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# PRELIMINARY STUDY OF WHITE AND BLACK SHADECLOTH AND GROUNDCOVERS ON THREE LANDSCAPE/CUT FOLIAGE CROPS

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*Abstract.* **Florida accounts for 81% of shade/temporary cover production of floricultural crops in the United States. In addition, Florida produces 75% of U.S. florists' greens and the majority of that production occurs under shade, especially under artificial shade provided using shadecloth. Black shadecloth is the common color used in the industry but other colors have become available. The purpose of this preliminary shadehouse experiment was to compare the growth and vase life of three cut foliage crops under white and black shadecloth. In addition, the effects of white and black groundcovers were evaluated. For ruscus (*Ruscus hypophyllum* L.) and umbrella plant (*Cyperus alternifolius* L.), stems produced under the white shadecloth or on the black groundcover were heavier than stems produced using the other color treatments. Neither shadecloth nor groundcover color affected stem weights of ming "fern" (*Asparagus retrofractus* L.). There were no interactions between shadecloth and groundcover treatments. Although not readily apparent visually, a* values (a measure of greenness) for ruscus cladophylls were affected by shadecloth treatments. Stem vase lives were not affected by treatments and averaged 141, 44 and 9.3 days after one week of storage, respectively, for ruscus, umbrella plant and ming "fern". In a longer-term storage study, ruscus stems stored for 54, 96 and 148 days lasted for 54, 54 and 29, respectively. Ruscus cladophyll transpiration rates and stem water potentials were not affected by treatments. Air, cladophyll, pot and growing medium temperatures were affected by shadecloth and/or groundcover temperatures; however, there were no treatment interactions. These effects were attributed to differing shade factors and permeabilities of the shadecloths and differences in the absorptance/reflectance of the groundcovers.**

Florida leads the nation in the production of floricultural crops in shadehouses with 6,837 acres of production in 2005 (USDA/NASS, 2006). In addition, Florida accounts for 75% of U.S. cut cultivated greens (florists' greens, cut foliage) sales. The majority of cut foliage production (Boggess et al., 1991) and production of landscape plants adapted for use in shaded areas occurs under artificial shade. Almost all of this shade is provided using black shadecloth. However, shadecloth is now available in a number of other colors including white. The same is true for groundcovers but there has not been any published research on the effects of these two factors when used in combination.

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The purpose of this study was to conduct a preliminary comparison of the effects of white versus black shadecloth in combination with white versus black groundcovers on three landscape/cut foliage crops suitable for use/production under shade.

## Materials and Methods

Two 24' × 24' wood-framed shadehouses at the Mid-Florida Research and Education Center, Apopka, Fla. were used in the experiment. In each shadehouse, two 12' × 12' floor sections were covered with white groundcover and two with black groundcover (VisQueen®, Ethyl Corp., VisQueen Film Products Div., Richmond, Va.). One shadehouse was covered with black woven polypropylene shadecloth (Pak Unlimited, Norcross, Ga.) and the other was covered with white knitted polyethylene shadecloth (Weathashade, Apopka, Fla.). Both shadecloths were designed to provide 40% light exclusion (40% shade factor); however, the photosynthetically active radiation shade factors (including shading from the shadehouse frame, etc.) measured in the middle of the day using a radiation meter (LI-185A, LI-COR, Lincoln, Nebr.) were 45% in the black and 51% in the white shadehouse. The higher shade factor in the shadehouse covered with the white shadecloth may have been due, in part, to the fact that shade factors of woven materials are affected by the amount of tension (stretching) that is applied when these knitted fabrics are installed. During winter, temperatures in the shadehouses were maintained above 45°F by lining the shadehouses with clear polyethylene film and heating them using kerosene-fueled space heaters.

