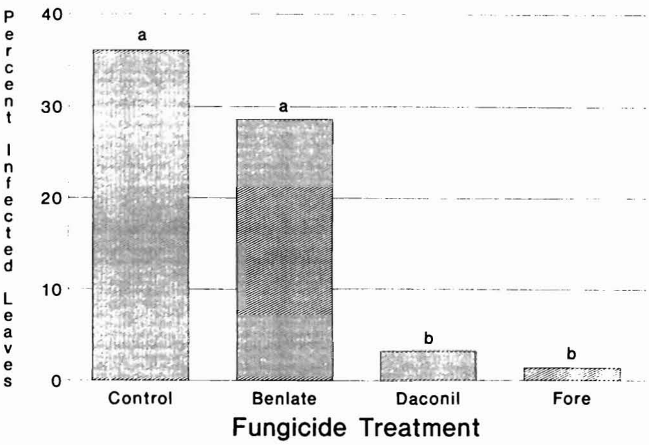

Fig. 4. Effect of fungicide treatments on the percent of *Tolmiea menziesii* leaves infected with *Colletotrichum gloeosporioides*. Values followed by the same letter are not significantly different according to Duncan's multiple range test (P = 0.01).

would suggest that this is a disease of cooler climates, since *Tolmiea* is a native of the cool, foggy north Pacific coast.

Daconil and Fore both provided excellent fungicidal control with an average of only 3.2 and 1.4% respectively, of the leaves infected (Fig. 4). Disease incidence on plants treated with Benlate was not significantly different than the control plants.

There are numerous genera and species of fungi listed as causing anthracnose type diseases. *Colletotrichum* and *Gloeosporium* are common genera causing anthracnose. However, the taxonomy and pathogenicity of these fungi have not been well studied. Host specificities of these fungi often have not been established. It is unlikely that the piggyback anthracnose fungus (*C. gloeosporioides*) will infect other nursery crops, however, this has not been tested.

(*Ed. note:* This paper reports the results of research only, and does not imply registration of a pesticide under amended FIFRA. Before using any of the products mentioned in this research paper, be certain of their registration by appropriate state or federal authorities.)

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Influence of Spectral Filters on Height, Leaf Chlorophyll, and Flowering of *Rosa x hybrida* 'Meirutral'[1]

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Abstract

Growth of *Rosa x hybrida* 'Meirutral' under different spectral filters was evaluated. Two filters that altered far-red (730 nm)/red (660 nm) light (FR/R) were developed. One, a blue textile dye, increased FR/R by filtering out a portion of red light. The second, a salt (copper sulfate) decreased FR/R by filtering out a greater portion of far-red than red light. A third filter that did not alter light quality was the control. The filters were installed in specially built growth chambers. Photosynthetic photon flux (PPF) was adjusted to equal values in each chamber.

Plants were significantly shorter and had higher leaf chlorophyll when grown under the reduced FR/R filter. The number of flower buds and number of buds showing color at termination of the experiment was not affected by light quality treatments.

Index words: Photomorphogenesis, light quality, phytochrome, potted rose, growth regulation, red light, far-red light

Significance in the Nursery Industry

Potted miniature roses have become increasingly popular in the nursery industry for seasonal sales such as for Valentine's Day and Mother's Day. Among the many cultivars being utilized for production, one common problem is the need to manipulate excessive vegetative growth to produce an aesthetically pleasing crop. Currently, there are no growth regulators labelled for use on potted roses. Light quality manipulation can be used to reduce stem elongation and increase plant quality and value. Our results show that light with reduced far-red/red (FR/R) light quality can be used to produce superior quality potted roses. Although few, if any, materials are currently produced for specifically reducing FR/R, many manufacturers of nursery shading materials are developing materials that can alter light quality.

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Introduction

Production of attractive, compact potted plants is a constant concern for growers. Potted roses are a crop of increasing importance that requires pinching and/or application of chemical growth regulators to maintain desired form (9, 11). Increasing labor costs and awareness of the environmental impact of chemicals is limiting the use of these growth regulating techniques. It is imperative that alternative growth control methods with low environmental impact be developed for a wide range of nursery and floricultural crops.

Light quality has been demonstrated to influence many aspects of plant growth and morphology (1, 2, 10, 12). Phytochrome, the primary pigment of photomorphogenesis, has two forms, Pr and Pfr, which absorb at 660 and 730 nm light, respectively, and upon absorption, convert to the other form (2). The ratio of FR/R light determines the predominate form of phytochrome which, in turn, determines plant morphology (5). Blue light (400–500 nm) may also affect phytochrome activity or that of another, unidentified photoreceptor that has morphological activity (3). Plants that receive high natural FR/R light, such as plants growing under a leaf canopy, are generally taller and have a different chloroplast arrangement than plants grown under lower FR/R as in full sun (4, 6).

