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Consequences of Water and Nitrogen Management on Growth and Aesthetic Quality of Drought-Tolerant Woody Landscape Plants[1]

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Abstract

Two drought-tolerant California native plant species (a nonselected form of *Ceanothus griseus* var. *horizontalis*, *C. griseus* var. *horizontalis* 'Santa Ana', a nonselected form of *Rhamnus californica*, and *R. californica* 'Eve Case') and a widely planted non-native landscape species (*Photinia fraseri*) received the same total volume of water (63.8% ET_0) over a 14 week period in one of four irrigation treatments (water applied daily, every three days, every five days, or every seven days). Each irrigation treatment also received one of three rates of nitrogen application (0, 20 g N/m^2, and 40 g N/m^2 [0, 180, and 360 lb. N/A]). The irrigation frequencies or fertilization rates had few significant effects on plant growth and survival. Selection of a cultivar of *R. californica* has resulted in increased growth rates and aesthetic quality, but has also increased susceptibility to root pathogenic fungi.

Index words: drought tolerance, water stress, irrigation frequency

Species used: Carmel Creeper (*Ceanothus griseus* var. *horizontalis*); Santa Ana (*Ceanothus griseus* var. *horizontalis* 'Santa Ana'); California Coffeeberry (*Rhamnus californica*); Eve Case (*Rhamnus californica* 'Eve Case'); Fraser photinia (*Photinia fraseri*).

Significance to the Nursery Industry

Xerophytic plants have been adapted to landscape use in a limited way. Although the interest in using these plants is continuing to grow, the production and sale of the plants have been relatively minor parts of the landscape plant industry. Traditional attitudes towards the form and appearance of landscape plants, as well as misperceptions of the shape and color of drought-tolerant plants, have slowed acceptance of the xerophytic species. Consequently, plant breeders have selected new cultivars of the drought tolerant species to conform to more traditional views. Also, there is a conventional wisdom suggesting that the xerophytic species are either hard to maintain or short-lived in the landscape because of their sensitivity to irrigation schedules. The study presented here demonstrates that the frequency of irrigation (total water applied at 63.8% ET_0) and fertilization of the nonselected form of *Ceanothus griseus* var. *horizontalis*, *C. griseus* var. *horizontalis* 'Santa Ana', the nonselected form of *Rhamnus californica*, *R. californica* 'Eve Case', or *Photinia fraseri* have only minor impacts on plant growth and survival. The results suggest that if the

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total volume of water is within the tolerances of the species, the frequency and duration (frequent shallow applications or infrequent deep applications) are not critical. There was a high mortality rate attributable to root pathogenic fungi (*Phytophthora* spp.) except for *R. californica* and *Photinia fraseri*. Because the nonselected form of *R. californica* was apparently resistant and the 'Eve Case' cultivar was susceptible, this suggests that in addition to visual appeal, care should be taken to preserve disease resistance (or insects) when selecting cultivars for propagation and sale.

Introduction

In parts of the arid southwestern United States, there is a growing concern over water management as urbanization continues to increase. Water conservation becomes a potential source of supply for other needs, and one of the most visible areas for water conservation is in the landscape. Consequently, there is increasing interest in the use of drought-tolerant plants, both native and introduced species, in commercial and residential landscapes. However, it is not well understood how these plants will perform under managed landscape conditions.

There have been many studies on the physiological and biochemical responses of plants to water stress (2, 4), as well as the morphological characteristics of plants adapted to limited moisture conditions (3, 5). However, there seem to be few controlled studies on the growth response of drought-adapted plants to applications of water and nitrogen that might be expected in the landscape. There are anecdotal accounts suggesting that excessive water will cause drought-tolerant plants to develop rank foliage growth (7) and become more susceptible to insects (8) and diseases (6). These are broad generalizations and do not specify particular species or cultivars. There is evidence that reduced irrigation frequency can result in water savings and limit vegetative growth (10), but there is little, if any, information to relate the response of drought-tolerant species to a range of water and fertilizer applications.

