Effects of Photoselective Shade Cloths on Potted *Dracaena deremensis* 'Janet Craig' and *Dracaena marginata* 'Colorama'

Authors: Andrew F. Kawabata*, Joanne S. Lichty[a], Kent D. Kobayashi[a] and William S. Sakai[b]

[a] Tropical Plant and Soil Sciences Department, University of Hawaii at Manoa, 3190 Maile Way, St. John 102, Honolulu, Hawaii 96822
[b] College of Agriculture, Forestry and Natural Resource Management, University of Hawaii at Hilo, 200 W. Kawili Street, Hilo, Hawaii 96720

**Corresponding* author: Email: kawabataa@ctahr.hawaii.edu
875 Komohana Street, Hilo, Hawaii 96720 USA

ABSTRACT

Tip cuttings of *Dracaena deremensis* Engl. 'Janet Craig' and *Dracaena marginata* Lam. 'Colorama' were grown for 4 months under 70% black, red, blue, and gray photoselective shade cloths. The 70% designation referred to the weave of the cloth with 70% covered by the fabric and 30% open. Because the fabric of the blue, gray and red shade cloth did not fully block radiation this weave produced 80%, 79%, 76%, and 68% shade of photosynthetically active radiation (PAR) and 72%, 66%, 74%, and 48% shade of total solar irradiance (TSI) for the black, blue, gray, and red shade cloths, respectively. These differences in PAR and TSI are closely related to the differences in growth reported in this study. *D. deremensis* 'Janet Craig' plants, under the red shade cloth, produced the most new leaves, 10.4, and this appeared to be related to the higher level of PAR. The red shade cloth grown plants had the smallest first fully expanded leaf of all treated plants, 341 cm^2. This appeared to be related to the very high level of TSI. Grower evaluation ratings were lowest for the red shade cloth treatment. Blue shade cloth grown plants had decreased SPAD chlorophyll measurements, 48.2 versus 52.9 for the standard black. Although blue light is essential for synthesis of chlorophyll in angiosperms, the relationship between lower levels of red light and photosynthesis is discussed. Simulated shipping treatment had no effect on SPAD readings. *D. marginata* 'Colorama' plants under the red shadecloth produced more new cane growth, 20.2 cm, and the highest number of new leaves, 26.2. This is related to the increased level of PAR. No difference in the number of new leaves produced per centimeter of new growth and internode length indicated that the red shade cloth produced a taller plant while maintaining a full appearance.

KEYWORDS: photosynthetically active radiation, PAR, total solar irradiance, light quality, vegetative growth.

INTRODUCTION

Concerns regarding the use of chemicals in nursery operations have led to increased interest in alternative methods to regulate plant growth and improve quality. Growth of various plants has been manipulated by varying the ratio of various wavelengths in a light source with spectral filters and colored plastic films (Rajapakse et al., 1999). Responses of ornamental plants to changes in light composition increased foliage volume of crotons under red shadecloth (Gaffney, 2004), and reduced internode length in chrysanthemums under blue polyethylene films and copper sulfate filters that increase red:far red and blue light ratios (Oyaert et al., 1999; Rajapakse and Kelly, 1992). A similar compact growth response was observed with Easter lilies grown under copper sulfate filters (Kambalapally and Rajapakse, 1998).

Container grown dracaenas are utilized in interiorscapes because of its attractive form, color, and durability. Finished potted plants can range from 0.5 to over 2 m in height. Tip cuttings or taller canes are harvested from stock fields grown in full sun and planted with multiple canes per pot. These plants are finished in 70-80% shadehouses for 10 to 12 weeks to acclimatize plants for interior use. The objective of this study was to determine growth responses of potted *Dracaena deremensis* ‘Janet Craig’ and *Dracaena marginata* ‘Colorama’ to red, gray, and blue photoselective shadecloths and compare growth to black shade cloth.

MATERIALS AND METHODS

Photoselective shadecloth material (Signature Supply, Inc., Lakeland, FL) was draped over 1.8 m x 1.8 m PVC hoop houses. Each experimental unit consisted of a 70% black, 70% ChromatiNet® red, blue, and gray colored house placed under a polyethylene-covered greenhouse at the Komohana Agricultural Research Center in Hilo, Hawaii.

