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Effect of different coloured shade nets on production and quality of cordyline

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ABSTRACT

Cordyline terminalis is an important ornamental plant used for its beautiful foliage as cut green. This plant prefers shade for optimum growth. The effect of different coloured shade nets (red, green, black, and white with 50% shading intensity) along with control (without shade net) on production and quality of *Cordyline terminalis* was studied. The effect of spectral control of light on physiology and vegetative development was evaluated at different crop growth stages. The results showed that plants grown under shade nets produce good quality foliage and biomass irrespective of colour. The cut greens grown under red and white shade nets were exposed to higher PAR and transmittance than other colour nets and hence had better performance in terms of plant height, number of leaves, biomass, leaf area, photosynthetic rate, harvest index compared to control. Vase life of the foliage was higher under coloured shade nets when compared to open condition but significance difference was not found between different colours. White and red shade nets were found to be best for growing cordyline.

Key words: Colour-net, Cordyline, Cut greens, Leaf area, Photosynthetically active radiation

Cut greens are an important component of the floricultural industry and are largely used for decoration as a-filler in floral compositions. They provide freshness, colour and variety to various decorations, arrangements and bouquets**.** Cordyline plants are used extensively as cut florist greens for its beautiful foliage. Nets are commonly used to protect the agricultural crops from excessive solar radiation, extreme temperature and pests. In recent period, nets are used for specific modification of sunlight, improving micro-environment, and providing physical protection. Colour nets represent new agrotechnological concept which combine physical protection with differential filtration of solar radiation and promoting desired physiological response. The utilization of solar radiation by ornamental crops is based on selective filtration of light by different colour shade nets with special optical properties that modify the quality of natural radiation. Use of shade nets aims to optimize desirable physiological responses, in addition to providing physical protection and the substantial effect on shoot elongation, branching and flowering in ornamentals crops (Oren-Shamir *et al*. 2001). The colour shade nets approach was evaluated in ornamentals (Nissim-Levi 2008), vegetables (Fallik *et al*. 2009) and fruit trees (Shahak *et al*. 2004). Coloured shade nets not only exhibit special optical properties that allow the control of light, but also have the advantage of influencing the micro-climate to which the plant is exposed and offer physical protection against excessive radiation, insect pests and environmental changes (Shahak *et al*. 2004). Shade nets are frequently used to protect agricultural crops from excessive solar radiation and, improving the thermal climate (Kittas *et al*. 2009). The air temperature was lower than that of ambient air, depending on the shading intensity. Shade net not only decrease light quantity but also alters light quality to a varying extent and might also change other environmental conditions (Smith *et al*. 1984).

Nettings, regardless of colour, reduce radiation reaching crops underneath which is directly proportional to the shade factor and modify micro-environment. Keeping these facts in view, the present study was undertaken to study the production and quality of cordyline under different colour shade nets.

MATERIALS AND METHODS

A field experiment was conducted at the Research Farm of the Division of Floriculture and Landscaping, IARI, New Delhi during 2013-14 with *Cordyline terminalis*. They were planted during September 2013 under four different coloured shade nets (white, red, black and green) with shading

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intensity of 50%. The micro-environment and production under these shade levels were compared with the open field micro-environment and production (without shade nets).

Weather parameter like temperature, and relative humidity were measured under different shade levels along with control (without shade nets) by pocket weather tracker. Light measurements were carried out periodically during the growth stages under the nets, to monitor the actual light conditions to which the plants were exposed. All measurements were done on clear days at noon. The light intensity was measured by the digital light meter (Extech Instruments, 401025). Transmitted photosynthetically active radiation (PAR) as well as intercepted radiation by plant under each treatment was measured by the Line Quantum Sensor (LICOR-3000), whereas transmittance inside the net was calculated as the ratio of the PAR radiation spectra under a net and outdoor. Canopy temperature was measured using infrared thermometer.

Different plant characteristics like plant height (cm) was taken up to the center of growing young leaves, petiole length (cm) of 4th mature was taken, and length of 3rd inter-node was measured using standard scale during different growth stages. Number of matured leaves was also counted during stages. Leaf readings to determine chlorophyll content were taken with a Minolta chlorophyll meter (model SPAD-502) by averaging the 10-15 reading/plant. The photosynthesis/CO_2 uptake rate (µmol $CO_2/m^2/s$), transpiration (µmol $H_2O/m^2/s$), stomatal conductance (µmol/m^2/s), PS2 efficiency and total light intensity (µmol/m^2s/) were taken by LICor-6400 leaf gas exchange instrument, i.e. Infra-red gas analyzer (IRGA) during different growth stages (Long *et al.* 1996). The leaf area was measured using leaf area meter (Licor-3100) while fresh weight also taken using same leaves. The SLA was computed using the fresh weight and leaf area. HI was calculated as percentage yield of economic yield to the biological yield, whereas, vase life was estimated by placing the petiole of mature leaves of cordyline in distilled water in test tube. The experiment was laid out in randomized block design (RBD) and the data were analyzed accordingly.