The objective of the study was to compare the growth and aesthetic quality of a "wild type" and a horticultural cultivar of two species of native California drought-tolerant plants when grown under different water application and fertilization regimes. The named cultivars were developed through a process of selection primarily for horticultural or aesthetic qualities and not necessarily for their tolerance for adverse conditions. In contrast, the "wild type" of the species might not be as tolerant of managed landscape conditions.

Materials and Methods

Two species of California native drought-tolerant plants and two selected cultivars of those species to be used in the test were obtained from commercial nursery sources. The nonselected form and named cultivar 'Santa Ana' of *Ceanothus griseus* (Trelease) McMinn var. *horizontalis* as well as both the nonselected and the cultivar 'Eve Case' of *Rhamnus californica* Eschscholtz were transplanted into the field plots from 19-l (5 gal.) containers. To reduce the variation among plants, all plants of a species came from the same source and had been propagated at the same time (approximately one year before use in the study). In addition, *Photinia fraseri*, a commonly planted shrub of similar growth form that has broad tolerances for temperature and moisture conditions, was included as a horticultural standard.

Container-grown plants were transplanted in a block of land (soil type Hanford Coarse Sandy Loam) at the University of California Moreno Valley Field Station (Moreno Valley, CA) in November 1988. The field was divided into four irrigation treatments and three fertilization treatments. The irrigation treatments were assigned along the north-south axis of the field and the fertilizer treatments along the east-west axis. Five rows of ten plants spaced at 2-m (6.56 ft.) intervals were established within each irrigation and fertilizer block. Each row contained one species or cultivar of plant and the ordering of the rows within each block was randomized. During the period of plant establishment, all plants were irrigated at approximately 60% of historical reference evapotranspiration (ET_0) for the area. Historical ET_0 provides an average value for the evapotranspiration (ET) of a large area of 4- to 7-inch tall, cool-season turfgrass that is not water stressed. Estimated ET_0 values have been calculated indirectly from measured weather data at numerous locations in California. These values provide standards of comparison for the actual ET of the other plant species growing in the area. It has been demonstrated that many landscape plant materials can grow well at considerably lower ET rates than ET_0 (9, 10). Plants were replaced if individuals died prior to the initiation of the treatments in the study. Counts of plant mortality were made weekly during the period of treatment. In addition, roots from an arbitrary sample of both living and dead plants of all cultivars were assayed for the presence of pathogenic fungi. Differences in plant mortality by irrigation or fertilization treatment were determined with repeated measures analysis of variance and Scheffe's F test for mean separation using statistical software (StatView II) (1).

All plants in each irrigation treatment received the same amount of water, but the interval between applications and the length of application varied among treatments (12 minutes daily, 36 minutes every three days, 60 minutes every five days, or 84 minutes every seven days). An emitter with a flow rate of .444 l/min (.12 gal./min) was placed at the base of each plant. A total of 522.14 l (138 gal.) of water, or 63.8% ET_0, was applied to each plant during the test period that began on July 2 and ended on October 5, 1990. There was no natural precipitation during the time of the test. Three fertilizer rates (0, 20, and 40 g N/m^2 [0, 180, and 360 lb. N/A] using 33.5-0-0 ammonium nitrate) were applied to blocks of plants within the water treatments.

Two types of growth measurements were made on each plant. An index of plant growth was calculated by summing the height and widths (two measurements taken at 90° from each other) of each plant and dividing the total by three at the beginning of the study. The measurements were repeated at the end of the study to determine changes in the plant growth index. Seasonal terminal growth was also measured on each plant. Four branches on each plant were examined and the points where new seasonal growth had been initiated were tagged. Distance from the tag to the terminal was recorded for each branch. At the end of the study, the measurements were again made from the tag to the terminal. Subtraction of the measurements at the beginning of the study from those at the end of the study reflected seasonal growth. In addition, visual quality ratings of the plants (0 rating for dead plants to a 10 rating for the most vigorous plants) were made by two observers at the end of the study.