Cuttings were harvested from field stock grown in full sunlight. Tip cuttings of *Dracaena deremensis* ‘Janet Craig’ and *Dracaena marginata* ‘Colorama,’ approximately 75 cm in length, were planted in 70% black cinder : 30% peat moss media. Industry standards consisting of 3 ‘Janet Craig’ cuttings/10 liter pot and 4 ‘Colorama’ cuttings/10 liter pot were utilized. The media was amended with 3.0 kg of dolomite AG65 (Chemical Lime Co., Salinas, CA) and 1.2 kg of Micromax® (The Scotts Co., Marysville, OH)/meter^3. One month after planting, 15-9-12 Osmocote® (The Scotts Co., Marysville, OH) 3-month controlled release fertilizer was top dressed at a 57 gm/pot rate. There were 6 pots/ treatment house and 3 replicates/shade treatment. Plants were irrigated 3 times/week with one spot-spitter/pot.

Initial cane height from pot level to the top leaf whorl, leaf number, and length and width of the first fully expanded leaf from the top whorl were recorded for ‘Janet Craig’ within one week after planting. Initial cane height and leaf number were determined for ‘Colorama’. There were no differences in the measured parameters at the start of the trial. Plants were re-evaluated 4 months after planting.

Six growers evaluated the ‘Janet Craig’ plants using a visual rating scale (1 = poor to 10 = excellent) based on height, canopy fullness, foliage color, and marketability. Six ‘Janet Craig’ pots/treatment (2/replicate plot) were subjected to simulated shipping conditions of nine days of darkness at 17.0^{o} C average temperature in an enclosed chamber with an individual air conditioning unit. Leaf readings to determine chlorophyll content were taken with a Minolta chlorophyll meter (model SPAD-502). SPAD readings of the tip, center and lower sections of the first fully expanded leaf were measured and averaged for each plant before and after simulated shipping.

Ambient temperature in the shade cloth enclosures was recorded with a Hobo H8 data logger. PAR measurements of photosynthetic photon flux (in µmolm^{-2}s^{-1}) were made using a Li-Cor Quantum Sensor, and radiometric measurements of total solar irradiance (TSI, in W m^{-2}) were made using a Li-Cor Pyranometer. Both were attached to a Li-Cor Quantum/Radiometer/ Photometer Model LI-189. Measurements were made in full sunlight, under the polyethylene cover and inside the shade cloth frames at the height of the foliage of the plants. The percent transmission of the PAR and TSI under each of the shade cloths were calculated in relation to the PAR and TSI passing through the polyethylene film and are listed in Tables 1 and 2. Eighty three percent of PAR and 89 percent of TSI was transmitted through the polyethylene film when compared with full sunlight. Measurements of the relative intensity and wavelength of light passing through the four types of shade cloth were made using a PP Systems Unispec® Spectral Analysis System and are shown in Figure 1. Data were analyzed using the General Linear Model (GLM) procedure (SAS, 1981) with mean separation by Waller-Duncan K-ratio test.

RESULTS AND DISCUSSION

Dracaena deremensis 'Janet Craig

The red shade cloth transmitted 32% of photosynthetically active radiation (PAR) versus only 24%, 21%, and 20% for the gray, blue, and black shade cloths, respectively. This higher level of PAR light presumably lead to increased photosynthesis and the increased number of leaves with the red shade cloth (Table 1). The very high transmission of total solar irradiance (TSI) by the red shade cloth, 52% versus 26%, 34% for the gray, blue, and 28% for the standard black shade cloth, probably led to the decreased leaf size 341 cm^2 versus 386, 380, and 388 cm^2 for the gray, blue and black shade cloths respectively and appears to show that 'Janet Craig' plants form sun leaves, which are smaller and thicker than shade leaves, in response to higher light levels (after Hanson, from Larcher, 1995). The smaller leaf size probably led to the lower grower's evaluation for the red shade cloth grown plants (Grower evaluations were based on four things—height, canopy fullness, foliage color, and marketability; growers considered all plants to be marketable).

The blue shade cloth grown 'Janet Craig' plants showed a decreased level of chlorophyll in the leaves when compared to plants grown under the standard black shade cloth, SPAD measurements of 48.2 versus 52.9 (Table1). Research has shown that blue light is essential for chlorophyll synthesis in angiosperms, but in cultured tobacco cells, additional sucrose is required if only blue light is supplied (Groß and Richter, 1982; Matters and Beal, 1995). The lower levels of red light and its effect on reduced sugar production during photosynthesis, under the blue shade cloth might explain the reduced chlorophyll levels of these plants. Future research should measure dry matter to determine the level of photosynthesis under the different shade cloths.

