Saline Irrigation of Five Diverse Landscape Species for the Southeastern United States©[1]

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Greywater is a recycled water source that can help reduce the demand for potable water. Use of greywater for irrigation is limited by a primary contaminant, sodium chloride (NaCl). Research was conducted to evaluate five landscape species for tolerance of saline irrigation. Species used were *Illicium parviflorum*, *Itea virginica* 'Henry's Garnet,' *Muhlenbergia capillaris*, *Portulaca oleracea*. 'Big Bloom Red' and *Begonia* Semperflorens Cultorum Group Cocktail®, Whisky® wax leaf begonia. Plants were irrigated with tap water containing one of the following concentrations of NaCl: 0, 2000, 4000, 6000, 8000, or 10000 mg·L^{-1}. *Portulaca oleracea* and *Begonia* Semperflorens Cultorum Group were harvested after 6 weeks. Three replications from the remaining species were harvested after 5 and 10 weeks, and the final four replications were harvested after 15 weeks. Root dry weight (RDW) and shoot dry weight (SDW) were determined at each harvest; survival was determined at experiment termination. Root dry weight and SDW of *I. parviflorum, I. virginica, P. oleracea*, and *Begonia* decreased linearly with increasing NaCl conc, at each harvest. RDW of *M. capillaris* decreased with increasing NaCl conc 10 and 15 weeks after treatment initiation however; there was no effect of NaCl concentration on SDW of *M. capillaris* 10 and 15 weeks after treatment initiation. *I. virginica* exhibited foliar damage at the lowest NaCl conc. Plant mortality occurred for *I. virginica* which had 0% survival in 8000 and 10000 ppm (mg·L^{-1}) NaCl treatments at 15 weeks, while *Begonia* Semperflorens Cultorum Group had foliar damage at 6000 ppm (mg·L^{-1}) and mortality at 6000 ppm (mg·L^{-1}) (90% mortality) and 10000 ppm (mg·L^{-1}) (50% mortality). All species evaluated, except *I. virginica*, were tolerant of saline irrigation that could be expected from greywater.

INTRODUCTION

Water reuse has become increasingly important recently due to population increase and drought. In the United States water consumption increases by 40-60% in summer months due to landscape irrigation (Kjeldren et al., 2000). The potential exists to reduce potable water consumption by supplementing it with recycled greywater. Greywater is defined as wastewater without any input from toilets; this includes water produced from bathtubs, showers, hand basins, laundry machines, and kitchen sinks. Greywater is thus less polluted than combined wastewater due to the absence of feces, urine, and toilet paper (Eriksson et al., 2002). The reuse of greywater shows the most promise when used for irrigation. Sodium chloride (NaCl) is one of the primary contaminants in greywater, potentially limiting greywater as an irrigation source. While it is understood that greywater contains high salinity, limited research has been done to study the effects of saline greywater on landscape plants. Salinity tolerance evaluation has been conducted on landscape plant species however this research has primarily been conducted in the arid climate of the American south west (Marcotte et al., 2004; Miyamoto et al., 2004; Niu et al., 2007, 2012; Niu and Rodriguez, 2006; Wu et al., 2001).

Miyamoto et al. (2004) studied the ability of common landscape plants of the southwest United States to withstand soil salinity. The plants were irrigated with one of five levels of salinity (predominantly NaCl): 800, 2000, 5000, 7500, and 10000 mg·L^{-1}, for 6 months to determine which level of salinity caused a 50% reduction in growth. Results identified several highly salt tolerant species that are common in landscapes of the southeastern United States. These species include: *Cynodon dactylon* L. (Bermuda grass),

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Stenotaphrum secundatum Walt. (St. Augustine grass), *Phoenix canariensis* Chabaud (Canary Island date palm), *Phoenix dactylifera* L. (date palm) and *Carpobrotus chilensis* (Molina) N.E. Br. (ice plant).