The crops used in this study were umbrella plant (*Cyperus alternifolius*), Florida/Israeli ruscus (*Ruscus hypophyllum*) and ming "fern" (*Asparagus retrofractus*). Plants were grown in 1-, 3- and 7-gallon (respectively, for umbrella plant, ruscus and ming) plastic nursery containers filled with a soilless growing medium composed of Florida sedge peat:pine bark:builders' sand (6:3:1 by volume) amended with 7 lb/$yd^3$ of dolomite for a pH of 5.9. Four pots of each plant were distributed evenly in each quadrant of the groundcover/shadecloth color treatment combinations. Pots were watered three to seven times a week with 0.7" of water using overhead irrigation depending on season and rainfall. A 17N-2.6P-10K controlled-release fertilizer containing additional macro- and micronutrients (Sierra 17-6-12 plus minors with 3-4 month term, Scotts, Marysville, Ohio) was applied every two months at half the recommended rates for nursery stock.

Temperatures inside and outside the shadehouses were monitored using copper-constantan thermocouple wire (AWG No. 24, Omega Engineering, Stamford, Conn.) connected to an insulated multiplexer (AM32, Campbell Scientific, Logan, Utah) and a datalogger (CR10, Campbell Scientific). Thermocouples were attached to vertical nylon guy lines located in the center of each shadehouse quadrant and outside, half way between the shadehouses. Thermocouples were protected from direct sunlight using inverted funnels and were installed at three heights (18, 48 and 84 inches above the ground) to measure air temperatures from about the middle of the crop canopy to just below the roofs of the shadehouses. In addition, late morning (11:30 AM) groundcover, pot exterior (southeast side) and growing medium surface temperatures were measured remotely using an infrared thermometer (Model 210, Everest Interscience, Fullerton, Calif.).

Color (L★, a★, b★) values were measured for the second mature cladophyll from the top of a stem from each ruscus plant using a colormeter (Chroma Meter CR-100, Minolta). L★ is the lightness coefficient (0 = black, 100 = white) and a★ (0 = achromatic gray, –60 = green) and b★ (0 = achromatic gray, 60 = yellow) are the chromaticity components. Chroma (C★), an index of saturation (vividness), and hue angle (h°) were calculated (McGuire, 1992). Hue angle (color) for green cladophylls is in the range from 90° (yellow) to 180° (green). On a sunny day in August, cladode transpiration rates and temperatures were measured in mid-morning and mid-afternoon using a steady-state porometer (LI1600, LI-COR). Concurrently, stem water potentials were determined using a Scholander pressure chamber (Soil Moisture Equipment, Santa Barbara, Calif.). Additional non-contact infrared thermometer temperature measurements were made from top-of-the-canopy cladophylls.

In September, the three most recently matured stems from each pot of each crop were harvested with clippers, weighed, submereged in tap water for 15 min and packed in polyethylene floral wrap lined wax coated fiberboard boxes. The boxes were then stored in a cooler at 39°F (Nowak and Rudnicki, 1990). After one week in storage, stem bases were re-cut using hand clippers to remove about one inch and each set of stems from a pot were inserted into individual floral foam blocks (Smither-Oasis, Kent, Ohio) sitting in deionized water-filled plastic trays. Separate trays were used for each crop. Conditions in the rooms simulated home/office conditions with light levels of 107 ft-candles provided for 12 h per day using cool white fluorescent lamps, temperatures of 75 ± 2°F and relative humidities of 60 ± 5%. Vase life of an individual stem was terminated when it began to exhibit chlorosis (yellowing), necrosis (brown or black tissue), desiccation (graying, curling, wilting) or cladophyll drop (abscission) affecting about 5% or more of the stem surface area. In addition, ruscus stems were harvested in December, stored as described above and removed from the cooler after 54, 96 and 148 d for vase life evaluations for Valentine's Day, Easter and Mother's Day, respectively.

Statistical analyses were done using analysis of variance (SAS Institute, Cary, N.C.).

