Interior Performance of Temperate Zone Landscape Plants[1]

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Abstract

Cleyera (*Ternstroemia gymnanthera*), spreading lilyturf (*Liriope spicata*), Southern magnolia (*Magnolia grandiflora*), heavenly bamboo (*Nandina domestica*), mondo grass (*Ophiopogon japonicus*), climbing fig (*Ficus pumila*), and variegated waxleaf privet (*Ligustrum japonicum* 'Variegatum') grown under 3 production light levels and shade-grown golden Japanese euonymus (*Euonymus japonica* 'Aureomarginata'), plantain lily (*Hosta ventricosa*), King's Ransom Oregon grapeholly (*Mahonia aquifolium* 'King's Ransom'), dwarf gold-dust plant (*Aucuba japonica* 'Variegata Nana'), Wood's Dwarf heavenly bamboo (*Nandina domestica* 'Wood's Dwarf'), Japanese anise-tree (*Illicium parviflorum*), and Pink Lady Indian hawthorn (*Raphiolepis indica* 'Pink Lady') adapted well to interior conditions following production. Bugleweed (*Ajuga reptans*) and variegated wintercreeper euonymus (*Euonymus fortunei* 'Variegata') grown under 64% light exclusion were of acceptable quality while plants grown in full sun and under 47% light exclusion were of poor quality. Quality of Wintergreen Korean boxwood (*Buxus microphylla koreana* 'Wintergreen') grown under all production light levels was unacceptable after 15 weeks in the interior environment.

Index words: acclimatization, interior landscaping

Introduction

Several temperate zone woody landscape plants have recently proven to adapt and perform well in the interior environment (1, 3, 4). In addition to offering a new and varied source of plant materials for interior landscapes, temperate species are generally more tolerant than tropical or semi-tropical species to cooler interior conditions that may result from energy-conserving measures or placement near building entrances where drafts of cold air frequently enter.

Successful indoor performance of temperate landscape plants is dependent upon the plant's ability to acclimate to low light conditions and to maintain vigor without experiencing a natural dormancy environmentally enhanced by shortening daylength and decreasing temperatures. Acclimatization to low light can be facilitated by production under a specific shade level for a portion of or the entire production cycle (2). Characteristically longdays and relatively constant temperatures of interior environments will delay or prevent dormancy of temperate woody plants; however, the response is species-dependent (5). The objective of this study was to continue previous research (4) to evaluate production light level effects on the interior performance of selected temperate zone woody landscape plants typically used in the exterior landscape. In addition, several non-woody species typically used as ground covers were evaluated.

Materials and Methods

Experiment 1. Thirty uniform liners each of *Euonymus japonica* 'Aureomarginata' (golden Japanese euonymus), *Hosta ventricosa* (plantain lily), *Liriope spicata* (spreading lilyturf), *Magnolia grandiflora* (Southern magnolia), *Mahonia aquifolium* 'King's Ransom' (King's Ransom Oregon grapeholly), *Nandina domestica* (heavenly bamboo), *Ophiopogon japonicus* (mondo grass), and *Ternstroemia gymnanthera* (cleyera) were potted March 12, 1985, in 15 cm (6 in) containers. A 100% milled pine bark growth medium was amended with 3.6 kg/m^3 (6 lb/yd^3) dolomitic limestone, 1.2 kg/m^3 (2 lb/yd^3) gypsum, and 0.9 kg/m^3 (1.5 lb/yd^3) Micromax micronutrient fertilizer. Plants were topdressed monthly during production with 4.0 g (0.14 oz) 12N-2.6P-5.0K (12-6-6) per container. Plants of each species were divided into 3 groups of 10 plants and grown under the following light conditions: 1) full sun; 2) 47% shade; and 3) 64% shade. On August 16, 1985, growth indices (height + width + width/3) were taken prior to transferring plants to an interior environment (11.0 μE sec^{-1} m^{-2} irradiance from 40 watt cool white fluorescent lamps, 12-hr photoperiod (6 A.M.–6 P.M.), 21.1°C (70°F) temperature, and 80% RH). Plants were completely randomized among species indoors and evaluated weekly during a 15-week period for leaf drop. After 15 weeks, growth indices, leaf color (1 = light green; 3 = medium green; 5 = dark green), and plant quality (1 = poor, not saleable; 3 = good, saleable; 5 = excellent) were determined. Following data collection, plants were transferred to a polyethylene covered greenhouse (21.1°C/70°F minimum temperature) for 5 additional months and fertilized every 3 weeks with 100 ppm N from Peters 20N-8.6P-16.6K (20-20-20) soluble fertilizer to determine if plants would resume or continue vegetative growth without exposure to low temperatures.

