Screening Potential New Tropical Ornamentals for Alkalinity, Salinity, and Irradiance Tolerances

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Abstract

With the rapid introduction of new herbaceous or woody perennial tropical and subtropical taxa to the U.S. nursery trade for use as summer annuals, methods for quickly assessing their tolerances to various environmental stresses will be needed. Three screening methods, one each for substrate alkalinity, soil salinity, and varied irradiance levels, were tested on four tropical taxa, *Rotheca myricoides* (Hochst.) Steane & Mabb. (blue butterfly bush), *Graptophyllum pictum* (L.) Griff. (caricature plant), *Jatropha integerrima* Jacq. (firecracker jatropha), and *Chrysothemis pulchella* (Don. ex J. Sims) Desc. (dozakie), with potential for use as summer annuals. Specialized portable structures for testing irradiance levels were developed which minimized confounding of restricted air movement often associated with imposing shade treatments. Irradiance and salinity screening procedures were deemed successful, while further refinement is needed with the alkalinity screening method tested. Decreased irradiance levels suppressed flowering of *R. myricoides*, while full sun exposure decreased foliar appearance and growth of *C. pulchella*. Only *J. integerrima* showed adverse responses to elevated substrate alkalinity. *Jatropha integerrima* and *G. pictum* exhibited adaptation to a wide range of light exposures and salinity levels while maintaining attractive foliage. Although flowering of *J. integerrima* was reduced with heavy shade (66%), some flowering continued.

**Index words:** container plants, patio pots, salt tolerance, shade tolerance, container substrates, summer annuals

**Species used in this study:** *Chrysothemis pulchella*, *Graptophyllum pictum*, *Jatropha integerrima*, *Rotheca myricoides*

Significance to the Nursery Industry

Growing popularity of tropical ornamentals as summer annuals grown in patio pots, containers, or as temporary screening or massing materials is resulting in the introduction of many new plants to the U.S. nursery trade. Limited information is available concerning the cultural requirements of these taxa. Rapid methods to screen these plants for common landscape stresses would be useful for both production and marketing purposes. In addition, it would permit the quick elimination of plants from more expensive long-term replicated field evaluation for common regionally important landscape stresses. Three methods were tested on four promising tropical species which have limited use in U.S. landscapes to determine if these methods could be used as initial screening tools for differentiating irradiance (sun/shade), soil salinity, and substrate alkalinity tolerances within these taxa.

Introduction

One of the most popular current trends in landscape plant production is the use of tropical and subtropical species as summer annuals in cool temperate landscapes or root hardy perennials in warmer temperate regions (1, 3). Success in the industry with such plants as the tropical Texas SuperstarsTM, blue plumbago (*Plumbago auriculata* Lam.), gold star esparanza (*Tecoma stans* (L.) Juss. ex Kunth ‘Gold Star’), variegated tapioca (*Manihot esculenta* Crantz ‘Variegata’) and Mexican firebush (*Hamelia patens* Jacq.), has fueled the interest in marketing perennial tropicals as heat tolerant summer annuals, collectively termed as ‘per-annual’ plants (6). Independent growers, government researchers, and plant collectors are regularly introducing new species and cultivars into the trade, but often little is known about their adaptation to the specific challenges of our regional environments. Basic questions, such as the need for sun or shade exposures, tolerance to salts in irrigation water, or ability to grow in alkaline soils are often unknown. Systematic evaluations of these tolerances would allow a quick narrowing of the field of introductions to those with the greatest potential for specific markets. Once these plants are identified, they could be promoted in cooperation with the nursery and landscape industry in regional marketing and demonstration programs (6).

The objectives of this research were 1) to test methods to provide an orderly screening of new tropical plants for potential use as annuals by the regional nursery industry, with particular emphasis on screening for light requirements, alkalinity tolerances, and salinity tolerances, and 2) to obtain additional information on environmental tolerances of four promising tropical/subtropical taxa for our regional landscapes.

