to proceed faster in plants which had experienced quiescence, however. Photoperiodic growth response in *Koelreuteria* was similar to *Acer rubrum* L. (red maple) grown under similar conditions (2).

Dalbergia grown under ND ceased growth in mid October, whereas those grown under LD continued growth until mid December when temperature presumably became a limiting factor for this species (Fig. 2). LD and ND plants resumed vegetative growth simultaneously in late February. In *Dalbergia,* as in *Swietenia mahagoni* (L.) Jacq. (West Indian mahagony) (1), and *Tabebuia caraiba* (Mart.) Bur. (silver trumpet tree) (2), LD allowed continued vegetative growth in the fall, but all growth ceases once average minimum temperatures drop below 15 °C (59 °F).

Fall and winter vegetative growth patterns in seedling *Bucida* showed that ND plants were significantly taller than LD plants during most of the experimental period (Fig. 2). This is unusual since in older specimens of this species, growth flushes occur almost exclusively during the spring and summer months.

Significance to the Nursery Industry

In mild climates such as that of southern Florida, many landscape tree species are capable of year round growth, but may not do so because of unfavorable photoperiods. By providing an artificial LD photoperiod it may be possible to produce saleable sized trees of certain species in much less time and thereby reduce production costs. Growth response to photoperiod varies considerably among species, however, and of the 7 species examined in this study, only *Dalbergia* and *Koelreuteria* appear to be good candidates for growth enhancement by photoperiod manipulation.

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Effect of Fall Temperature and Lighting on Growth of Rhododendron Rooted Cuttings[1]

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Abstract

Summer-rooted rhododendron cuttings were forced into growth using natural photoperiod, incandescent or red light (660nm) as a night break between 2200 and 0100 hours at both 17 °C (63 °F) and 10 °C (50 °F) minimum night temperature (MNT) for 3 weeks beginning September 28, 1982. Longer shoots were produced on *Rhododendron* 'PJM hybrids' under incandescent light than under red light or natural photoperiod. *Rhododendron* 'Roseum Elegans' produced longer shoots under both light regimes than under natural photoperiod and longer shoots at 17 °C (63 °F) MNT than at 10 °C (50 °F) MNT. Neither temperature nor light treatments significantly increased the average number of breaks per plant of either cultivar. Spring growth of *Rhododendron* 'Roseum Elegans' was delayed by both red and incandescent fall light treatments, but not by the high temperature fall treatment.

Index words: Phytochrome, growth induction, photoperiod, spring carry-over, temperature

Introduction

Attempts to accelerate fall growth of summer-rooted rhododendron cuttings have utilized incandescent light breaks to interrupt the dark period, various temperature regimes and a spring or fall induction period of 2 weeks at 17 °C (63 °F) (4). For both *Rhododendron* 'PJM hybrids' and 'Roseum Elegans,' an incandescent light break of 3 hours during the induction period at 15.6 °C (60 °F) increased total shoot growth, but plants held at this temperature were the last to initiate growth in the spring (4). This delay can be as much as one month (1). Much of the forced fall growth was elongated shoots from a few lateral buds, which had to be pinched back

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in the spring to produce more breaks. Recent work indicates that red light can be used to obtain greater lateral branching and production of cuttings in various horticultural crops (2, 3, 5). It is possible that a red light break interrupting the dark period in the fall may increase the number of lateral bud breaks per cutting of rhododendron; normally produced by pinching back the terminal shoots in the spring. Red light creates a phytochrome photoequilibrium inhibitive to elongation, yet stimulative to lateral branching (6). The objectives of this study were to determine whether red light as a night break would produce increased numbers of lateral bud breaks per cutting, without the elongation obtained under incandescent light, and to determine whether fall red light breaks produced less of a spring delay than that produced by fall incandescent light breaks.