## Results and Discussion

During hot weather, afternoon temperatures measured just below the top of the black shadehouse (seven foot height) were similar to those outside; however, temperatures were higher in the house covered with white shadecloth (Fig. 1). These results were likely related to differences in air permeabilities of the white and black shadecloth. To obtain equivalent light exclusion requires more threads for the white than for the black shadecloth because the white threads are less opaque than the black and more light is transmitted through them. The use of more threads results in smaller openings and less overall open area. In addition, in this case, the shade factor for the white was actually higher than the black by about 6%. At a height of 18 inches above the ground,

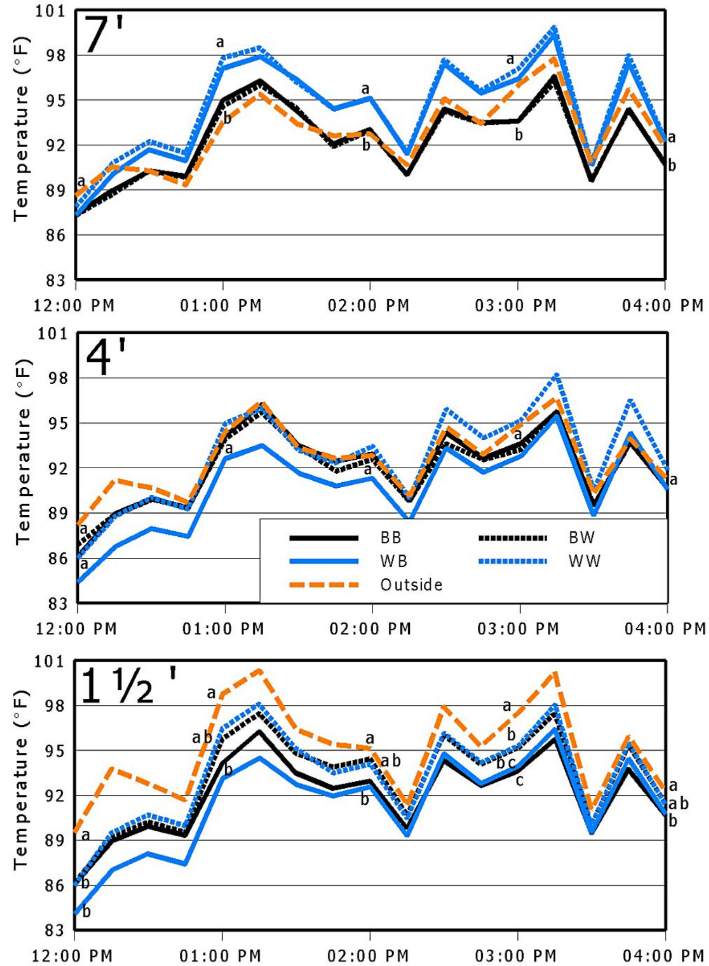


Fig. 1. Air temperatures at three heights outside and inside shadehouses covered with white or black shadecloth and white or black groundcovers. BB = black shadecloth and groundcover, BW = black shadecloth and white groundcover, WB = white shadecloth and black groundcover, WW = white shadecloth and groundcover.

temperatures were higher outside than inside in the quadrants with black groundcover. Temperatures in the quadrants with white groundcover were intermediate. This pattern is likely due to the higher emissivity and reflectivity of the white groundcover compared to the black. In fact, at 11:30 AM black groundcover temperatures were higher by 8°F ($P$ = 0.09), indicating greater absorptivity. This could account for the tendency for higher air temperatures to occur in the white groundcover quadrants. At a height of 4 feet, neither shadecloth nor groundcover color made any difference in air temperatures. There were no interactions between shadecloth and groundcovers.

Ruscus leaf temperatures were not affected by shadecloth or groundcovers at 9:00 AM or 4:30 PM, however at 11:00 AM ($P$ = 0.048) and 2:00 PM ($P$ = 0.062) leaf temperatures were about 2°F higher in the shadehouse covered with black shadecloth than in the one covered with white (data not shown). In addition, pot exterior and growing medium surface temperatures measured at 11:30 AM were higher by 10.2 and 7.2°F ($P$ = 0.004 and 0.056), respectively (data not shown). These differences reflect the differences in shade factors for the two coverings. Groundcover color had no effect and there were no treatment interactions.