Simulated shipping treatment had no effect on SPAD readings. There was no interaction between the simulated shipping treatment and shadecloth treatment SPAD readings.

Though not statistically different, the trend of decreased new cane growth for the blue shade cloth 67.8 cm versus 69.1, 69.1, and 69.3 for the red, gray, and black shade cloths, respectively, may be related to the blue light-phytochrome B-cryptochrome effect on reducing auxin transport (Ballaré et al., 1995). Blue light has been reported to reduce auxin transport on the side of the plant receiving blue light in the phototropic-gap-filling response. Because all sides of the plant under the blue shade cloth are receiving blue light the reduction in auxin transport would reduce cell elongation all around the stem just below the zone of cell division in the apical meristem and reduce stem length as has been reported in chrysanthemums and Easter lilies (Oyaert et al., 1999; Rajapakse and and Kelly, 1992; Kambalapally and Rajapakse, 1998). Unfortunately, we did not measure root growth, because the reduction in auxin transport under the blue shade cloth would be expected to also reduce root growth. Future research will involve measurements of root and shoot growth.

Draceana marginata 'Colorama'

'Colorama' plants grown under the red shade cloth had more new cane growth and produced more new leaves compared to other treatments (Table 2). The new cane growth appears to mirror the differences in PAR transmission. For the red shade cloth, 32% PAR transmission and 20.2 cm new cane growth and. 24% and 13.3 cm for the gray, 21% and 12.5 cm for the blue and 20% PAR transmission and 10.4 cm new cane growth for the black. The number of new leaves for ‘Colorama’ also mirrored the differences in PAR transmission with 26.2 new leaves under the red shade cloth versus 21.4, 18.1, and 18.0 for the gray, blue and black shade cloths, respectively. No difference in the number of new leaves produced per centimeter of new growth and internode length indicated that red shadecloth produced a taller plant while maintaining a full appearance (Table 2). This increased growth may allow for an earlier finishing time, at a cost saving to the grower, or a larger marketable plant at a higher sales price during the same growing period as black shade cloth. Apparently, *D. marginata* ‘Colorama’ is able to adapt to higher light levels because no differences in appearance were discernable between the red, gray, blue, and black shade cloth grown plants.

CONCLUSIONS

D. deremensis ‘Janet Craig’ plants, under the red shade cloth, produced the most new leaves and this appeared to be related to the higher level of photosynthetically active radiation (PAR). The red shade cloth grown plants had the smallest first fully expanded leaf of all treated plants. This appears to be related to the very high level of total solar irradiance (TSI). Grower evaluation ratings were lowest for the red shade cloth treatment. Blue shade cloth grown plants had decreased SPAD chlorophyll measurements, 48.2 versus 52.9 for the standard black. This appears to be related to the lower levels of red light, required for the normal pathway of photosynthesis, under the blue shade cloth. Simulated shipping treatment had no effect on SPAD readings.

D. marginata ‘Colorama’ plants under the red shade cloth produced more new cane growth and the highest number of new leaves. This is related to the increased level of PAR. No difference in the number of new leaves produced per centimeter of new growth and internode length indicated that the red shadecloth produced a taller plant while maintaining a full appearance.

ACKNOWLEDGEMENTS

This study was funded by the Hawaii County Research and Development Office. We thank Enrique Martinez and Mark Akiyama, California Hawaii Foliage Growers, and Patrick McGrath, Hawaii Nurseries, for the plant material. Special thanks to Laura Pena and Cynthia Thurkins for their technical assistance and Dr. Sheldon Furutani for use of the Li-Cor Quantum/ Radiometer/ Photometer. The PP Systems Unispec Spectral Analysis System was purchased earlier from a USDA, CSREES, Alaska Native/Native Hawaiian Educational Grant. #2001-38426-11493 to UH Hilo.

LITERATURE CITED

Bajaj, Y.P.S. and J.W. McAllan. 1969. Effects of various light treatments on chlorophyll formation in excised potato roots. Physiologia Plantarum 22: 25-28.

Ballaré, C.L., A.L. Scopel, and R.A. Sánchez. 1995. Plant photomorphogenesis in canopies, crop growth, and yield. HortScience 30:1172-1181.

Gaffney, M. 2004. ChromatiNet-Light Spectrum Management. Greenhouse Product News 14(12):54.

Groß, M. And G. Richter. 1982. Influence of sugars on blue light-induced synthesis of chlorophyll in cultured plant cells. Plant Cell Reports 1: 288-290.