The objective of this study was to determine the effect of specific light filters that alter blue, red, and far-red light on the growth and development of the greenhouse-grown potted rose 'Meirutral' which is marketed under the trade name Red Sunblaze.

Materials and Methods

Ten growth chambers were constructed (Agricultural Engineering Department, Clemson University) as a lean-to on the side of an existing greenhouse. The glass wall on the south side of the greenhouse was removed and vertical aluminum panels were installed 55 cm (21.6 in) apart and 2.5 cm (1 in) from the bottom of the chambers at each glazing bar, forming reflective walls for each chamber. The bottom of the chambers was a continuous aluminum pan which spanned the width and length of all 10 chambers. A 7 cm (2.7 in) wide strip of flat black paint was applied to the pan centered beneath each vertical wall to prevent light from reflecting between adjacent chambers. The back of the chambers was a sheet of black polyethylene between two layers of white polyethylene which could be rolled up to allow access to the chambers. The front of each growth chamber was a 54 × 140 cm (21 × 56 in) sheet of columned polycarbonate with columns 6 mm (0.25 in) deep and 11 mm wide (4.3 in) (Polygal, Inc. Janesville, WI 53545) treated for resistance to ultraviolet (UV) light and sealed at one end with caulk. A fan located at the top of each growth chamber circulated heated or cooled air from the attached greenhouse through each unit. Thermistors in each chamber and connected to a computer allowed constant monitoring of chamber temperature. Temperatures in the chambers were maximum of 32.1°C (90°F, S.E. = ±0.48), minimum night of 19.0°C (66.2°F, S.E. = ±0.24), and average 23.4°C (74.1°F, S.E. = ±0.15). Pots were placed 11.25 cm (4.5 in) apart in each chamber on a white plastic grid with openings of 1.75 × 1.75 cm (0.5 × 0.5 in) (manufactured for use as a diffusing panel for fluorescent light fixtures). The grid was secured 14 cm (5.5 in) below the top of the pan. The distance of the grid from the bottom of the pan increased because the depth of the pan increased from east to west.

The polycarbonate panel channels were filled with solutions chosen for their spectral properties and resistance to photodegradation. The spectral filters were a red dye # 259 (Ciba-Geigy, Inc., Greensboro, NC 27420) solution that filtered out much of the blue and green light, a blue dye # 178 (Ciba-Geigy, Inc., Greensboro, NC 27420) that filtered much of the red light, and $CuSO_4$ which filtered some of the red, and much of the far-red light (Figure 1). Water-filled panels were the control. FR and R light were measured at 725–730 and 655–660 nm, respectively. The FR/R ratios were 0.86 for natural light, the control, and the red dye, 1.01 for the blue dye, and 0.30 for the $CuSO_4$.

All concentrations of the spectral filtering solutions were adjusted to provide similar photosynthetic photon flux density (PPFD) i.e. a 40–43% reduction in PPFD. The copper sulfate solution (16% w/v) was the reference for all other treatment concentrations. A gray, neutral-density shade material was placed over the control panels to provide an equal reduction in PPFD. All light measurements were made with a LI-COR LI-1800 spectroradiometer equipped with a LI-1800-10 remote cosine sensor (LI-COR, Inc. Lincoln, NE 68504). Light measurements were taken at approximately solar noon (sun at its zenith) on cloudless days. Measurements were expressed as percent of full sun.

Four adjacent growth chambers were one replication and the next four were the second with the treatments randomly assigned to each replication. Spectral qualities of the panels were checked weekly. The red and blue dye solutions were replaced every two weeks because preliminary experiments indicated that red dye had spectral changes after three weeks and blue dye changed after four weeks.

Forty uniform ''Meirutral' plants (Yoder Bros., Inc., Pendleton, SC 29670) in 10 cm (4 in) plastic pots containing commercial potting media (Fafard #3B, Fafard, Inc., Anderson, SC 29621) were cut back to 6.5 cm (2.5 in) above pot rim. Four pots were placed in each chamber on June 15, 1989. The plants were fertilized every other day with 20N-8.6P-16.6K (20-20-20), (Peter's, Inc., Fogelsville, PA 18051) at a rate of 300-132-249 ppm for the first week.