Niu et al. (2012) evaluated six cultivars of *Zinnia marylandica* (D.M. Spooner et al., 1991) and one cultivar of *Z. maritima* Kunth for tolerance of saline irrigation in two different experiments. Treatments consisted of nutrient saline irrigation with 1.4 (control), 3.0, 4.2, 6.0, or 8.2 $dS \cdot m^{-1}$ electrical conductivity (EC) solutions made from a combination of sodium chloride, magnesium sulfate, and calcium chloride at a ratio of 87:8:5. No cultivar survived treatments of 6.0 or 8.2 $dS \cdot m^{-1}$ and there was a reduction in size and shoot dry weight with increasing treatment level. Based on these results the authors determined that *Zinnia* cultivars used in this experiment were not tolerant of saline irrigation and should not be used in areas with high soil salt concentration or areas receiving saline irrigation.

Greywater irrigation can provide homeowners and municipalities with an alternative use for this water resource; however, few landscape species have been studied to determine the possible side effects of greywater. If greywater is to be used as an irrigation source for landscapes it is necessary to identify plants that are tolerant of salinity from greywater. Therefore, the objective of this research was to evaluate the tolerance of five native landscape plants to saline irrigation water.

MATERIALS AND METHODS

Liners [2 in. (5.1 cm)] of *Illicium parviflorum* Michx. ex Vent. (small anise tree), *Itea virginica* L. 'Henry's Garnet' (Virginia sweetspire), *Muhlenbergia capillaris* (Lam.) Trin. (pink muhly grass), *Portulaca oleracea* L. 'Big Bloom Red' (purslane), and *Begonia* x Semperflorens Cultorum Group hort. Cocktail® Whisky® wax leaf begonia were planted in 2.5 L (trade gallon) containers in a pinebark, peat and perlite (5:3:1, by vol.) substrate. Substrate was pre-plant amended with 9.1 $lb \cdot yd^{-3}$ (4.5 $kg \cdot m^{-3}$) controlled released fertilizer [Polyon with micros 17N-5P_2O_5-11K_2O (Harrel's LLC, Lakeland, FL)], and dolomitic limestone [4 $lb \cdot yd^{-3}$ (1.8 $kg \cdot m^{-3}$)]. Plants were irrigated by hand daily with 10.1 oz (300 ml) of tap water containing one of the following concentrations (treatments) of sodium chloride (NaCl): 0 (tap water), 2,000, 4,000, 6,000, 8,000, or 10,000 ppm ($mg \cdot L^{-1}$). While these rates are much higher than normally found in greywater [Na 7.4-480 ppm ($mg \cdot L^{-1}$), Cl 9-88 ppm ($mg \cdot L^{-1}$)] they are intended to test higher levels of salt tolerance so that this research could be applicable to other saline irrigation sources (Christova-Boal et al., 1996; Eriksson et al., 2002). Plants received tap water only (no NaCl) irrigation on weekends. Treatments on *I. parviflorum*, *I. virginica*, and *M. capillaris* were initiated on 20 June 2011 and terminated on 30 September 2011. Treatments on *B.* Semperflorens Cultorum Group and *P. oleracea* were initiated on 11 July 2011 and terminated on 22 August 2011. Plants were grown under natural photoperiod on raised benches in a greenhouse at Paterson Horticulture Greenhouse Complex at Auburn University in Auburn, Alabama.

There were ten single container replications per treatment per species. Experimental design was a completely randomized design with each species representing a separate experiment. In regards to *I. parviflorum*, *I. virginica*, and *M. capillaris* three plants of each species in each treatment were harvested five and ten weeks after treatment initiation, and the remaining plants (n=4) were harvested fifteen weeks after treatment initiation (experiment termination). In regards to *B.* Semperflorens Cultorum Group and *P. oleracea* all ten replications were harvested at 6 weeks after treatment initiation (experiment termination). Root dry weight (RDW) and shoot dry weight (SDW) were determined at each harvest. Data were subjected to analysis of variance and regression analysis using PROC GLM in SAS (SAS Institute, Cary, North Carolina).