Materials and Methods

**Test plants.** Cuttings of *R. myricoides* and *G. pictum* were rooted on April 10, 2007. Cuttings were treated with a 1000 mg/liter-1 (1000 ppm) IBA (indole butyric acid formulated as Hormodin 1, E.C. Geiger, Inc., Harleysville, PA) and were placed in 36 × 51 × 10 cm (14 × 20 × 4 in) deep flats (Kadon Corp., Dayton, OH) filled with Metro-Mix 700 (SunGro Horticulture, Bellevue, WA). Flats were placed under an intermittent mist (15 sec dawn to dusk).
Irradiance screenings. Liners of *G. pictum, R. myricoides, J. integerrima,* and *C. pulchella* were planted on 1 m (3.3 ft) spacings under three levels of shade, i.e. full sun, 33% light exclusion, or 66% light exclusion, on May 21, 2007. Plants were planted in raised beds containing approximately a 30 cm (12 in) depth of sandy loam topsoil. Shade treatments were imposed by constructing a frame of 3.2 cm (1.25 in) inside diameter steel gas pipe and malleable cast-iron slip on pipe fittings (Kee Klamp, Grainger Inc., Bryan, TX) which supported a black woven shade cloth (DeWitt, Sikeston, MO). The shade structures (5) were enclosed on the east, south, and west sides, but were open on the north side. The top was suspended slightly above the sides [15.2 cm (6 in) on north side, 30.5 cm (12 in) on south side] and over hung [30.5 cm (12 in) on south side, 145 cm (57 in) tall on the north side, 30.5 cm (12 in) on south side] and allowed for ventilation while minimizing gaps in the shade. Overall dimensions of each structure were: height on the south side, 145 cm (57 in) tall on the north side, the south and north sides are 244 cm (96 in) wide and the east and west sides are 305 cm (120 in) long (Fig. 1). All four sides were raised approximately 10.2 cm (4 in) above the soil to permit ground level air flow. Each shade treatment was replicated twice, once in each of the two raised beds used in the study. Four individual plants of each taxa were included within each of the shade replicates, a total of eight plants of each taxa per shade treatment. Within each shade treatment, the plants of a given species were grouped together to avoid mutual shading beyond that of the imposed treatment due to potential differential growth rates among species, thus each species was treated as a concurrent but separate experiment. The statistical model for each species was three shade levels × three dates × two blocks with four replicates per block. Variation associated with differences among shade structures were partitioned into blocking effects during analysis.

Irrigation was provided as needed to maintain plants in a turgid state from commercial drip tape (T-Tape®, T-Systems International Inc., San Diego, CA). At planting on May 21, 2007, mid-summer on August 14, 2007, and in late fall on November 7, 2007, measures of plant height, canopy spread (diameter in widest and narrowest directions), and in florescence counts were recorded. An estimate of canopy volume was made by multiplying the height × widest canopy diameter × narrowest canopy diameter. Light levels (Linear PAR/LAI ceptometer, Model PAR-80, Decagon Devices, Inc., Pullman, WA) were determined in three locations for each replicate of the shade treatments at three heights, just above the canopy, at mid-level canopy [76 cm (30 in)], and at the soil surface beneath the canopy (six total measurements per level beneath each shade treatment) on August 31, 2007.

**Salinity screenings.** The salinity screening study was initiated on May 30, 2007. NaCl (Mallinkrodt Chemicals, Phillipsburg, NJ) and CaCl₂ (EM Science, Gibbstown, NJ) were used in a ratio of 2:1 as a salinity source which was applied in the water at each irrigation. Treatment levels were based on Miyamoto et al. (9) and Denny (7) and included a control with no 2NaCl:1CaCl₂, a low 2NaCl:1CaCl₂ concentration [2000 mg·liter⁻¹ (2000 ppm)], an intermediate 2NaCl:1CaCl₂ concentration [4000 mg·liter⁻¹ (4000 ppm)], and a high 2NaCl:1CaCl₂ concentration [8000 mg·liter⁻¹ (8000 ppm)]. This produced irrigation solutions with the following electrical conductivities: 0.2, 3.9, 6.9, and 12.0 mS·cm⁻¹, respectively. The water source for the solutions was tap water treated with reverse osmosis to remove most background salinity. Each 2.5 liter container received two 250 mL applications of solution per irrigation beneath the foliage canopy, resulting in substrate salt exposure, but not foliar exposure. This yielded approximately a 25% leaching fraction per irrigation.