Table 1. Effects of shadecloth and groundcover color on cladophyll color of Florida ruscus.

| Shadecloth | Groundcover | L* | a* | b* | Chroma (C*) | Hue angle |
|---|---|---|---|---|---|---|
| Black | Black | 39.8 | –12.9 | 15.1 | 19.8 | 131.0 |
| | White | 40.8 | –13.4 | 16.3 | 21.1 | 129.6 |
| White | Black | 39.7 | –14.1 | 15.8 | 21.2 | 132.0 |
| | White | 39.8 | –14.0 | 15.6 | 20.9 | 132.0 |
| Significance | | | | | | |
| Shadecloth | | 0.355 | 0.025 | 0.961 | 0.541 | 0.089 |
| Groundcover | | 0.377 | 0.671 | 0.559 | 0.588 | 0.460 |
| *Shadecloth × groundcover* | | 0.476 | 0.372 | 0.412 | 0.394 | 0.458 |

Table 2. Effects of shadecloth and groundcover colors on fresh stem weights and vase lives of umbrella plant, Florida ruscus and ming "fern".

| | | Umbrella plant | | Florida ruscus | | Ming "fern" | |
|---|---|---|---|---|---|---|---|
| Shade cloth | Groundcover | Avg. stem fresh wt (oz) | Vase life (days) | Avg. stem fresh wt (oz) | Vase life (days) | Avg. stem fresh wt (oz) | Vase life (days) |
| Black | Black | 0.12 | 44.5 | 0.21 | 134 | 1.20 | 8.9 |
| | White | 0.11 | 45.0 | 0.19 | 122 | 1.33 | 8.7 |
| White | Black | 0.14 | 42.4 | 0.26 | 161 | 1.73 | 8.7 |
| | White | 0.12 | 44.6 | 0.20 | 147 | 1.81 | 11.1 |
| Significance | | | | | | | |
| Shadecloth | | 0.010 | 0.800 | 0.024 | 0.148 | 0.093 | 0.412 |
| Groundcover | | 0.008 | 0.773 | 0.006 | 0.464 | 0.723 | 0.360 |
| *Shadecloth × Groundcover* | | 0.918 | 0.854 | 0.307 | 0.961 | 0.928 | 0.312 |

Ruscus cladophyll transpiration rates (E) and stem water potentials ($\Psi_{stem}$) measured in the morning and afternoon were not affected by shadecloth or groundcover color (data not shown). Morning E rates and $\Psi_{stem}$ ranged from 4.3 to 5.7 $mmol\cdot m^{-1}\cdot s^{-1}$ and from –0.85 to –0.92 MPa, respectively. In the afternoon when radiation levels were higher, values ranged from 5.3 to 7.2 $mmol\cdot m^{-1}\cdot s^{-1}$ and –1.0 to –1.02 MPa, respectively. Ruscus cladophyll color was only affected for a*—cladophylls were brighter green in the white shadecloth covered house than in the one covered with black shadecloth (Table 1).

Ming "fern" average stem fresh weights were not affected by treatments; however, both shadecloth and groundcover color affected umbrella plant and ruscus stem weights (Table 2). In both cases, stems were heavier when produced under white shadecloth or in quadrants with the black groundcover. High root zone temperatures (104°F) have been shown to reduce root and top growth of *Pittosporum tobira* (Johnson and Ingram, 1984). The pot and growing medium temperatures measured in the black shadehouse reached that temperature while those in the white shadecloth covered house were in the range where there was no growth inhibition in the pittosporum study. Since cut foliage prices generally increase with increasing stem size, these factors may have real economic significance.

Vase lives of the three crops were not affected by treatments and averaged 9.3, 44, and 141 days, for ming "fern", umbrella plant and ruscus, respectively. The vase life results for ming "fern" are consistent with recently published values (Stamps et al., 2006). Interestingly, vase lives of ruscus stems harvested in mid-December were not affected by treatments and averaged 54, 54 and 29 d when removed from the cooler for Valentine's Day, Easter and Mother's Day—54, 96 and 148 d after harvest, respectively. These results suggest that harvesting of ruscus stems when sales of Florida-produced cut foliages are at their yearly low (Palmer and Cunningham, 1998) and prior to possible freeze events could be a viable option provided adequate cold storage space is available.

Although the shade factors for the white and black shadehouses were not identical, this preliminary study showed that the plants grew well under the white shadecloth. In addition, groundcover color was shown to have an effect even with the reduced radiation levels in the shadehouses.

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