade colored net and ornamental plants on plant height (cm) at 180 DAP

	Name of Ornamental foliage plant (P)					
Shade color (C)	***Pandanus veitchii* (P_1)**	***Epipremnum aureum* (P_2)**	***Sansevieria trifasciata* (P_3)**	***Aglaonema commutatum* var. Red gold (P_4)**	***Rhoeo spathacea* (P_5)**	**Mean**
Green (C_1)	38.33	62.67	37.66	34.00	41.39	42.81
White (C_2)	36.09	45.19	43.86	33.43	38.16	39.35
Black (C_3)	47.36	87.60	42.73	43.16	39.53	52.08
Red (C_4)	47.03	48.63	35.70	38.76	35.33	41.09
Open (C_5)	49.66	30.12	40.73	34.56	36.71	38.36
Mean	**43.69**	**54.84**	**40.14**	**36.78**	**38.22**	
Source	**Shade colors (C)**		**Ornamental plants(P)**		**CxP**	
SEm(±)	**0.28**		**0.28**		**0.63**	
LSD(0.05)	**0.80**		**0.80**		**1.80**	

Table 3: Effect of different shade colors net and ornamental plants on plant spread (cm) at 90DAP

	Name of Ornamental foliage plant (P)					
Shade color(C)	***Pandanus veitchii* (P_1)**	***Epipremnum aureum* (P_2)**	***Sansevieria trifasciata* (P_3)**	***Aglaonema commutatum* var. Red gold (P_4)**	***Rhoeo spathacea* (P_5)**	**Mean**
Green (C1)	40.67	28.50	24.17	16.50	33.67	28.70
White (C2)	47.83	22.67	22.00	15.83	35.95	28.85
Black (C3)	59.15	39.80	23.02	27.78	40.07	37.96
Red (C4)	60.86	34.75	18.08	20.23	35.95	33.97
Open (C5)	53.38	29.17	21.93	13.37	31.03	29.78
Mean	**52.38**	**30.98**	**21.84**	**18.74**	**35.33**	
Source	**Shade Color(C)**		**Ornamental plants(P)**		**CxP**	
SEm(±)	**0.21**		**0.21**		**0.48**	
LSD(0.05)	**0.61**		**0.61**		**1.36**	

Table 4: Effect of different shade colors net and ornamental plants on plant spread (cm) at 180 DAP

	Name of ornamental foliage plant (P)					
Shade color (C)	***Pandanus veitchii* (P_1)**	***Epipremnum aureum* (P_2)**	***Sansevieria trifasciata* (P_3)**	***Aglaonema commutatum* var. Red gold (P_4)**	***Rhoeo spathacea*(P_5)**	**Mean**
Green (C_1)	47.33	35.16	30.83	23.17	40.33	**35.36**
White (C_2)	54.50	37.64	28.67	22.50	42.62	**37.19**
Black (C_3)	65.82	46.47	29.68	34.45	46.73	**44.63**
Red (C_4)	67.53	41.42	24.75	26.90	50.89	**39.80**
Open (C_5)	60.05	35.83	28.60	20.03	37.70	**36.44**
Mean	**59.04**	**29.33**	**28.50**	**25.40**	**43.65**	
Source	**Shade colors (C)**		**Ornamental plant (P)**		**CxP**	
SEm (±)	**0.25**		**0.25**		**0.56**	
LSD(0.05)	**0.71**		**0.71**		**1.58**	

Table. 5: Effect of different shade colors net and ornamental plants on total leaf area plant^{-1} (cm^2) at 90 DAP