Experiment 2. Uniform liners of *Aucuba japonica* 'Variegata Nana' (dwarf gold-dust plant), *Ligustrum japonicum* 'Variegatum' (variegated waxleaf privet) and *Nandina domestica* 'Wood's Dwarf' (Wood's Dwarf heavenly bamboo) were potted in 15 cm (6 in) containers, and *Ajuga reptans* (bugleweed), *Buxus microphylla koreana* 'Wintergreen' (Wintergreen Korean boxwood), *Euonymus fortunei* 'Variegata' (wintercreeper euonymus), *Ficus pumila* (climbing fig), *Illicium parviflorum* (Japanese anise-tree), and *Raphiolepis indica* 'Pink Lady' (Pink Lady Indian hawthorn) were potted in 11.7 cm (4.6 in) containers on April 16, 1986. Methods were the same as those in Experiment 1

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except plants were transferred to an interior environment on September 3, 1986.

Results and Discussion

Post-production. All plants grown in full sun were smaller than shade-grown plants except *Mahonia* grown in 47% shade and *Ophiopogon* and *Ficus* grown in 47% and 64% shade (Tables 1 and 2). Species grown in full sun were denser and more compact, with smaller, lighter green leaves than plants grown in shade. Marginal leaf necrosis was present on plants of *Hosta*, *Liriope*, *Mahonia*, *Nandina domestica* 'Wood's Dwarf', and *Aucuba* grown in full sun. With both *Euonymus* spp. and *Ligustrum* there was a reduction in the amount and intensity of variegation as production light levels decreased. Overall plant quality was generally poorer with plants grown in full sun due to a hard, stunted appearance. Only plants of *Ternstroemia* and *Magnolia* were of similar quality under all light regimes.

Post-interior. Plants of all species except *Buxus* continued to produce new growth during the 15-week interior period. Growth of full-sun grown plants in the interior environment was similar in color and leaf size to growth of shade-grown plants during production. Production size of *Nandina domestica* 'Wood's Dwarf' and *Illicium* were smaller for plants grown in full sun, but after 15 weeks indoors plant size was similar among light treatments. Other species maintained the same relative size among treatments as when brought indoors. Foliar color ratings were higher for shade-grown plants of *Euonymus* spp., *Magnolia*, *Liriope*, and *Mahonia* compared to ratings for full-sun grown plants. Ratings were similar for other species, regardless of production light treatment. These ratings indicate an improvement in leaf color of full-sun grown plants during the interior period.

Euonymus spp., *Mahonia*, *Aucuba*, *Nandina domestica* 'Wood's Dwarf', *Ligustrum*, and *Ficus* grown under both shade levels and *Ajuga* and *Magnolia* grown under 64% shade dropped fewer leaves than plants grown under higher light conditions. Plants of *Hosta* grown in full-sun lost fewer leaves than plants grown in shade; leaf drop from other species did not vary among production light levels.

Table 1. Response of 8 temperate zone landscape plants, grown under 3 light levels, to an interior environment, 1985.

Cultivar and production light level	Growth index[z]		Post-interior		
	Post-production	Post-interior	Color rating[y]	Leaf drop[x]	Quality rating[w]
Euonymus japonica 'Aureomarginata'					
full sun	20.5b[v]	20.5b	4.5b	76.6a	1.8c
47% shade	26.0a	26.1a	5.0a	14.2b	3.8b
64% shade	26.5a	26.7a	5.0a	8.6b	5.0a
Hosta ventricosa					
full sun	26.3b	42.3b	4.5a	6.0b	2.0b
47% shade	43.3a	47.1a	4.5a	9.2a	3.8a
64% shade	43.9a	47.4a	4.5a	9.4a	3.9a
Liriope spicata					
full sun	35.5b	35.6b	4.1b	0.0a	3.7b
47% shade	40.8a	41.1a	5.0a	0.0a	4.8a
64% shade	41.4a	41.7a	5.0a	0.0a	4.8a
Magnolia grandiflora					
full sun	37.4b	44.6b	4.2b	5.6a	4.6a
47% shade	48.3a	52.6a	5.0a	6.4a	4.8a
64% shade	51.8a	53.5a	5.0a	2.6b	4.8a
Mahonia aquifolium 'King's Ransom'					
full sun	35.0b	35.6b	2.1b	123.2a	1.1c
47% shade	38.5ab	39.6ab	4.5a	63.0b	3.2b
64% shade	43.6a	43.6a	4.7a	53.6b	3.4a
Nandina domestica					
full sun	51.3b	51.5b	4.2a	269.0a	4.2a
47% shade	61.3a	62.5a	4.4a	230.5a	4.6a
64% shade	64.2a	67.3a	4.9a	137.5a	4.8a
Ophiopogon japonicus					
full sun	19.1a	19.7a	5.0a	0a	5.0a
47% shade	19.4a	19.8a	5.0a	0a	5.0a
64% shade	18.3a	19.8a	5.0a	0a	5.0a
Ternstroemia gymnanthera					
full sun	48.8b	49.2b	5.0a	15.4a	5.0a
47% shade	53.9a	54.8a	5.0a	13.2a	5.0a
64% shade	56.3a	56.5a	5.0a	17.4a	5.0a

[z]Growth index: (height + width + width)/3; in cm.