Plants were arranged in a completely randomized design with 5 replicates in each species per treatment. Each species represented concurrently conducted independent experiments located on adjacent benches in a greenhouse with 26.7/23.9°C (75/80°F) day/night temperature set points. Height and canopy diameters at the widest and narrowest locations were recorded at the beginning and end of the study. A canopy volume estimate was calculated as using these measures as previously described. Shoot fresh mass and shoot root dry masses were measured at the end of the study. The percentage of the foliage in the canopy with salt injury symptoms (chlorosis, cupping, necrotic margins) were also estimated at harvest on August 13, 2007. Samples of the substrate were collected at the end of the study and EC and pH were measured using a 2:1 soil-water extraction method described by Richards (10).
Alkalinity screenings. Rooted cuttings of *R. myricoides* and *G. pictum* and liners of *J. intergerrima* were transplanted on May 21, 2007, into 2.5 liter containers (Nursery Supplies, Inc., Kissimmee, FL) filled with pine bark:coarse perlite (3:1, by vol) mix amended with 8.31 kg m\(^{-3}\) (14 lb yd\(^{-3}\)) 18N-2.6P-9.9K controlled-release fertilizer (Osmocote® Classic, Scotts Company, Marysville, OH), and 2.37 kg m\(^{-3}\) (4.0 lb yd\(^{-3}\)) CaSO\(_4\) (United States Gypsum Co., Chicago, IL). Plants were grown outdoors under 55% light exclusion in a nursery area and irrigated as needed. CaMgCO\(_3\) (Oldcastle Stone Products, Thomasville, PA) was used as an alkalinity source and was incorporated into the substrate prior to planting. The treatment levels of CaMgCO\(_3\) were 4.75, 7.12, 9.49, and 11.87 kg m\(^{-3}\) (8.0, 12, 16, and 20 lb yd\(^{-3}\), respectively). Each species represented a separate experiment which were run concurrently in adjacent plots, but not intermixed. Plants were arranged within an experiment in a completely randomized design with five replications of each species per treatment.

Height and diameter measurements were recorded at the initiation and termination of the experiment and dry masses of roots and shoots were measured at the end of the study on August 3, 2007. A subjective evaluation of foliar chlorosis was taken immediately before the study was harvested. The ratings were based on a four point scale: 1 – very chlorotic, 2 – slightly chlorotic, 3 – green, 4 – very green. Pooled subsamples of the substrate were collected at the end of the study and EC and pH were measured using a 2:1 soil-water extraction method described by Richards (10).

In all three experiments, quantitative measures were analyzed using the general linear regression procedures and means compared using least squares means pairwise comparisons in SAS version 9.1 for Windows (11). Percentage data were transformed to approximate a more normal distribution prior to analysis. Qualitative ratings for foliar chlorosis were analyzed using Chi-squares procedures.

Results and Discussion

Irradiance screenings. Shading treatments resulted in the desired light reductions to approximately two thirds and one third of full sunlight at the upper surface of the plant canopies, as measured by wavelengths of light consistent with photosynthetic activity (Fig. 2). Irradiance levels reduced in a nearly linear fashion to two thirds or half that of full sunlight at the upper surface of the plant canopies near ground level (Fig. 2). This reduction in irradiance levels would be expected as light passes through the plant canopies.

For *G. pictum* there was a significant (P ≤ 0.05) interaction among shade levels and time in the landscape, but not for canopy volume (Table 1). No inflorescences were produced on *G. pictum* during the study (Table 1), which is consistent with its use primarily as a variegated foliage plant when grown in annual outdoor plantings (3). Although height growth was greater over time with *G. pictum* grown in the shaded treatments than in full sun (Table 1), only slight differences in canopy volume occurred (Table 1), which is consistent with anecdotal reports of consistent growth of *G. pictum* across a wide range of light exposures (3).

Shade by date interactions were present for *R. myricoides* for canopy volume and inflorescence numbers, but only the main effect of date was significant (P ≤ 0.05) for plant height (Table 2). During summer *R. myricoides* grew to similar canopy volumes in shade as in full sun, but later in fall plants had larger canopy volumes in 66% shade than in full sun or the lighter 33% shade (Table 1). Conversely, *R. myricoides* inflorescence production was reduced progressively by increasing shade levels (Table 1), such that by the end of the season even though *R. myricoides* grown in shade had larger canopy volumes they produced substantially less flowers. Flowering of *R. myricoides* in the lightest shade treatment was half of that in full sun and was less than one third of that in full sun with the denser 66% shade treatment.

With *J. intergerrima* there were significant shade level by date interactions for height, canopy volume, and inflorescence number (Table 1). Initially height and canopy volume growth were similar for *J. intergerrima* under all three shade treatments, but later in the season the full sun and 33% shade treatments slightly reduced height growth and nearly halved canopy volume (Table 1). Flowering of *J. intergerrima* was unaffected by the lighter 33% shade treatment, but was substantially reduced by the denser shade treatment, especially later in the year (Table 1). This is consistent with landscape observations which indicate *J. intergerrima* continues to flower in partial shade all season (3), year-round in the tropics (8), being reduced only by very low light levels or cold temperatures (3).