Differences within species in growth estimates and visual appearance among fertilizer treatments and among moisture applications were determined by analysis of variance using general linear models procedure and the Ryan-Einot-Gabriel-Welsch Multiple F Test for mean separation (11). Data were analyzed only for those plants that survived to the end of the study.

Results and Discussion

The plant growth index determined for this study provided a measure of the change in size of the individual plants. There was significantly less change in size of *Ceanothus* when water was applied daily compared to applications every third or seventh day, but applications every fifth day produced intermediate levels of growth (Fig. 1). The interval between irrigations, and consequently, the volume of water supplied during each application, did not significantly affect the size of either *Rhamnus* or *Photinia*. In contrast, only the tip growth of *Rhamnus* was significantly longer in response to daily irrigations, but was not different between irrigations every three and five days, or three and seven days (Fig. 2). There were no significant differences in tip growth among irrigation treatments for either *Ceanothus* or *Photinia*. When only living plants were rated for visual appearance at the conclusion of the study, there were no significant differences for any plant species among irrigation treatments (Fig. 3).

Applications of nitrogen fertilizer did not influence the growth index for either *Ceanothus* or *Rhamnus*, but the growth index for *Photinia* was significantly less following application of the low rate of nitrogen compared to application of either the high rate or none (Fig. 4). Although the fertilizer application did not significantly change the tip growth of *Ceanothus* there were significant differences for the other two species (Fig. 5). Tip growth of *Rhamnus* was significantly greater following application of the low fertilizer rate compared to no application, but application of the high rate was not different from either of the two other treatments. As observed with the growth index, tip growth of *Photinia* was significantly reduced when grown with an application of the low fertilizer rate. In addition, there were no significant differences among fertilizer treatments for the visual rating of living plants (Fig. 6).

Evaluation of plant mortality demonstrated that in addition to the differences among the species, there were also differences between cultivars. The frequency of irrigations did not significantly change the mean weekly mortality for *C. griseus horizontalis* 'Santa Ana', *R. californica, R. cali-*

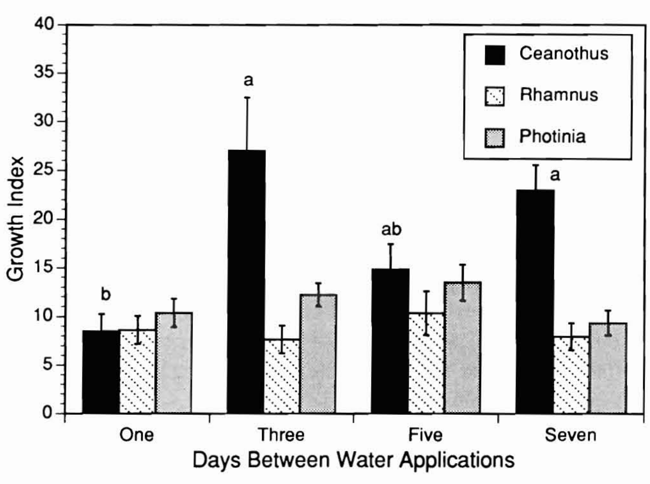

Fig. 1. Change in plant size (growth index) of three landscape plant species in response to four irrigation frequencies. Different lower case letters indicate significant differences among treatments within species (analysis of variance and Ryan-Einot-Gabriel-Welsch Multiple F test, P = 0.05; *Ceanothus* [F = 3.18, df = 3,99, P = .0274], *Rhamnus* [F = 2.37, df = 3,145, P = .0727], *Photinia* [F = 1.85, df = 3,107, P = .1432]).