RESULTS AND DISCUSSION

Coloured shade netting exhibit special optical properties and also influences the microclimate (Oren-Shamir *et al*. 2001). The main climatic parameter affected by shade net is solar radiation which depends upon type of shade net and density. The coloured shade cloth is designed to modify light in either the ultraviolet, visible, or far-red spectral regions, the cloth also enhances the relative content of scattered vs. direct light and absorbs infra-red radiation (Shahak *et al.* 2004). In the present investigation all the shade nets reduced light intensity, temperature, and improved humidity. Black shade net exhibited the lowest temperature, light intensity and highest RH levels. Light intensity under coloured nets was lower than outside. Average light intensity was 24892 lux, 10090 lux, 20847 lux and 24753 lux under green, black, red and white net, respectively, during growing season while in control it was 62178 lux. It was lowest under black (16.53%) followed by red (34.15%), green (44.77%), and white (40.55%) of the control. Solar radiation is the major mode of energy exchange between plant and environment. It provides the main energy input to plants, where much of this energy is converted to heat and drives other processes such as photosynthesis and transpiration. This energy is also involved in determining tissue temperatures with consequences for rates of metabolic processes and the balance between them (Jones 1992).

Reduction in radiations resulting from netting affects temperature and RH (Stamps 1994). The temperature under different coloured shade-nets varied. It was found to be higher under control as compared to shade net. Temperature reduction was highest in black shade net followed by green, white and red. But during winter months, temperature inside the nets was higher compared to control. Reduced air temperature was in agreement with the result of Campanha *et al.* (2005). The present study was in agreement with earlier studies that the temperatures reduced by 2-3°C under black shade net and this in turn affects plant processes (Smith *et al.* 1984). Relative humidity (RH) was higher under coloured nets even though temperature was low. It was highest under black shade net followed by green, red and white as compared to control.

In the present studies Photosynthetically active radiation (PAR) and transmittance levels were significantly lower under different colour shade net. PAR under each shade net was found to be lower than control. Its ranged was from 482.60 to 572.90 in green, 197.62 to 217.20 in black, 516.90 to 580.90 in red, and 480.80 to 584.20 while in control it ranged from 1233.90 to 1452.30 micro mol/m^2/s. The transmittance was recorded to be maximum in red coloured net and minimum under black net. Red and white shade nets exhibited higher PAR and transmittance than other colour nets (Fig 1). Due to lower light intensity, temperature

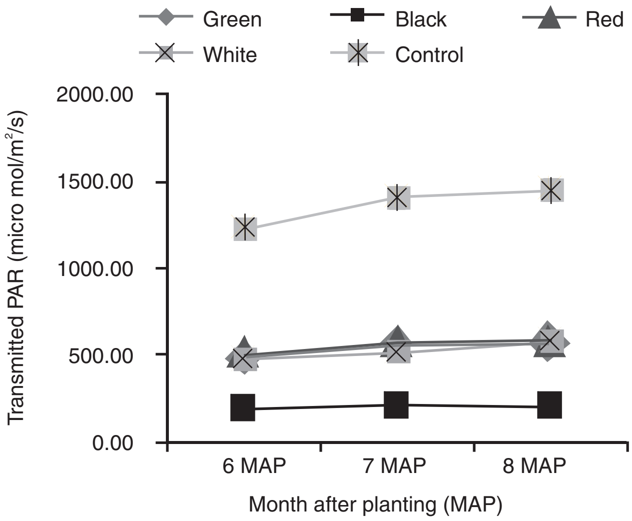

Fig 1 Transmitted PAR under different coloured nets during different months after planting.

Table 1 The influence of different coloured shade nets on the harvest index

Treatment	Harvest index (%)
Green	46.23
Black	50.45
Red	47.24
White	46.87
Control	41.12

and higher RH, canopy temperature under different coloured shade nets was lower as compared to control. Maximum reduction was found under black net (5.40-6.93 ºC) followed by in green, white and red. Smith *et al*. (1984) had also observed lower canopy temperature under shade nets than those of control (Table 2).

Leaf chlorophyll content was also found to be improved under all the nets. The SPAD reading was found to be significantly higher under different coloured net when compared to control, but it was non-significant among the different coloured net (Fig 2).