	Name of Ornamental foliage plant (P)					
Shade color(C)	***Pandanus veitchii* (P_1)**	***Epipremnum aureum* (P_2)**	***Sansevieria trifasciata* (P_3)**	***Aglaonema commutatum* var.Red gold (P_4)**	***Rhoeo spathacea* (P_5)**	**Mean**
Green (C_1)	657.80	730.61	547.80	239.70	2821.57	**999.50**
White (C_2)	755.32	282.08	722.00	218.48	3587.86	**1113.15**
Black (C_3)	958.64	441.76	865.90	728.48	2686.67	**1136.29**
Red (C_4)	911.84	405.31	647.61	507.53	6049.45	**1704.35**
Open (C_5)	1118.09	238.80	602.65	183.07	2040.40	**836.60**
Mean	**880.34**	**419.71**	**677.19**	**375.45**	**3437.19**	
Source	**Shade color (C)**		**Ornamental plant (P)**		**C x P**	
SEm(±)	**12.02**		**12.02**		**26.88**	
LSD(0.05)	**34.19**		**34.19**		**76.44**	

Table 6: Effect of different shade colors net and ornamental plants on total leaf area (cm^2) at 180 DAP

	Total leaf area (cm^2) at 180 DAP Name of ornamental foliage plant (P)					
Shade color(C)	***Pandanus veitchii* (P_1)**	***Epipremnum aureum* (P_2)**	***Sansevieria trifasciata* (P_3)**	***Aglaonema commutatum* var. Red gold (P_4)**	***Rhoeo spathacea* (P_5)**	**Mean**
Green (C_1)	934.79	1007.61	824.80	516.69	3098.56	**1276.49**
White (C_2)	1032.31	515.79	998.99	495.47	3864.85	**1381.48**
Black (C_3)	1235.64	718.76	1142.90	1005.48	2963.66	**1413.29**
Red (C_4)	1188.84	682.30	924.60	784.52	6326.45	**1981.34**
Open (C_5)	1395.09	559.07	879.65	460.07	2317.39	**1122.25**
Mean	**1157.33**	**696.71**	**954.19**	**652.45**	**3714.18**	
Source	**Shade Color (C)**		**Ornamental plant (P)**		**CxP**	
SEm(±)	**8.85**		**8.85**		**19.78**	
LSD(0.05)	**25.15**		**25.15**		**56.24**	

Table 7: Effect of different shade colors net and ornamental plants on Total chlorophyll content at 180 DAP

Total chlorophyll content (mg g^{-1})at 180 DAP Name of ornamental foliage plant (P)						
Shade color(C)	***Pandanus veitchii* (P_1)**	***Epipremnum aureum* (P_2)**	***Sansevieria trifasciata* (P_3)**	***Aglaonema commutatum* var. Red gold (P_4)**	***Rhoeo spathacea* (P_5)**	**Mean**
Green (C_1)	4.31	11.61	1.72	4.21	1.76	**4.72**
White (C_2)	2.24	4.76	2.42	5.88	3.50	**3.76**
Black (C_3)	3.70	8.38	4.38	9.06	1.96	**5.50**
Red (C_4)	4.80	5.61	2.34	9.95	1.09	**4.76**
Open (C_5)	2.50	3.37	1.12	2.86	4.76	**2.92**
Mean	**3.11**	**6.75**	**2.40**	**5.99**	**2.62**	
Source	**Shade Color(C)**		**Ornamental plant(P)**		**CxP**	
SEm(±)	**0.03**		**0.03**		**0.07**	
LSD(0.05)	**0.09**		**0.09**		**0.20**	

Among the ornamental plants grown under different colored shade nets reveals the significant difference in plant spread. The P_1 showed the significantly higher plant spread (52.38cm) which is followed by P_5 (35.33cm), P_2 (30.98cm), P_3 (21.84 cm) and lower plant spread was recorded in P_4 (18.74 cm). In interaction, the maximum plant spread (60.86cm) was recorded in (C_4 P_1) combination. The lowest plant spread (13.37 cm) was recorded in P_4 which was grown under open condition. Among different colored shade nets, plants grown under C_3 had maximum plant spread (44.63cm) after 180 days of planting which was followed by C_4 (39.80 cm), C_2 (37.19 cm) and C_5 (36.44cm). While the plant spread recorded was minimum under C_1 (35.36 cm) net. Findings for means of ornamental plant spread indicated a significant difference among them. P_1 recorded the greatest plant spread (59.04cm). Plant spread recorded was minimum (25.40cm) in P_4. Plant spread was significantly differ among interactions. Maximum plant spread (67.53cm) was recorded in the interaction of (P_1 x C_4). Lowest plant spread (20.03cm) was recorded in (P_4 x C_5).