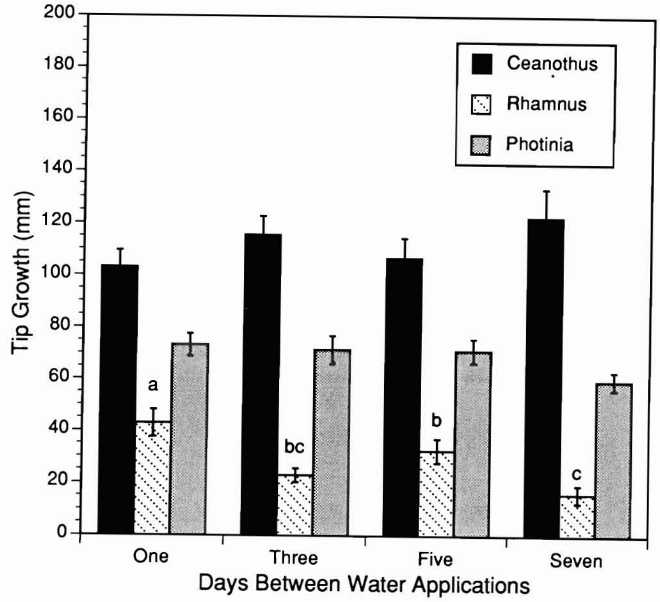

Fig. 2. Change in tip growth (mm) of three landscape plant species in response to four irrigation frequencies. Different lower case letters indicate significant differences among treatments within species (analysis of variance and Ryan-Einot-Gabriel-Welsch Multiple F test, P = 0.05; *Ceanothus* [F = 2.05, df = 3,39, P = .1226], *Rhamnus* [F = 9.53, df = 3,39, P = .001], *Photinia* [F = 2.61, df = 3,39, P = .0649]).

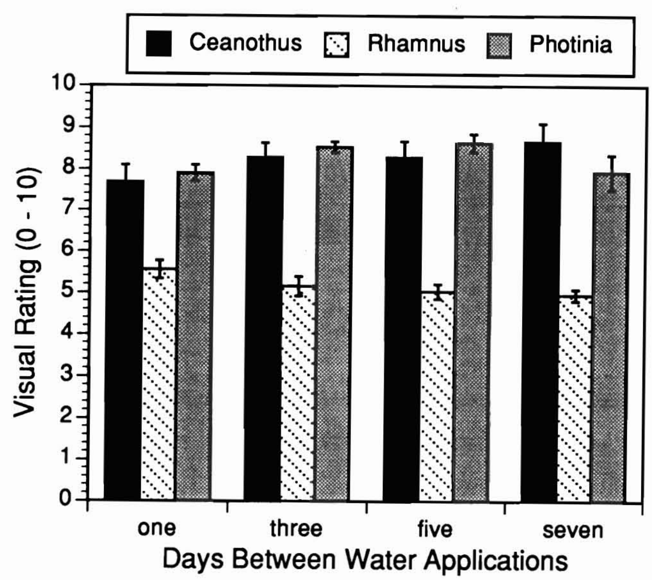

Fig. 3. Visual rating (0–10) of three landscape plant species in response to four irrigation frequencies. No significant differences (P = 0.05) were observed among treatments within species (*Ceanothus* [F = 0.2600, df = 3,99, P = .8509], *Rhamnus* [F = 2.69, df = 3,145, P = .0587], *Photinia* [F = 2.13, df = 3,107, P = .1011]).

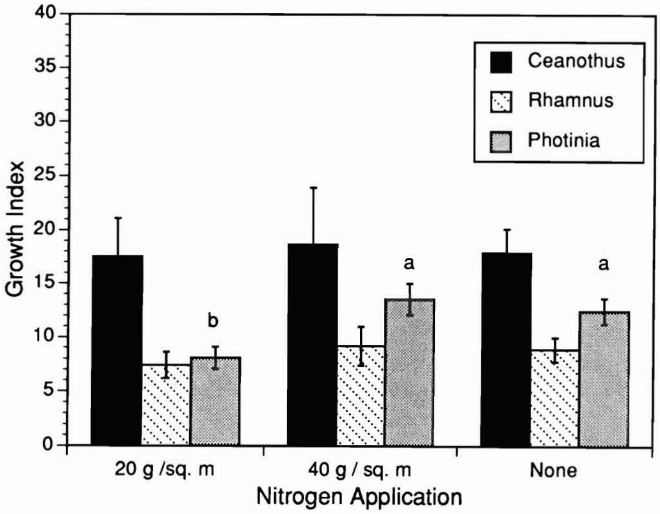

Fig. 4. Change in plant size (growth index) of three landscape plant species in response to three nitrogen fertilization rates. Different lower case letters indicate significant differences among treatments within species (analysis of variance and Ryan-Einot-Gabriel-Welsch Multiple F test, P = 0.05; *Ceanothus* [F = 0.01, df = 2,99, P = .9971], *Rhamnus* [F = 0.08, df = 2,145, P = 9.910], *Photinia* [F = 5.90, df = 2,107, P = .0037]).