Chloroplasts were more numerous and larger in plants grown under shading, while the accumulation of chloroplastic starch grains was greater in plants grown under red shading or in full sunlight (Costa *et al*. 2010). Because of the higher chlorophyll content, photosynthetic rates were higher in shade nets. Photosynthetic activity of the leaves was significantly higher under white net, followed by green, control and red while it was lowest under black net. It was 34% higher under white net over control. The stomatal conductance was also recorded maximum under white coloured net. The efficiency of Photosystem 2 is directly related with CO_2 absorbance. Along with transpiration rate, it was maximum under white. Overall all the gaseous exchange was found to be higher under white shade net (Table 2).

Plants grown under coloured nets had variable growth because of their spectral effect that influences the growth of the plant. Cordyline was found to be significantly taller under white net (40.81cm) and red nets (40cm) when compare to control (29.17cm) (Fig 3). Plants were taller under coloured nets due to increase in internode length and not due to increase in number of nodes (leaves). The internode length was found to be longer by 57.73 % under white coloured net which was closely followed by red with 54.21% when compared to control (Table 2). The number of leaves was found to be significantly higher in coloured shade nets over control but it was non-significant among them. In the present studies all the shade nets were on par in improving the production of leaves (Fig 4). Leaves quality was very poor in control due to the harsh weather. The

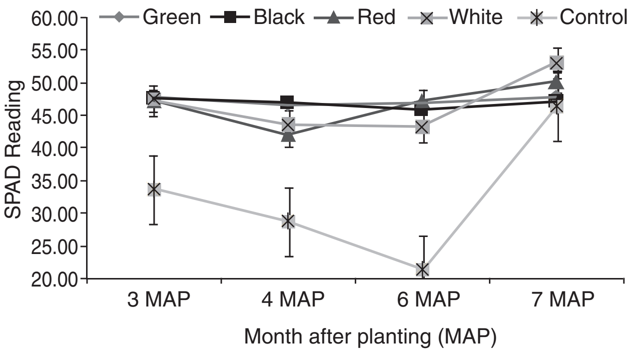

Fig 2 Influence of coloured shade net on total chlorophyll measured using at different MAP.

Table 2 The influence of different coloured shade nets on plant height, number of leaves, chlorophyll content (SPAD), canopy temperature, leaf area, leaf weight, specific leaf area (SLA), gas exchange characteristics and vase life of cordyline

Treatment	Plant height (cm)	Number of leaves	Petiole length (cm)	Internode length (cm)	SPAD Reading	Canopy temperature (°C)	Leaf area (cm^2)
Green	35.63±1.71	18.17±0.45	9.26±0.10	1.94±0.13	47.81±0.44	27.42±0.07	1,441.83±57.09
Black	33.84±0.71	18.36±0.23	8.91±0.08	1.96±0.02	47.52±0.52	26.45±0.07	1,421.98±58.72
Red	39.98±2.77	18.33±0.91	9.56±0.22	2.11±0.12	47.33±0.66	28.55±0.14	1,642.93±172.68
White	40.81±1.43	17.86±0.57	9.44±0.05	2.15±0.08	47.32±0.54	27.81±0.20	1,526.78±176.52
Control	29.17±1.45	12.69±0.21	8.18±0.14	1.37±0.04	33.54±0.51	33.05±0.12	879.38±69.82
CD (P=0.05)	5.75	1.71	0.41	0.22	1.22	0.42	204.58

Treatment	*Fresh weight (g)*	*SLA (cm^2/g)*	*Dry leaf weight (g)*	*Gas exchange characteristics.* Photosynthesis rate ($\mu molCO_2/m^2/s$)	Stomatal conductance ($\mu molH_2O/m^2/s$)	Efficiency of Photo system 2	Transpiration rate (μmol $H_2O/m^2/s$)	*Vase life (days)*
Green	44.37±8.76	34.86±5.41	10.06±1.70	7.78±0.24	0.005±0.001	0.207±0.003	0.27±0.04	30.25±2.59
Black	38.94±6.17	37.31±4.02	7.90±1.04	4.33±0.97	0.006±0.001	0.142±0.021	0.36±0.08	31.75±3.57
Red	55.96±15.64	31.38±5.00	11.81±3.03	6.20±0.24	0.009±0.001	0.208±0.006	0.54±0.06	26.25±4.33
White	51.45±14.89	31.39±4.76	10.88±3.14	10.00±0.47	0.024±0.001	0.259±0.004	1.29±0.05	28.75±5.59
Control	30.11±7.68	31.77±5.41	6.92±1.75	7.46±0.22	0.014±0.000	0.229±0.012	0.72±0.02	16.00±0.00
CD (P=0.05)	13.77	2.02	2.90	1.79	0.003	0.036±	0.18	6.81

Data (mean ± SE) at $P<0.05$.