Height of *C. pulchella* was statistically unaffected (P ≤ 0.05) by shade treatments, but increased in summer, then plants died back to the ground in fall as temperatures declined (Table 1), whereas an interaction among shade levels and date was present for canopy volume and inflorescence number. *C. pulchella* had three times as large a canopy in summer under 66% shade as compared to plants grown in full sun, with intermediate sizes under 33% shade (Table 1). However, the number of inflorescences produced was more than twice as much under 66% shade than in full sun, but by late fall no plants had flowers as the foliage was dying back due to lower temperatures. This data is consistent with anecdotal recommendations for placing *C. pulchella* in shady landscape locations (3, 12). The foliage of *C. pulchella* also appeared somewhat bleached or faded in full sun compared to shaded plants (Fig. 3).
Table 1. Effects of 0% (full sun), 33%, or 66% light exclusion on the growth and flowering of *Graptophyllum pictum*, *Rotheca myricoides*, *Jatropha integerrima*, and *Chrysothemis pulchella* outdoors in a sandy loam soil in College Station, Texas. Values represent means of observations from eight plants.

| Shade (%) | Date   | *G. pictum* |          |          | *R. myricoides* |          |          | *J. integerrima* |          | *C. pulchella* |          |
|-----------|--------|-------------|----------|----------|----------------|----------|----------|-----------------|----------|--------------|----------|
|           |        | Height (cm) | Canopy volume (cm$^3$) | Inflorescences (# per plant) | Height (cm) | Canopy volume (cm$^3$) | Inflorescences (# per plant) | Height (cm) | Canopy volume (cm$^3$) | Inflorescences (# per plant) | Height (cm) | Canopy volume (cm$^3$) | Inflorescences (# per plant) |
| 0         | May    | 32.5d       | 29847cd  | 0a       | 37.0c          | 63588d   | 0e       | 19.3d          | 6315d   | 0.0e         | 14.0c    |
| August    | 74.8e  | 175849b     | 66183b   | 0a       | 112.0b         | 942387c | 23.5c    | 72.3c          | 884386c | 5.7b         | 24.0b    |
| November  | 0.0e   | 0d          | 0a       | 0.0      | 190.3a         | 3806057b | 40.2a    | 127.8a         | 489883a | 12.5a        | 0.0      |
| 33        | May    | 34.7d       | 41505c   | 0a       | 34.8c          | 746576c | 0e       | 18.3d          | 48810d   | 0.0d        | 16.8c    |
| August    | 81.0b  | 221933a     | 68153a   | 0a       | 113.3b         | 947907c | 11.2d    | 72.3c          | 114601c | 5.7b         | 28.5b    |
| November  | 0.0e   | 0d          | 0a       | 0.0      | 178.0a         | 3372200b | 30.3b    | 129.5a         | 54361a   | 13.2a       | 0.0      |
| 66        | May    | 35.0d       | 41517c   | 0a       | 33.7c          | 68498d  | 0e       | 20.5d          | 7231d    | 0.0d        | 17.0c    |
| August    | 89.8a  | 240286a     | 64036a   | 0a       | 111.5a         | 860756e | 2.5e     | 78.6e          | 113317c | 3.8bc       | 30.2a    |
| November  | 0.0e   | 0d          | 0a       | 0.0      | 180.0a         | 4543970b | 13.2d    | 119.8b         | 261168b  | 3.2c        | 0.0      |

Partial ANOVA effects:

- Shade: ***
- Date: ***
- Shade × date: ***

Canopy volume estimated as height × widest width × narrowest width. Y Means followed by the same letter within a species and column do not differ significantly at \( P \leq 0.05 \) using least squares means procedures. **ns, *, **, *** indicates that the analysis of variance effect for the variable indicated by the column is not significant (ns) or is significant at \( P \leq 0.05, 0.01, \text{or } 0.001 \), respectively.
9.49 kg·m⁻³ (12 to 16 lb·yd⁻³) resulted in increases in height, canopy volume, and some dry masses for *G. pictum* (Table 3), suggesting that *G. pictum* may be tolerant of alkaline substrates. *R. myricoides* had increased height, canopy volume and some dry mass accumulation in substrates with intermediate CaMgCO₃ concentrations (Table 3), suggesting that this species may also be tolerant of alkaline substrates.