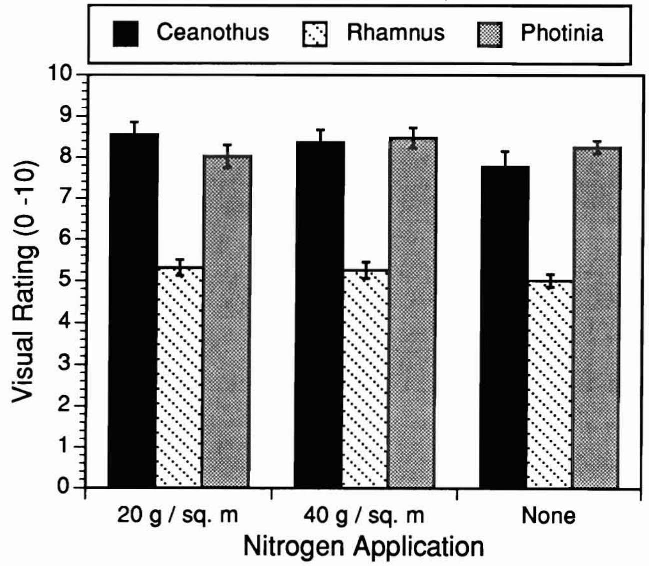

Fig. 6. Visual rating (0–10) of three landscape plant species in response to three nitrogen fertilization rates. No significant differences (P = 0.05) were observed among treatments within species (*Ceanothus* [F = 2.5700, df = 2,99, P = .0800], *Rhamnus* [F = 2.6500, df = 2,145, P = .0743], or *Photinia* [F = 0.9720, df = 2,107, P = .3824]).

fornica 'Eve Case', or *P. fraseri*. As shown in Fig. 7, only one plant of *R. californica* and none of the *P. fraseri* died during the 96 days of the study among any of the irrigation and fertilizer treatments. There was a significant difference in weekly mortality between water applications every three days and every seven days, but not among irrigations daily, every three days, or every five days, or for irrigations every day, every five days, or every seven days for *C. griseus horizontalis*. Different fertilizer applications did not significantly affect weekly plant mortality for any cultivar (Fig. 8). In all cases, *Phytophthora* spp. were isolated from the roots of plants that died during the study, but not from roots of living plants.

The growth index value for *C. griseus horizontalis* 'Santa Ana' (mean = 8.95, SE = 1.35, N = 60) was significantly less (F = 15.57, df = 1,99, P = .0001) than for the nonselected cultivar of that species (mean = 26.70, SE = 3.45, N = 63). Similarly, the tip growth of *C. griseus horizontalis* 'Santa Ana' was significantly less (mean =