RESULTS

Root dry weight (RDW) and shoot dry weight (SDW) of *I. parviflorum*, *I. virginica*, *P. oleracea*, and *B.* × Semperflorens Cultorum Group decreased linearly with increasing

NaCl concentration (Figs. 1, 2, and 3). While RDW and SDW of *M. capillaris* decreased with increasing NaCl over the first 5 weeks of treatment, there was no effect of NaCl concentration on SDW of *M. capillaris* 10 and 15 weeks after treatment initiation. Root dry weight of *M. capillaris* did decrease with increasing NaCl concentration 10 and 15 weeks while there was no effect of treatment on RDW at 5 weeks after treatment initiation. Despite decreasing with increasing NaCl concentration, RDW and SDW of *I. parviflorum* and *M. capillaris* did increase between harvest dates indicating both species continued to grow while receiving saline irrigation (Figs. 1 and 2). For *I. virginica*, only RDW increased over time, and this was only at lower NaCl concentrations (Figs. 1 and 2). Foliar damage was observed in *I. virginica* at lowest treatment level [(2000 ppm ($mg \cdot L^{-1}$)] (personal observation). Plant mortality occurred for *I. virginica* which had 0% survival in 8,000 and 10,000 ppm ($mg \cdot L^{-1}$) NaCl treatments at 15 weeks (Figs. 1 and 2). *Begonia* × Semperflorens Cultorum Group had foliar damage at 6,000 ppm ($mg \cdot L^{-1}$) and mortality at 6,000 ppm ($mg \cdot L^{-1}$) (90% mortality) and 10,000 ppm ($mg \cdot L^{-1}$) (50% mortality) (Fig. 3). While there was a reduction in RDW and SDW with increasing NaCl concentration for *P. oleracea*, there were no visible signs of salt stress (Fig. 3). *Muhlenbergia capillaris*, *I. parviflorum*, and *P. oleracea* had 100% survival even at NaCl irrigation rates of up to 20 times higher than generally found in greywater (Christova-Boal et al., 1996; Eriksson et al., 2002). This is likely due to their native habitats' proximity to saline environments (Dirr, 1998; Schroeder et al., 1976). Of the species evaluated, all species, except *I. virginica*, were tolerant of saline irrigation that occurs with greywater.

DISCUSSION

Previous research demonstrates that root zone salinity reduces the ability of plants to take up water, and this causes reductions in growth rate along with a suite of metabolic changes identical to those caused by water stress (Munns, 2002; Niu and Cabrerea, 2010; Wu et al., 2002). Watling (2007) suggested that plants that can tolerate saline irrigation levels of 2,000-3,000 ppm ($mg \cdot L^{-1}$) are considered to be salt tolerant. Under this criteria *I. parviflorum*, *M. capillaris*, *P. oleracea*, and *B.* Semperflorens Cultorum Group are all salt tolerant, whereas *I. virginica* is not. Additional research to identify landscape species that are salt tolerant will allow for greater utilization of greywater for landscape irrigation as well as other saline irrigation sources.