Kambalapally, V.R. and N.C. Rajapakse. 1998. Spectral filters affect growth, flowering, and postharvest quality of Easter lilies. HortScience 33(6):1028-1029.

Larcher, W. 1995. Physiological Plant Ecology, 3rd ed. Springer, Berlin, 506 pps.

Oyaert, E., E. Volckaert, and P.C. Debergh. 1999. Growth of chrysanthemum under coloured plastic films with different light qualities and quantities. Scientia Hort. 79:195-205.

Rajapakse, N.C. and J.W. Kelly. 1992. Regulation of chrysanthemum growth by spectral filters. J. Amer. Soc. Hort. Sci. 117(3):481-485.

Rajapakse, N.C., R.E. Young, M.J. McMahon, and R. Oi. 1999. Plant height control by photoselective filters: current status and future prospects. HortTechnology 9(4):618-624.

SAS Institute Inc. 1981. SAS for linear models: A guide to the ANOVA and GLM procedures. Gary, NC.

Table 1. Effects of photoselective shadecloths on light, temperature, growth and quality of potted *Dracaena deremensis* 'Janet Craig' after 4 months.

Shade Cloth color	Trans-mission PAR	Trans-mission total solar irradiance	Maximum air temp-erature ^{o}C (4/15-5/6/06)	New cane growth (cm)	Leaf size $(cm^2)^y$	No. of new leaves	Grow er's eval-uation^x	SPAD Chloro-phyll reading
Red	32 %	52 %	32.8	69.1 a	341 b	10.4 a	5.4	50.6 b
Gray	24 %	26 %	31.5	69.1 a	386 a	9.3 b	8.2	52.4 ab
Blue	21 %	34 %	32.3	67.8 a	380 a	9.1 b	7.2	48.2 c
Black	20 %	28 %	32.6	69.3 a^z	388 a	8.9 b	8.2	52.9 a

^{z}Mean separation in columns by Waller-Duncan K-ratio test at $P \leq 0.05$.
^{y}Leaf size = leaf length x leaf width. Leaf was the first fully expanded leaf from the top whorl.
^{x}Visual rating scale (1 = poor to 10 = excellent), based on height, canopy fullness, foliage color and marketability.

Table 2. Effects of photoselective shadecloths on light, temperature, and growth of potted *Dracaena marginata* 'Colorama' after 4 months.

Shade Cloth color	Trans-mission PAR	Trans-mission total solar irradiance	Maximum temper-ature ^{o}C (4/15-5/6/06)	New cane growth (cm)	No. of new leaves	No. new leaves/cm of new cane growth
Red	32 %	52 %	32.8	20.2 a^z	26.2 a	1.4 a
Gray	24 %	26 %	31.5	13.3 b	21.4 b	2.4 a
Blue	21 %	34 %	32.3	12.5 bc	18.1c	2.1 a
Black	20 %	28 %	32.6	10.4 c	18.0c	2.4 a

^{z}Mean separation in columns by Waller-Duncan K-ratio test at $P \leq 0.05$.

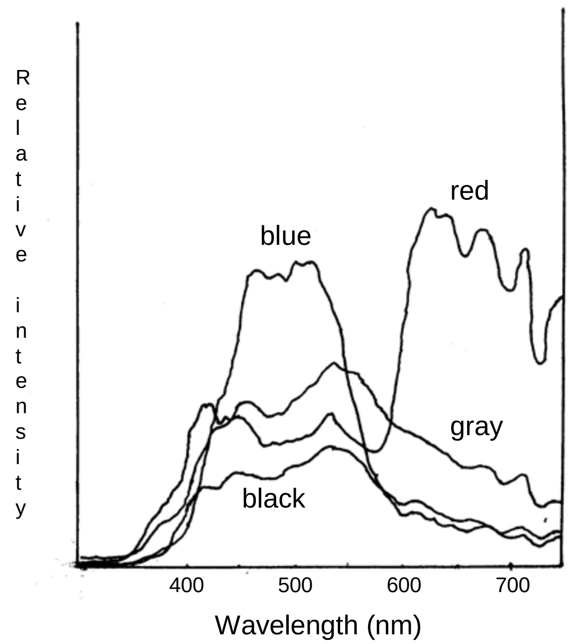

Figure 1. Relative intensity and wavelength of light passing through the four types of 70% shade cloth – red, blue, gray, and black.