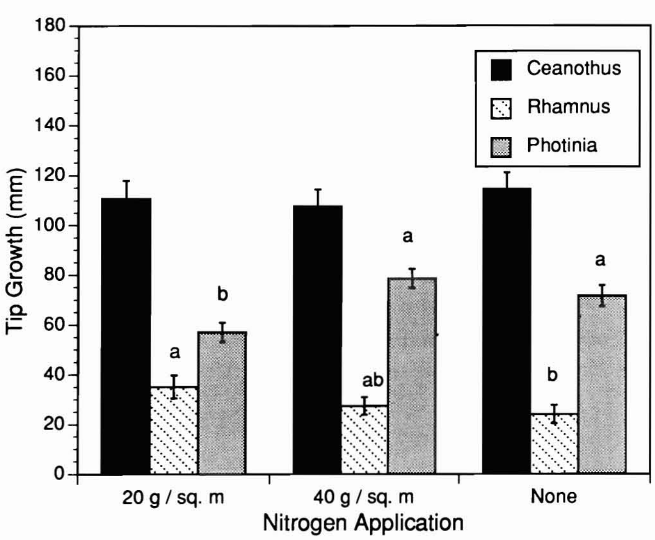

Fig. 5. Change in tip growth (mm) of three landscape plant species in response to three nitrogen fertilization rates. Different lower case letters indicate significant differences among treatments within species (analysis of variance and Ryan-Einot-Gabriel-Welsch Multiple F test, P = 0.05; *Ceanothus* [F = 0.6800, df = 2,39, P = .5129], *Rhamnus* [F = 3.54, df = 2,39, P = .0387], *Photinia* [F = 11.4400, df = 2,39, P = .0001]).

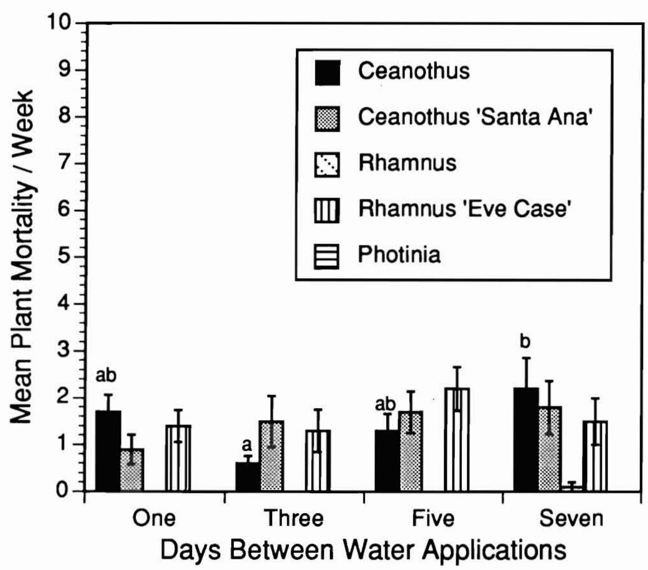

Fig. 7. Mean mortality per week of five cultivars of three landscape plant species in response to four irrigation frequencies. Different lower case letters indicate significant differences among treatments within species (analysis of variance and Scheffe's F test, P = 0.05; *C. griseus horizontalis* [F = 3.306, df = 3,27, P = .0352], *C. griseus horizontalis* 'Santa Ana' [F = 1.574, df = 3,27, P = .2186], *R. californica* [F = 1.00, df = 3,27, P = .4079], *R. californica* 'Eve Case' [F = 0.9570, df = 3,27, P = .4270], or *P. fraseri* [F = N/A]).

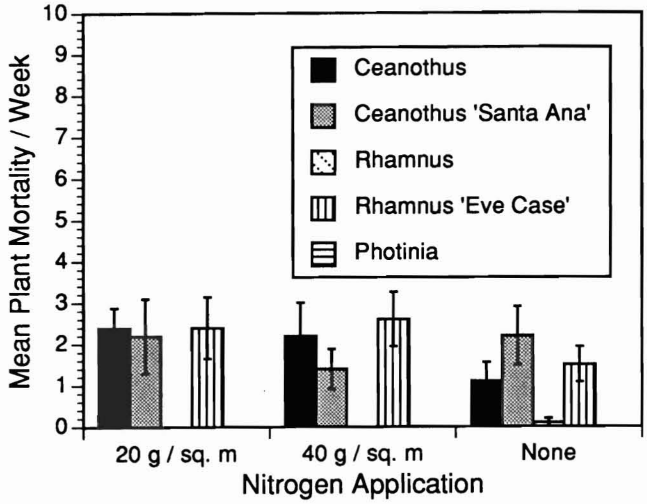

Fig. 8. Mean mortality per week of five cultivars of three landscape plant species in response to three nitrogen fertilization rates. No significant differences (P = 0.05) were observed among treatments within species (*C. griseus horizontalis* [F = 0.5440, df = 2,27, P = .5869], *C. griseus horizontalis* 'Santa Ana' [F = 0.2580, df = 2,27, P = .7743], *R. californica* [F = 0.0040, df = 2,27, P = .9965], *R. californica* 'Eve Case' [F = 0.3110, df = 2,27, P = .7351], or *P. fraseri* [F = N/A]).