This increase in plant spread under 50% shade net could be the outcome of better microclimatic conditions regarding light intensity, temperature, humidity and wind speed compared to the other shade levels (Thakur *et al.*, 2019). Similar variations due to photoselective shade net in cut foliages was also observed by Rasheed *et al.* (2018) in *Schefflera arboricola* 'Hicolour'. Among the species significant difference was noticed for plant spread.

Among various colored shade nets, plants grown under C_4 had maximum plant leaf area (1704.35cm^2) which was found significantly superior and followed by C_3 (1136.29 cm^2) and which was on par with C_2 (1113.15 cm^2) it is followed by C_1 (999.50 cm^2). However, leaf area $plant^{-1}$ recorded was lower in C_5 (836.60 cm^2). Among the ornamental plants grown under different colored shade nets showed the significant difference in total leaf area. The P_5 showed the significantly superior plant total leaf area (3437.19cm^2) which was followed by P_1 (880.34 cm^2), P_4 (677.19cm^2), P_2 (419.71cm^2), and lowest total leaf area was recorded in P_4 (375.45 cm^2). The interaction treatments with respect to leaf area were found significant. The maximum leaf area $plant^{-1}$ (6049.45cm^2) was recorded in (C_4 P_5) combination. The lowest leaf area $plant^{-1}$ (183.07 cm^2) was recorded in P_4 which was grown under C_5.

Among various shade colors, plants grown under C_4 color shade cloth had maximum plant leaf area after 180 DAP (1981.34 cm^2) which was found significantly superior and followed by C_3 (1413.29 cm^2), C_2 (1381.48 cm^2) and C_1 (1276.49 cm^2). Lowest plant total leaf area was recorded under C_5 (1187.14 cm^2). Among the ornamental plants grown under different colored shade nets showed the significant difference in total leaf area. The P_5 showed the significantly more plant total leaf area (3714.18cm^2) which is followed by P_1 (1157.33 cm^2), P_3 (954.19cm^2), P_2 (696.71cm^2) and lowest total leaf area was recorded in P_4 (652.45cm^2). The maximum total leaf area (6326.45cm^2) was recorded in (C_4 P_5) combinations. The lowest leaf area (460.07 cm^2) was recorded in P_4 which was grown under C_5. These results are in agreement with the findings of Loughrin and Kasperbahuer (2001). They reported that when soil covered with red plastic, *Ocimum basilicum* produced greater leaf area. Considering the fact that the red shade net transmits more energy in the 610–720 nm range, it nevertheless promotes stronger photosynthetic activity than the black shade net (Taiz and Zeiger, 2002).