[y]Color rating: 1 = light green; 3 = medium green; 5 = dark green. Recently matured leaves and green portions of variegated leaves rated.

[x]Leaf drop: total number of leaves dropped during interior period; leaflet drop for *Mahonia* and *Nandina*.

[w]Quality rating: 1 = poor, not saleable; 3 = good, saleable; 5 = excellent.

[v]Mean separation within columns and species by Duncan's multiple range test, 5% level.

Table 2. Response of 9 temperate zone landscape plants, grown under 3 light levels, to an interior environment, 1986.

Cultivar and production light level	Growth index[z]		Post-interior		
	Post-production	Post-interior	Color rating[y]	Leaf drop[x]	Quality rating[w]
Ajuga reptans					
full sun	18.5b[v]	19.6b	3.0a	118.1a	1.6b
47% shade	21.8a	22.7a	3.0a	101.9a	1.9b
64% shade	22.6a	23.6a	3.0a	47.3b	3.0a
Aucuba japonica 'Variegata Nana'					
full sun	16.2b	17.9b	5.0a	14.5a	1.6b
47% shade	24.8a	26.4a	5.0a	7.8b	4.8a
64% shade	24.3a	26.1a	5.0a	7.7b	4.8a
Buxus microphylla koreana 'Wintergreen'					
full sun	13.3c	0.0[u]	0.0[u]	0.0[u]	0.0[u]
47% shade	16.4b	16.1b	3.4a	76.2a	2.6a
64% shade	19.1a	18.7a	3.5a	59.0a	2.8a
Euonymus fortunei 'Variegata'					
full sun	21.0c	19.4b	4.2a	495.0a	1.0c
47% shade	25.0a	25.8a	4.2a	308.8b	2.8b
64% shade	22.9b	24.3a	4.2a	131.6c	4.0a
Ficus pumila					
full sun	21.6a	24.5a	4.8a	433.4a	3.5c
47% shade	22.4a	25.1a	4.8a	306.0b	4.1b
64% shade	23.3a	25.9a	4.8a	280.1b	4.6a
Illicium parviflorum					
full sun	18.7b	22.4a	3.5a	7.0a	2.6c
47% shade	21.7a	23.2a	3.5a	5.4a	3.7b
64% shade	22.9a	25.4a	3.5a	5.4a	4.1a
Nandina domestica 'Wood's Dwarf'					
full sun	35.7b	38.6a	4.8a	152.3a	1.9c
47% shade	40.0a	42.7a	4.8a	26.3b	4.2b
64% shade	39.6a	42.6a	4.8a	22.6b	4.6a
Ligustrum japonicum 'Variegatum'					
full sun	20.5b	21.3b	4.8a	7.3a	3.6b
47% shade	25.5a	27.1a	4.8a	2.6b	4.7a
64% shade	27.3a	28.7a	4.8a	3.4b	4.8a
Raphiolepis indica					
full sun	17.9b	—	—	—	—
47% shade	22.4a	22.8a	4.5a	26.1a	3.6a
64% shade	24.4a	24.5a	4.7a	20.3a	3.9a

[z]Growth index: (height + width + width)/3; in cm.

[y]Color rating: 1 = light green; 3 = medium green; 5 = dark green. Recently matured leaves and green portions of variegated leaves rated.

[x]Leaf drop: total number of leaves dropped during interior period; leaflet drop for *Nandina*.

[w]Quality rating: 1 = poor, not saleable; 3 = good, saleable; 5 = excellent.

[v]Mean separation within columns and species by Duncan's multiple range test, 5% level.

[u]All plants died during the interior period.