70.27, SE = 3.51, N = 240; F = 101.91, df = 2,39, P = 0.0001) than the nonselected cultivar (mean = 153.41, SE = 6.13, N = 232). However, there were no differences (F = 2.6300, df = 1,99, P = .1080) in the visual rating between the two cultivars (*C. griseus horizontalis* [mean = 8.302, SE = .340, N = 63], *C. griseus horizontalis* 'Santa Ana' [mean = 8.050, SE = .195, N = 60]).

The growth index values were not significantly different (F = 0.17, df = 1,145, P = .6792) between the 'Eve Case' cultivar of *R. californica* (mean = 8.024, SE = 1.25, N = 51) and the nonselected cultivar (mean = 8.763, SE = 1.02, N = 117). However, tip growth of *R. californica* (mean = 26.49, SE = 2.54, N = 458) was significantly less (F = 6.5100, df = 1,39, P = 0.0148) than in the 'Eve Case' cultivar (mean = 33.46, SE = 3.52, N = 178). Reflecting the differences in growth, the visual rating of *R. californica* (mean = 4.8030, SE = 0.09, N = 111) was significantly lower than that of the 'Eve Case' cultivar (mean = 6.039, SE = .22, N = 51).

Changing the frequency of irrigation and volume of water applied at each time, but not the total volume applied over a 14 week period, had limited impact on growth, visual appearance, and survival of drought-tolerant plants. Although the growth index for *C. griseus horizontalis* was higher for the longest intervals between irrigations compared to the daily water applications, there were no differences in tip growth or appearance. In contrast, *R. californica* showed the greatest tip growth with the most frequent irrigations and the lowest for the least frequent applications. As with the other species, there were no differences in the visual ratings of plants among treatments at the end of the study.

It is entirely possible that the total volume of water applied may be a critical factor in plant performance. That is, application of excess or inadequate water relative to the requirements of the plant species may result in poor growth and increase the risk of mortality. However, the volume of water applied in the present study was within the appropriate range for the species based on the limited findings of previous work (9, 10). Thus within that range, it seems that the irrigation frequency (infrequent deep watering compared to frequent shallow watering) of these plants in managed landscapes may not be as critical an issue as species or cultivar selection.

There were no differences in mortality or visual rating between the cultivars of *C. griseus horizontalis*, but the non-selected cultivar had more growth during the study. In contrast, the non-selected cultivar of *R. californica* grew less and had a lower visual rating than did the 'Eve Case' cultivar. However, many plants of the 'Eve Case' cultivar were killed by *Phytophthora* spp. fungal root pathogens, while only a single plant of the wild-type cultivar died. The differences in mortality rates did not appear to be related to the irrigation schedule, but rather to a differential susceptibility to the pathogens. Selection for horticultural characteristics, including more rapid growth, may not have taken disease resistance into account.

Fertilization affected the growth of *R. californica* and *P. fraseri*, but not *C. griseus horizontalis* and not in the same pattern. The low rate increased the tip growth of *R. californica* relative to no fertilization, but that rate reduced tip growth of *P. fraseri* relative to no nitrogen applications. The visual ratings and the mortality rates of any species were not affected by fertilization. Under the conditions of this study, it does not appear that additional applications of nitrogen fertilizer substantially improved the performance of these species.

Although the same total volume of water was applied to all treatments (63.8% of the historical ET_0), it is likely that the results may have been very different if comparisons were made among a range of percentages of ET_0. The primary advantage of using drought-tolerant plants in landscape plantings is their reduced requirement for water and fertilizer. However, proper culture of xerophytic plants, including application of appropriate amounts of water and fertilizer, is not well understood. Although the present study was conducted under only a single set of field conditions, it suggests that failure of these species to survive in landscape culture is probably not directly attributable to the frequency of irrigation.