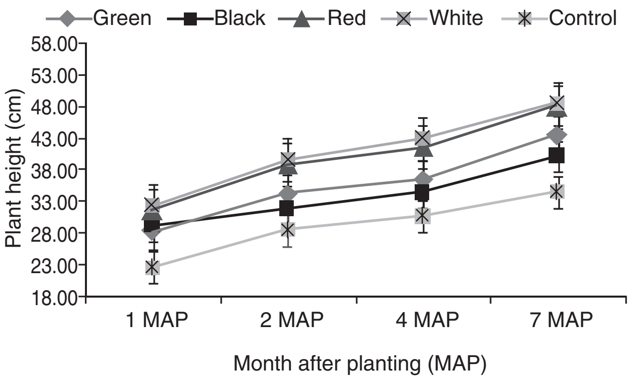

Fig 3 Influence of coloured shade nets on plant height during different months after planting.

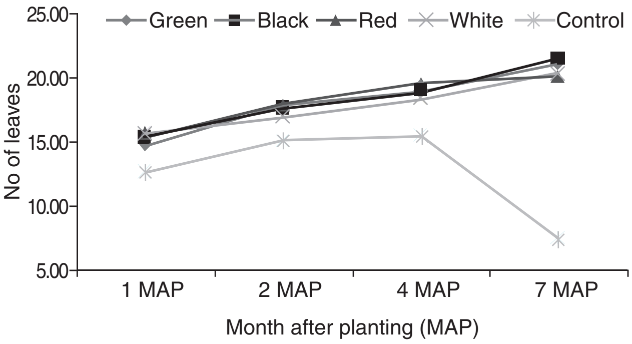

Fig 4 Influence of coloured shade nets on number of leaves during different months after planting.

present study was in contradiction to Kawabata *et al*. (2007) reported that red shade cloth produced greater number of leaves in dracaena. The leaf petiole length was found to be longer in red followed by white, green, black and control. The petiole length was longer by 17% under red and 15.40% under white compared to control (Table 2).

Leaf area is a very useful parameter of growth as it interprets the capacity of a crop for producing dry matter in term of the intercepted utilization of radiation and amount of photosynthesis synthesized. Leaf area was calculated and results showed that, it was highest under red coloured net, followed by white, green and black while it was lowest under control. Leaf area was almost double (increased by 86.83% in red and 73.62% in white) under nets compared to control. The fresh weight of leaves was also found to be highest under red net followed by white, green, black and lowest under open condition showing higher accumulation of photosynthates. It increased by 85.88% in red net over control (Table 2). The SLA was highest under black (higher by 17.44% over control) followed by red and green shade net indicating thinner leaves in shade net compare to outdoor environment. Stomatal density and leaf thickness increased in plants maintained in full sunlight owing to the expansion of the abaxial epidermis and the spongy parenchyma. The dry leaf weight denotes the solid matter present in the leaf. Dry weight was found to be highest in red closely followed by white net, while it was recorded lowest under open condition (Table 2).

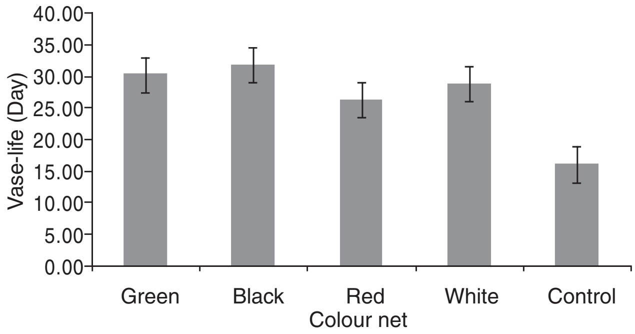

Fig 5 Influence of coloured shade nets on vase life of cordyline leaves taken after 7 month of planting.

The harvest index was found to be higher under nets but there were not much difference among them, lowest HI was recorded under open condition (Table 1). Vase life is an important parameter which determines the commercial value of cut greens and higher vase life was always preferred in trade as it increases its storability. It was found to be higher by at-least 10 days under different coloured shade nets over control. Although it was maximum under black shade nets, the improvement under other shade nets would be sufficient in trade (Fig 5).

In the present studies, improved vase life under different coloured net was in contradiction to earlier reports (Stamps and Chandler 2008) although it is non-significant among them. It may be due to the reason that shade net protects the leaves from excessively high light intensity.

White and red coloured shade nets were found to be superior in improving most of the plant parameters compared to green net, black net and control. They were found to be best shade nets for commercial cultivation of *Cordyline terminalis,* as plant height, inter-node length, photosynthesis rate, PS 2 efficiency and other important characteristics were superior. Hence, red or a white coloured net can be recommended to replace the commercially used green shade net for cut greens production.

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