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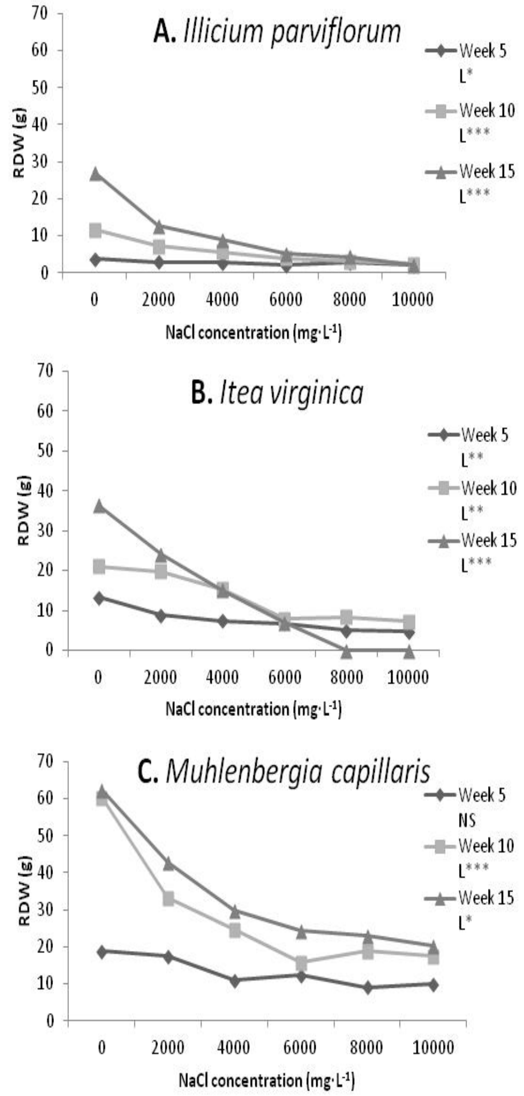

Fig. 1. Effect of NaCl concentration in irrigation water on root dry weight (RDW) of (A) *Illicium parviflorum*, (B) *Itea virginica*, and (C) *Muhlenbergia capillaris* grown in a greenhouse in Auburn, Alabama and harvested at 5, 10, and 15 weeks after treatment initiation. Data were subjected to regression analysis using PROC GLM in SAS (SAS Institute, Cary, North Carolina).

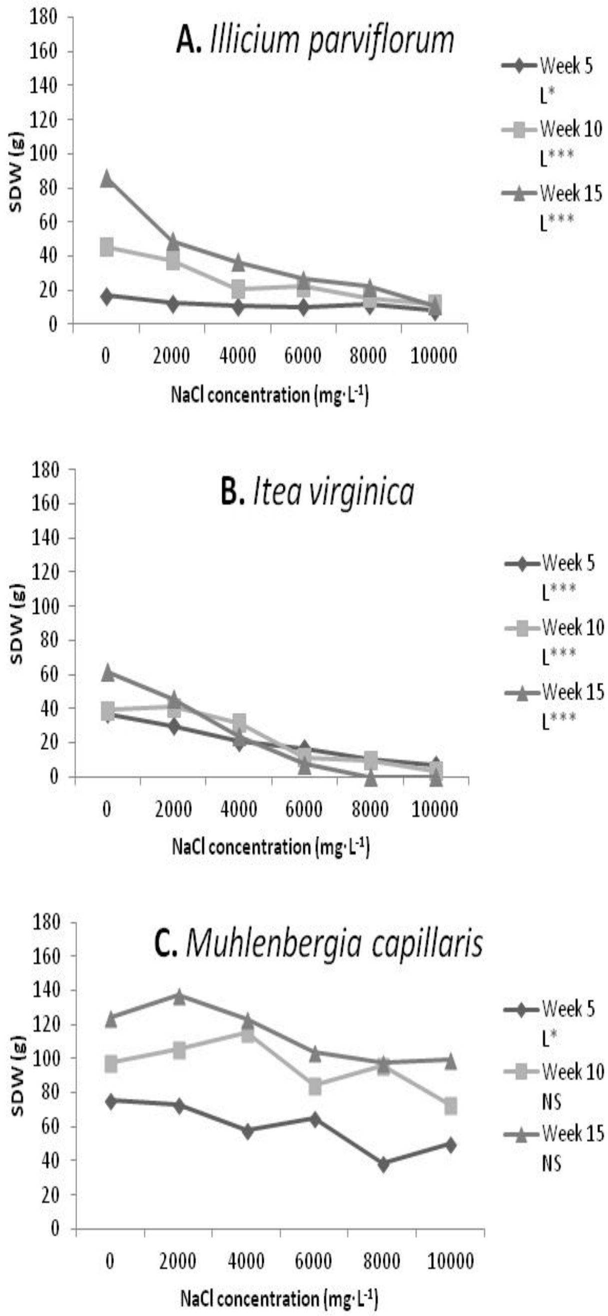

Fig. 2. Effect of NaCl concentration in irrigation water on shoot dry weight (SDW) of (A) *Illicium parviflorum*, (B) *Itea virginica,* and (C) *Muhlenbergia capillaris* grown in a greenhouse in Auburn, Alabama and harvested at 5, 10, and 15 weeks after treatment initiation. Data were subjected to regression analysis using PROC GLM in SAS (SAS Institute, Cary, North Carolina).