Materials and Methods

July-rooted cuttings of *Rhododendron* 'PJM hybrids' and 'Roseum Elegans' were placed in 10.2 cm (4 in) square plastic pots in an unsterilized 1:1 (by vol) mixture of peatmoss and sand on September 10, 1982. The cuttings were stored for 18 days in a glasshouse under normal photoperiod, during which time they were fertilized twice with a 20N-8.7P-16.6K (20-20-20) soluble fertilizer at 200ppm N. Beginning September 28, one group of 33 rooted cuttings of 'PJM hybrids' was exposed to 10 °C (50 °F) MNT for 3 weeks in a polyethylene covered house. Another group of 33 rooted cuttings was simultaneously exposed to 17 °C (63 °F) MNT in a glasshouse. During each induction, 11 rooted cuttings were exposed to natural photoperiod, 11 were given additional 15 $uEM^{-2}sec^{-1}$ (2 Klx or 185 fc) incandescent light between 2200 and 0100 hours, and 11 were given additional 5 $uEM^{-2}sec^{-1}$ red light (660nm) between 2200 and 0100 hours. Red lighting was supplied by two, GE 34 watt cool white fluorescent tubes in fixtures enclosed in poly-vinyl-acetate filter. Beginning September 28, groups of 20 'Roseum Elegans' rooted cuttings were exposed to the same temperature and lighting treatments as described above for 'PJM hybrids.' On October 19 all rooted cuttings were placed at 10 °C (50 °F) MNT without a light break in a polyethylene covered house. The MNT was lowered to 1 °C (33.4 °F) on November 9, 1982 and raised to 5 °C (41 °F) on February 1, 1983. On February 15 all 'Roseum Elegans' plants were transferred to a glasshouse where they were stored at 17 °C (63 °F) MNT for a two-week induction period.

Ten plants from each fall temperature/photoperiod treatment received supplemental incandescent lighting between 2200 and 0100 hours and the remaining 10 plants from each treatment received natural photoperiod. On March 1 all plants were returned to 5 °C (41 °F) MNT in a polyethylene covered house.

Results and Discussion

Rhododendron 'PJM hybrids' averaged 1.1, 1.2, and 1.5 shoots per plant from fall treatments of no light break, red light and incandescent light, respectively. The averages were not significantly different. Also, the number of shoots were not different between plants in the two temperature regimes (data not shown). Timmerman (4) reported that a light break during an induction at 18.3 °C (65 °F) MNT for 10 days increased the number of shoots on rooted cuttings of 'PJM hybrids,' suggesting that a longer exposure to high MNT's may allow for greater initiation of growth in buds ready to expand. The results of this study do not support this hypothesis.

Incandescent light produced elongated shoots of 'PJM hybrids' while the red light and natural photoperiod treatments were not significantly different (Table 1). Maintaining the lower MNT of 10 °C (50 °F) for the 3 week period did not influence the length of the shoots in any of the treatments. Heins and Wilkins (2) reported that increased far red wavelengths, such as from incandescent sources, produced elongated growth of chrysanthemums. Heins, Wilkins and Healy (3) observed that incandescent light had a high far red-to-red wavelength ratio which inhibited secondary shoot development on *Dianthus carophyllus.* Although our red light treatment kept the shoots as short as the natural photoperiod treatment, there was no accompanying increase in breaks beyond that obtained with the incandescent treatment.

An average 1.8 buds per plant grew on 'Roseum Elegans' to November 10, but differences among means in the temperature or lighting treatments were not significantly different from each other (Table 2). Both types of lighting produced longer shoots than the natural photoperiod treatment.

Rhododendron 'PJM hybrids' showed indications of a favorable response to fall red light treatments in that red light did not cause the elongation of the shoots that was obtained with incandescent light. However, red light did not increase the number of bud breaks. Red light cannot be recommended as a fall treatment for *Rhododendron* 'Roseum Elegans' cuttings at this time, since it produced elongation equivalent to that produced by incandescent light and it did not produce more bud breaks than either incandescent light or natural photoperiod. Possibly the duration of the red irradiance, 3 hours per night for 3 weeks, was insufficient, or the intensity was too low to produce a phytochrome effect in rhododendrons. It is also possible that the duration of the light break was too long. One of the two forms of phytochrome, Pfr, inhibits flowering and stimulates branching in short day plants when there exists a high red-to-far red ratio (6). Chrysanthemums required a

Table 1. Effect of temperature and lighting[z] on fall shoot length (cm) of *Rhododendron* 'PJM hybrids.'