Increasing levels of CaMgCO₃ in the substrate, reduced nearly all growth measures with *J. integerrima* (Table 3), however, plants did not exhibit any visible foliar chlorosis or symptoms of nutrient deficiency.

The lack of severe reactions to the alkalinity treatments may have been related to increased leaching due to the greater rainfall than normal, 36.6 cm (14.4 in) actual versus 19.1 cm (7.5 in) average for the period. Alkalinity levels were not well correlated with changes in substrate pH by the end of the study (data not presented), suggesting that better screening techniques are needed to separate the effects of substrate pH and substrate alkalinity.

The shade and salinity screening methods developed in this study appear to be useful to provide comparative estimates of irradiance and substrate salinity tolerances for new landscape taxa. Salinity or shade screening methods used allowed statistical separation among treatments in response to differential salinity or shade levels. While relative responses to salinity exposure can be determined with these methods, landscape responses would need to be documented for possible interactions with local soil and climatic conditions. Alkalinity screening methods will require additional development as current methods were subject to leaching under high rainfall conditions and a more reliable technique is needed for large scale screening.

### Table 2. Effects of irrigation with 0, 2000, 4000, or 8000 mg·liter⁻¹ (ppm) ratio of NaCl:CaCl₂ (2:1) on the growth of *Graptophyllum pictum*, *Rotheca myricoides*, and *Jatropha integerrima*. Values represent means of observations from five plants.

| Species         | Salt (mg·liter⁻¹) | Height (cm) | Canopy volume (cm³) | Foliar damage (% canopy) | Shoot (mg) | Root (mg) | Total (mg) | Root:Shoot (mg·mg⁻¹) |
|-----------------|-------------------|-------------|---------------------|--------------------------|-------------|------------|------------|----------------------|
| *G. pictum*     | 0                 | 47.6a       | 81590a              | 0a                       | 26.1a       | 10.0a      | 36.1a      | 0.38a                |
|                 | 2000              | 44.8a       | 90637a              | 0a                       | 28.5a       | 6.7b       | 35.2a      | 0.23b                |
|                 | 4000              | 36.4b       | 63432b              | 0a                       | 25.5a       | 5.5b       | 30.9a      | 0.21b                |
|                 | 8000              | 32.2b       | 37643c              | 0a                       | 14.6b       | 2.6c       | 17.2b      | 0.19b                |
| *R. myricoides* | 0                 | 53.2a       | 186878a             | 0c                       | 20.9a       | 4.8a       | 25.6a      | 0.30a                |
|                 | 2000              | 47.4a       | 115647b             | 0c                       | 20.6a       | 6.9a       | 27.6a      | 0.33a                |
|                 | 4000              | 47.2a       | 125859b             | 10b                      | 27.8a       | 8.4a       | 36.2a      | 0.29a                |
|                 | 8000              | 28.6b       | 36219c              | 80a                      | 16.2a       | 4.3a       | 20.5a      | 0.27a                |
| *J. integerrima*| 0                 | 56.8a       | 121540a             | 0a                       | 32.2a       | 6.0a       | 38.2a      | 0.18a                |
|                 | 2000              | 54.8a       | 78055ab             | 0a                       | 26.1a       | 7.1a       | 33.3a      | 0.26a                |
|                 | 4000              | 44.4a       | 50966b              | 0a                       | 29.7a       | 6.2a       | 35.9a      | 0.20a                |
|                 | 8000              | 44.4a       | 45979b              | 0a                       | 38.3a       | 5.3a       | 43.5a      | 0.15a                |

ANOVA effects of salt concentration:

- *G. pictum*: *** *** ns *** *** *** **
- *R. myricoides*: *** *** *** ns ns ns ns ns
- *J. integerrima*: ns * ns ns ns ns ns

Canopy volume estimated as height × widest width × narrowest width.

Means followed by the same letter within a species and column do not differ significantly at *P* ≤ 0.05 using least squares means procedures.

ns, *, **, *** indicates the analysis of variance effect for the species and variable indicated by the column is not significant (ns) or is significant at *P* ≤ 0.05, 0.01, or 0.001, respectively.