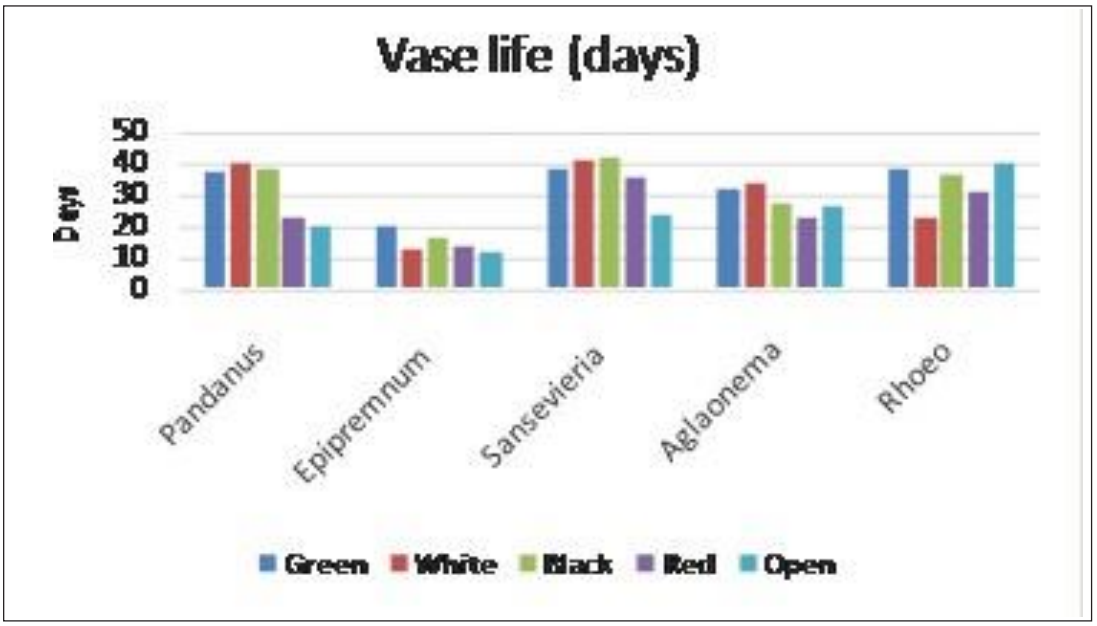

Fig. 1: Effect of multiple colored shade nets and ornamental plants on Vase life (days) at 180 DAP

Amongst different coloured shade nets, plants grown under C_3 net recorded highest total chlorophyll content (5.50 mg g^{-1}) which was followed by C_4 (4.76 mg g^{-1}) and it is on par with C_1 (4.72 mg g^{-1}) and followed by C_2 (3.76 mg g^{-1}). The lowest total chlorophyll content was reported under C_5 (2.92 mg g^{-1}). Findings for means of total chlorophyll content, P_2 (6.75 mg g^{-1}) recorded the greatest total chlorophyll content it is followed by P_4 (5.99 mg g^{-1}), P_1 (3.11 mg g^{-1}), P_5 (2.62 mg g^{-1}) and P_3 (2.40 mg g^{-1}). Total chlorophyll content showed significance among interactions. Maximum total chlorophyll content (11.61 mg g^{-1}) was recorded in the interaction of (P_2 C_1). The lowest total chlorophyll content (1.12 mg g^{-1}) was recorded in C_5 x P_3.

Chlorophyll concentration is at its highest in some shadow situations (Brand, 1997) because the synthesis of chlorophyll is limited by high light intensities (Taiz and Zeiger, 2002), while the breakdown of chlorophyll is extremely active under high light intensities. This suggests that in actuality, some shading levels could be advantageous. In begonia, plants cultivated in sunshine had lower chlorophyll contents (Hamerlynck *et al*., 2000), whereas plants planted with 76% shade had the greatest chlorophyll contents. In the current investigation, similar outcomes were attained. This is most likely because plants in the shadow require less light for photosynthesis (Hosseini *et al*., 2014), thus they grow more leaves and alter their photosynthetic pigments to make up for the lack of light (Hamerlynck *et al*., 2000).

Among the different color shade net treatments, C_2 showed highest vase life (32.10 days) followed by C_1 (30.24 days), C_5 (28.13 days) and it is on par with C_4 reported 27.56 days (Fig.1). The lowest vase life was reported under C_3 (26.13 days). The maximum vase life was found in P_3 (35.80 days) followed by P_5 (33.62 days), P_1 (31.73 days) and P_4 (28.11 days). The lowest vase life 14.90 days) was reported in P_2. In the interactions, the maximum vase life (41.40 days) was observed in (C_3 P_3). The lowest vase life was recorded under (C_5 P_2) (11.58 days).

Vase life is one of the most important factors influencing the utility of a cut foliage crop and always the plants with long vase life are preferred. The findings are consistent with those of Kumar *et al*. (2014), who also observed that Dracaena leaves collected from plants kept under white shade net had the longest vase life. It could be because the white shade net provides better shelter for the fronds from intense light, resulting in better-quality cut foliage. In comparison to other colour shade nets, black and red shade nets were found to be more effective at improving the majority of plant parameters. Therefore, it is possible to suggest using black or red net instead of the commercially available green shade net for the production of cut greens and potted plants.

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