	Minimum night temperature		
Light break	**10 °C (50 °F)**	**17 °C (63 °F)**	**Mean**
None	2.3	2.6	2.5
Red[y]	2.9	3.9	3.4
Incandescent[x]	4.9	6.3	5.6**
Mean	3.4	4.3	

[z]Rooted cuttings were exposed to either 10 °C (50 °F) or 17 °C (63 °F) and either natural photoperiod or natural photoperiod plus light break from 2200 to 0100 hours between September 28 and October 19, 1982.

[y]5 $uEM^{-2}sec^{-1}$ at 660nm

[x]15 $uEM^{-2}sec^{-1}$ (2Klx)

**Mean is significantly different from no light break at the 1% level. The lighting X temperature interaction was not significant.

Table 2. Effect of temperature and lighting[z] on fall shoot length (cm) of *Rhododendron* 'Roseum Elegans.'

	Minimum night temperature		
Light break	10°C (50°F)	17°C (63°F)	Mean
None	3.9	5.1	4.5
Red[y]	6.4	6.9	6.6**
Incandescent[x]	6.2	7.4	6.8**
Mean	5.4	6.5*	

[z]Rooted cuttings were exposed to either 10°C (50°F) or 17°C (63°F) and either natural photoperiod or natural photoperiod plus light break from 2200 to 0100 hours between September 28 and October 19, 1982.

[y]5 $uEM^{-2}sec^{-1}$ at 660nm

[x]15 $uEM^{-2}sec^{-1}$ (2Klx)

*Means are significantly different at the 5% level.

**Means are significantly different from no light break at the 1% level. The lighting X temperature interaction was not significant.

Table 3. Effect of temperature and lighting[z] on mean number of days to initiate growth the following spring for *Rhododendron* 'Roseum Elegans.' Days were counted from February 15.

	Fall minimum night temperature		
Fall Light break	10°C (50°F)	17°C (63°F)	Mean
None	34.0	35.7	34.9
Red[y]	39.0	41.2	40.1**
Incandescent[x]	42.7	41.9	42.3**
Mean	38.6	39.6	

[z]Rooted cuttings were exposed to either 10°C (50°F) or 17°C (63°F) and either natural photoperiod or natural photoperiod plus light break from 2200 to 0100 hours between September 28 and October 19, 1982.

[y]5 $uEM^{-2}sec^{-1}$ at 660nm

[x]15 $uEM^{-2}sec^{-1}$ (2Klx)

**Means are significantly different from no light break at the 1% level. The lighting X temperature interaction was not significant.

single one minute exposure to cool-white fluorescent light (high red-to-far red) to inhibit flowering (2). Vince-Prue (6) stated that red light inhibited flowering when the duration of irradiance was short, therefore it is probable that the response of stimulating branching would also require a short duration of red irradiance. It is necessary to define 'short' as it relates to rhododendron branching.

The fall temperature treatments had no significant effect on the number of days to initiate spring growth of *Rhododendron* 'Roseum Elegans' as counted from February 15 (Table 3). The fall light treatment means, however, contributed significantly to the number of days to spring growth (Table 3). The fall natural photoperiod treatment broke dormancy at an earlier date than either the fall red or incandescent light treatments. The latter two treatments were not statistically different from each other and they delayed spring growth. This agrees with previous work (1, 4) where a fall light break was found to delay growth in the spring. A 3 hour light break in the spring, during the two week induction period, did not overcome the delay, or carryover effect, produced by the fall light breaks. *Rhododendron* 'Roseum Elegans' averaged 38.8 and 39.3 days to spring growth from February 15 from spring treatments of no light break and incandescent light break, respectively. The averages were not significantly different.

Significance to the Nursery Industry

Red light cannot be recommended as a fall treatment to stimulate growth of Rhododendron cuttings at this time. Although this research indicated a response of *Rhododendron* 'PJM hybrids' to fall red light treatments (the shoots were shorter in the red light treatment than in the incandescent light treatment), it did not yield an indication of the same response of *Rhododendron* 'Roseum Elegans' to fall red light treatments. Additional work needs to be done on the duration of the night break lighting, the length of the induction period, and the intensity of the irradiance before it can be stated that branching in rhododendron cuttings does or does not involve the phytochrome system. Both fall lighting treatments failed to increase bud breaks and caused a spring delay in growth. There appears to be no advantage in forcing fall growth on summer-rooted cuttings of *Rhododendron* 'PJM hybrids' and 'Roseum Elegans.'

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