Fig. 3. *Chrysothemis pulchella* grown in a landscape setting under 66% light exclusion (A) remained a darker green and grew more vigorously than the same species grown in full sun (B). Note the bleached paler appearance of the foliage in full sun (B).
Table 3. Effects of increasing alkalinity (in form of CaMgCO$_3$) from 4.75, 7.12, 9.49, to 11.87 kg m$^{-3}$ in the substrate on the growth of Graptophyllum pictum, Rotheca myricoides, and Jatropha integerrima. Values represent means of observations from five plants.

| Species            | Alkalinity as CaMgCO$_3$ (kg m$^{-3}$) | Height (cm) | Canopy volume$^c$ (cm$^3$) | Shoot Dry mass (mg) | Root Dry mass (mg) | Total Dry mass (mg) |
|--------------------|---------------------------------------|-------------|-----------------------------|---------------------|-------------------|--------------------|
| C. pulchella       | 4.75                                  | 19.4a       | 36.378a                     | 8.13a               | 5.41a             | 13.53a             |
|                    | 7.12                                  | 16.4a       | 27.151a                     | 6.12a               | 4.68a             | 10.79a             |
|                    | 9.49                                  | 16.0a       | 18.448a                     | 4.31a               | 3.35a             | 7.66a              |
|                    | 11.87                                 | 16.4a       | 18.954a                     | 6.32a               | 4.22a             | 10.54a             |
| G. pictum          | 4.75                                  | 22.0c       | 14.841b                     | 6.07bc              | 2.41b             | 8.48b              |
|                    | 7.12                                  | 25.2b       | 20.213b                     | 7.97ab              | 3.82a             | 11.80a             |
|                    | 9.49                                  | 30.4a       | 27.062a                     | 8.47a               | 4.39a             | 12.86a             |
|                    | 11.87                                 | 19.0c       | 16.674b                     | 4.90c               | 2.25b             | 7.15b              |
| R. myricoides      | 4.75                                  | 7.2c        | 996b                         | 8.84a               | 3.08a             | 11.91a             |
|                    | 7.12                                  | 9.6bc       | 1,333ab                      | 9.70a               | 3.34a             | 13.03a             |
|                    | 9.49                                  | 10.6b       | 1,075ab                      | 6.15b               | 2.34a             | 8.49b              |
|                    | 11.87                                 | 15.0a       | 1,705a                       | 7.92ab              | 3.11a             | 11.04ab            |
| J. integerrima     | 4.75                                  | 53.0a       | 94,446a                      | 28.58a              | 5.20a             | 33.78a             |
|                    | 7.12                                  | 50.0a       | 74,685ab                     | 23.83a              | 5.03ab            | 28.86b             |
|                    | 9.49                                  | 51.8a       | 54,887bc                     | 18.17ac             | 4.39a             | 22.56a             |
|                    | 11.87                                 | 45.4a       | 74,685ab                     | 18.17ac             | 4.39a             | 22.56a             |

ANOVA effects of CaMgCO$_3$ concentration by species:

- *G. pictum* ***
- *R. myricoides* ***
- *J. integerrima* ns
- *C. pulchella* ns

$^c$Canopy volume estimated as height × widest width × narrowest width.

$^a$Means followed by the same letter within a species and column do not differ significantly at $P \leq 0.05$ using least squares means procedures.

ns, *, **, *** indicates the analysis of variance effect for the species and variable indicated by the column is not significant (ns) or is significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

Solid information was obtained on four promising tropical taxa for use as summer annuals or perennials in USDA cold hardiness zone 8b. Only *J. integerrima* showed adverse responses to elevated substrate alkalinity. *J. integerrima* and *G. pictum* exhibited adaptation to a wide range of light exposures and salinity levels while maintaining attractive foliage. Although flowering of *J. integerrima* was reduced with heavy shade, flowering did continue. Based in part on these attributes and responses at other trial sites throughout the region, *J. integerrima* was named a Texas Superstar® plant in 2007 (2) and *G. pictum* in 2009 (4) by the Coordinated Education and Marketing Assistance Program (6), the region’s cooperative university and industry plant trialing and promotion organization.

*Rotheca myricoides* exhibited good growth and strong flowering in full sun conditions, but should be used with caution in heavy shade or where salinity might be elevated in irrigation water. *C. pulchella* exhibited a strong potential for flowering in dense (66%) shade, but had poor growth and foliar characteristics, as well as reduced flowering, in full sun conditions. *C. pulchella* was also the slowest grower of the four species and appears to be highly susceptible to chilling damage as temperatures decline in autumn. *G. pictum* was also injured by chilling temperatures in autumn.

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