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Propagation of a Hawthorn Lace Bug-Resistant Cotoneaster (*Cotoneaster buxifolius*) by Stem Cuttings[1]

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Abstract

Semi-hardwood cuttings of *Cotoneaster buxifolius* Wallich ex Lindl. were treated with indolebutyric acid (IBA) at rates of 0, 2000, 4000, 6000, or 8000 ppm, and rooted in flats containing either peat:perlite (1:1 by vol) or 100% perlite. Rooting percentage, numbers of roots, and root quality were generally higher in the 100% perlite medium. The greatest numbers of roots and highest root quality were obtained with the 4000 or 6000 ppm IBA.

Index words: rooting media, rooting hormone, insect resistance

Significance to the Nursery Industry

The production of insect resistant plant material can provide an environmental emphasis for marketing strategies. A cost effective propagation procedure has been developed for the production of *Cotoneaster buxifolius*, a species resistant to hawthorn lace bug. *Cotoneaster buxifolius* can be optimally propagated under intermittent mist using a 100% horticultural perlite rooting medium. A 5 sec dip in 4000–6000 ppm IBA consistently produced the greatest number of roots, with a high percentage of the cuttings successfully rooted.

Introduction

The hawthorn lace bug, *Corythucha cydoniae* (Fitch), selectively attacks numerous plants in the family Rosaceae, and is the primary insect pest of *Cotoneaster* (13), a shrub commonly planted in urban areas. Insect feeding results in foliar injury from mechanical removal of chlorophyll. Injury appears on the new foliage in spring and, if not controlled, may result in total browning of the leaves by mid-summer. Differences in susceptibility to feeding injury caused by hawthorn lace bug were evaluated among species and cultivars of rosaceous hosts (8, 9, 10). Two species of *Cotoneaster, C. lacteus* W. W. Sm. and *C. buxifolius* Wallich ex Lindl., were identified as possessing a high level of insect resistance to hawthorn lace bug.

Cotoneaster buxifolius is spreading, evergreen, much-branched, and grows to about 3 feet high. Leaves are oval to obovate, 5–10 mm (0.25–0.5 in) long, pubescent above when young and wooly beneath (1). The young stems are covered with pale, downy hairs. The fruit is bright red, about 5 mm (0.25 in) in diameter, and remains on the plant through late winter. The pubescence of the leaves and stems gives the plant an attractive blue-gray color that, combined with the long-lasting, bright red berries provides horticultural desirability. We feel this *Cotoneaster* is currently underutilized by the nursery industry. This may be due in part to its incorrect identification as *C. glaucophyllus* in California (6).

A key factor for introduction to the nursery industry is the grower's ability to successfully propagate this species. General recommendations for rooting cuttings of *Cotoneaster* spp. include use of a sand or peat:perlite medium and treatment with 1000–3000 ppm IBA (4). However, specific recommendations for rooting of *C. buxifolius* were not found. The objective of this study was to develop a propagation procedure that could optimize successful and cost effective production of this species by the nursery industry.

Materials and Methods

Semi-hardwood cuttings were taken from a single large *C. buxifolius* shrub on November 7, 1989, and November 9, 1990. Cuttings were also taken on July 26, 1990; however, serious losses occurred due to a mist system malfunction, and the summer rooting portion of the experiment was eliminated.

The cuttings were approximately 10 cm (4 in) in length. The basal 4 cm (1.5 in) were stripped of leaves, and dipped in solutions of 0, 2000, 4000, 6000, or 8000 ppm IBA in 50% ethanol for 5 sec. The cuttings were allowed to dry for 10–15 min before inserting them into the rooting medium. The rooting medium was either peat:perlite (1:1 by vol) or 100% horticultural perlite contained in plastic flats 53 cm (21 in) × 27.5 cm (10.75 in) × 6 cm (2.5 in) deep. There were 5 flats of each medium, and 80 cuttings per flat

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