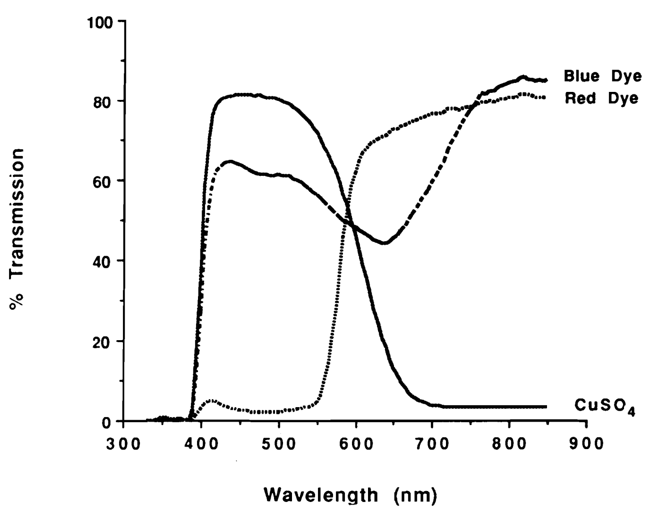

Fig. 1. Transmission characteristics of blue dye #171, red dye #259, and $CuSO_4$, using sunlight as the light source.

Water was applied as needed between fertilizations. All pots received the same fertilizer/water regime.

The experiment was terminated on July 10, 1989. Data were collected on plant height above pot rim, chlorophyll content, number of buds, and number of buds showing color. Chlorophyll was extracted by the method of Moran and Porath (8). Five leaf disks from each plant (one 0.28 cm^2 (0.04 in^2) disk from each of the most recently expanded leaves) were removed, chlorophyll was extracted in N,N-dimethylformamide for 48 to 72 hr in darkness at 14.4°C (40°F) (5 disks/5 ml) and absorbance measurements were made with a Spectronic 1001 (Bausch and Lomb, Rochester, NY 14603). Chlorophyll content was calculated by the formulas of Moran (7). Polycarbonate panels were randomized again and the experiment was repeated on August 10, 1989, terminating on September 7, 1989.

Data were subjected to analysis of variation (ANOVA) and treatment sums of squares partitioned among orthogonal contrasts. No differences occurred between replications, therefore, data presented are for one replicated experiment.

Results and Discussion

Plants grown under $CuSO_4$ filters were shorter (25 to 35%), and had greater leaf chlorophyll content (20 to 25%) than controls. There were no differences in height or chlorophyll content between plants grown under dye filters and controls (Table 1). There were no differences in number of buds or buds showing color between $CuSO_4$ or dye filters and control (Table 2).

The reduction in height and increased leaf chlorophyll content of plants grown under $CuSO_4$ filters is consistent with the results of other research where reduced height and/or increased leaf chlorophyll content or darker green leaves was observed with single-stem chrysanthemum, tomato, and lettuce (10) and for pinched chrysanthemum, exacum, geranium, and poinsettia (McMahon, unpublished results).

The absence of differences between plants grown in environments deficient in blue light or with FR/R greater than natural light indicates that these light environments are less influential than decreased FR/R on the morphology of 'Meirutral' pot rose.

The compact, dark green roses grown under $CuSO_4$ filters resembled the description of a similar cultivar (Meijikatar) treated with the growth regulator uniconazole (11).

Table 1. Height and leaf chlorophyll content of *Rosa* × *hybrida* 'Meirutral' at harvest as influenced by spectral filters.

Filter	FR/R	Height (in)	Chlorophyll ($\mu g/cm^2$)
Red Dye	0.86	9.2	36.0
Blue Dye	1.01	8.0	41.9
$CuSO_4$	0.30	6.4	49.5
Control	0.86	8.5	38.4
Contrasts (probability)			
Control vs Red Dye		NS	NS
Control vs Blue Dye		NS	NS
Control vs $CuSO_4$		**	**

NS, ** Nonsignificant, significant at 0.01 level, respectively.

Table 2. Number of flower buds and buds showing color of *Rosa* × *hybrida* 'Meirutral' at harvest as influenced by spectral filters.

Filter	FR/R	Number of flower buds	Number of buds showing color
Red	0.86	6.9	2.1
Blue	1.01	7.1	1.4
$CuSO_4$	0.30	7.5	1.3
Control	0.86	6.5	2.5
Contrasts (probability)			
Control vs Red Dye		NS	NS
Control vs Blue Dye		NS	NS
Control vs $CuSO_4$		NS	NS

NS Nonsignificant

The results of our experiment indicate that reducing the FR/R environment may be an alternative technique for producing compact, attractive pot rose cultivars that currently require chemical growth retardants. Investigations are being conducted to identify dyes more stable than those used in this experiment. Further experiments are also underway to determine the effects of altered light environments on additional cultivars, flower development, and postharvest characteristics of potted roses.

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