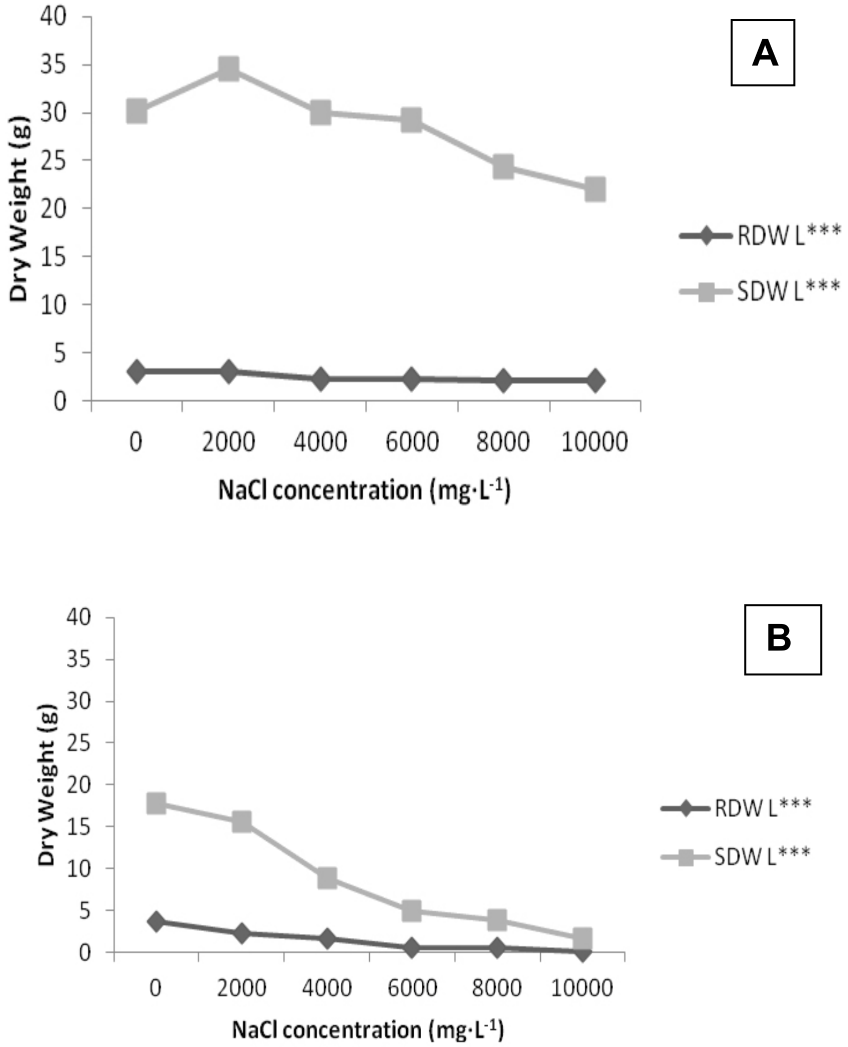

Fig. 3. Effect of NaCl concentration in irrigation water on shoot dry weight (SDW) of (A) *Portulaca oleracea* and (B) *Begonia* Semperflorens Cultorum Group grown in a greenhouse in Auburn, Alabama and harvested at 6 weeks after treatment initiation. Data were subjected to regression analysis using PROC GLM in SAS (SAS Institute, Cary, North Carolina).