Plant quality, as determined by visually rating the plants following the 15-week interior period, considered numerous plant characteristics including habit of growth (density), leaf size and spacing, foliage color, leaf drop, and overall appearance. At the end of the interior period, the quality of *Ternstroemia*, *Liriope*, *Magnolia*, *Nandina domestica*, *Ophiopogon*, *Ficus* and *Ligustrum* was good to excellent for plants grown under all production light levels (Tables 1 and 2). Of these species, quality was higher for shade-grown plant of *Liriope*, *Ficus*, and *Ligustrum* than for sun-grown plants. Quality of *Euonymus japonica*, *Hosta*, *Mahonia*, *Aucuba*, *Nandina domestica* 'Wood's Dwarf', *Illicium*, and *Raphiolepis* was good to excellent for plant grown in shade, while quality of plants grown in full sun was unacceptable, due to excessive leaf drop, stunting and foliar necrosis from the production period or both. All plants of *Raphiolepsis* grown in full sun, 10% grown in 47% shade, and 20% grown in 64% shade died in the interior environment, while 20% of *Illicium* grown in full sun died. Plants of *Ajuga* and *Euonymus fortunei* grown under 64% shade were of acceptable quality but plants grown in full sun or 47% shade were of poor quality. With *Euonymus*, 70% of plants grown in full sun died during the 15 weeks indoors. Plants of *Buxus* grown under all production light levels were of unacceptable quality due to excessive leaf drop and death (100% of plants grown in full-sun, 50% grown in 47% shade, and 10% grown in 64% shade) during the interior period.

Species that performed well in the interior environment continued to produce new growth indoors or in the greenhouse, indicating that dormancy was not a limiting factor during the 15-week interior period and 5 months in the greenhouse. Similar results have been reported previously (1, 3, 4). Plants of several species, including *Buxus* and sun-grown *Raphiolepis*, exhibited extensive branch dieback

and death of entire plants. These symptoms may have been dormancy- or disease-related or simply the results of the plant's inability to tolerate the low light levels of the interior environment. The fungus *Rhizoctonia* was isolated from dead plants of *Raphiolepis*. *Raphiolepis* plants grew and improved in appearance during the 5 months in the greenhouse.

Significance to the Nursery Industry

Temperate-zone landscape plants, characteristically more cold tolerant than tropical or semitropical species, can be successfully used in the interior environment. Plants of *Euonymus* spp., *Hosta*, *Liriope*, *Magnolia*, *Mahonia*, *Nandina*, *Ophiopogon*, *Ternstroemia*, *Aucuba*, *Ligustrum*, *Ajuga*, *Ficus*, *Illicium*, and *Raphiolepis* performed well when placed indoors for 15 weeks. Quality was generally higher for shade-grown plants but not always, as exemplified by *Magnolia*, *Nandina domestica*, *Ophiopogon* and *Ternstroemia*. Some species, such as *Buxus*, do not appear to adapt to interior conditions, regardless of production light levels. It is suggested that before committing to a large scale planting with plants that performed well in this study a trial of a few plants be conducted over 12 to 18 months indoors.

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Cambial Peroxidase Enzymes Related to Graft Incompatibility in Red Oak[1]

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Abstract

Variation in cambial isoperoxidase banding patterns was greater in northern red oak (*Quercus rubra* L.) than in any of the other oak species studied, with all combinations of the 3 major anodal bands (A,B,C) being present (A,B,C,AB,AC,BC,ABC). Bark-ring grafts between seedlings of similar enzyme constitution were successful and xylem vascular continuity was restored across the graft union. When the isoperoxidase pattern in the bark-ring donor differed from that of the stock, no common cambium was formed and normal vascular connections did not occur. The graft "failures" (not incompatibility) that have been common in the propagation of 'Crownright' and 'Sovereign' pin oaks are probably caused by the hypersensitivity of these scion cultivars to a virus transmitted by soil-borne nematodes. The disruption at the graft union was more severe when stock and scion had different isoperoxidase constitutions. Propagation problems engendered by isozyme incompatibility and virus hypersensitivity can be solved by developing "seed orchards" for the production of desirable seedling rootstocks.

Index words: *Quercus, Q. rubra, Q. palustris*, nepovirus, hypersensitivity, lignification, isozymes

Introduction

This paper is the third in a series which began with a general exposition of the hypothesis that graft compatibility in woody plants could be related to variation in cambial peroxidase isozymes (11) and continued with specific data on Chinese chestnut (12).

Hundreds of cultivars of the various oak (*Quercus*) species have been described (5, 6, 7), mostly from Europe, but aside from those propagated by seed, few are currently available in the United States or European nursery trade. This non-availability is the result of real or imagined problems of graft incompatibility, which has reduced practical experimentation.

Among native American oaks, *Q. palustris* Muenchh. (pin oak) has proved to be highly adapted to transplanting, grows well over a wide geographic range, and usually produces an attractive reddish autumn leaf color. Unfortunately, the growth habit is usually not amenable to roadside planting because of the drooping growth pattern of the branches in the lower portion of the crown, which necessitate continual pruning to eliminate interference with pedestrian or vehicular traffic beneath the trees.

Cultivars with a more upright, non-drooping, branching habit were selected, patented, named, and introduced in the late 1960's. 'Sovereign' (Plant Patent 2662) was a product of the Cole Nursery Co., Circleville, OH (now defunct) and 'Crownright' (Plant Patent 2936) was introduced by Prince-

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