Effects of Varying Water Quality on Growth and Appearance of Landscape Plants[1]

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Abstract

Increasing demand for limited water supplies in populated arid regions over the next decade may require implementation of new water-use practices. Eliminating use of high-quality water for landscape irrigation by using low-quality water delivered through secondary systems is an ideal option for conserving potable water. However, irrigation of woody landscape plants using waters high in inorganic salts may adversely affect soil fertility, structure, plant growth and appearance. Twelve woody ornamentals commonly used in landscapes in Salt Lake County, Utah, were treated with three blends of Utah Lake and Provo River water to assess the quality of plants produced.

Three irrigation treatments, designated high-, medium-, and low-quality water were blended to maintain sodium concentrations of 15, 80 and 120 mg/liter respectively. Soils irrigated with medium- and low-quality water developed significantly higher adjusted sodium absorption ratio (SAR) and salinity than soils irrigated with high quality water and the effect varied with time. Except for four species, medium- and low-quality water did not significantly lower scores for plant appearance. Results of this two-year study support development of secondary water systems and use of lower-quality water for landscape irrigation.

Index words: electrical conductivity, secondary irrigation system, water-quality, woody landscape plants.

Species used in this study: Japanese black pine (*Pinus densiflora* Sieb. & Zucc.); thornless honey locust (*Gleditsia tricanthos* var. *inermis* Willd.); purple leaf flowering plum (*Prunus cerasifera atropurpurea* Dipp.); barberry (*Berberis thunbergii* var. *atropurpurea* Jaeg.); Austrian pine (*Pinus nigra* Arnold.); green ash (*Fraxinus pennsylvanica* var. *lanceolata* (Borkh.) Sarg.); 'Aristocrat' pear (*Pyrus calleryana* Decne.); Japanese yew (*Taxus cuspidata* Sieb. & Zucc.); Colorado blue spruce (*Picea pungens* Engelm.); little-leaf linden (*Tilia europaea* L.); Chinese 'Pfitzer' juniper (*Juniperus chinensis* var. *pfitzeriana* Spaeth.); Japanese euonymus (*Euonymus japonica* L.).

Significance to the Nursery Industry

In arid regions, where secondary systems must be implemented to conserve culinary water and make use of non-potable water sources for nursery production and landscape irrigation, understanding the limitations of landscape plants to irrigation with low-quality water is critical. Effects of low-quality water on woody landscape plants in this study indicate some variation in growth and appearance from one species to another. Understanding specific plant responses will allow growers using non-potable water to select plant material able to tolerate the high levels of inorganic salts without reducing marketability. In this study, growth and appearance of twelve species was not reduced by use of medium-quality water (80 mg Na/liter; EC = 0.98 ds/m) when compared with growth and appearance of plants irrigated with high-quality, potable, water (15 mg Na/liter; EC = 0.30 ds/m). Irrigation with low-quality water (120 mg Na/liter; EC = 2.10 ds/m) reduced the height of yew and juniper, and the appearance of ash, linden, euonymus and yew while improving growth of honey locust when compared with control plants. All species used in this study have been recommended for use when salinity of water is lower than 0.98 ds/m. When salinity of irrigation water is less than or equal to 2.10 ds/m, pear, plum, honey locust, Japanese pine, Australian pine and barberry will not likely experience reduced growth or appearance. It should be noted that recommendations are based on plant effects when specific water-quality parameters are known. However, further investigation is suggested since effects of long-term use of these waters on soil structure and salinity may alter plant response.

Introduction

Demand on potable water supplies as populations grow in arid regions has led to use of alternate irrigation sources. One of these alternatives is the use of low-quality water, delivered in a duplicate infrastructure specifically for landscape irrigation, called a secondary system. This water-use practice substantially reduces the demand for potable water and effectively makes use of otherwise unused waters. However, the low-quality water used in these systems may adversely affect growth and appearance of landscape plants and must be used with some caution. Although growth rate, size, and appearance are important criteria in setting permissible levels of salinity for landscape plants, growth reductions of 50% are acceptable if plants appear healthy and attractive (8). A report by the Salt Lake County Water Conservation District revealed appearance of woody landscape plants to be the most important factor in determining the degree of acceptance for a given water source (1).

While growth reduction is not the most important criteria for determining permissibility levels, growth parameters do provide a means to assess the treatment impact. Growth reductions known to occur from use of irrigation water or soils containing high levels of salinity include reductions in leaf area (10, 15), branch diameter (15) and growth (12, 15) including height, width and new growth.

This study evaluated the effects of sprinkler irrigation with water of differing qualities on the appearance and growth of woody landscape plants.

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Materials and Methods

A level, isolated, and relatively fertile area of approximately 1200 m^2 (10,000 ft^2) was used. The soil was a Loamy Borrow Pits Soil, ‘a miscellaneous land type consisting of deep, stratified alluvial sediments’ from which 0.6–6.7 m (2–20 ft) of topsoil had been removed (14). Soil was loamy-skeletal, mixed frigid from the Little Pole series (14). Sprinkler systems were installed to allow controlled blending of canal and culinary water.

The experiment was set up as a one-way ANOVA with three water-quality treatments blocked three times. Twelve species were randomly assigned within each block and within each water-quality treatment. Plants within each of the nine, 44.4 m^2 (400 ft^2) plots were planted 1.7 m (5 ft) apart. Plots within each treatment were separated from each other by 3.3 m (10 ft) and between treatments were separated from each other by 5.0 m (15 ft) to eliminate the possibility of over spray and contamination of adjacent plots. Sprinkler heads were checked for even flow rate over each plot and valves were adjusted for individual treatments to ensure equal amounts of water were applied to all treatments. All analysis was done using SAS.

In October 1995, one plant of each of the following were transplanted into each of the nine plots from 5-gallon containers: Japanese black pine, thornless honey locust, purple leaf flowering plum, purple leaf barberry, Austrian pine, green ash, ‘Aristocrat’ pear, Japanese yew, Colorado blue spruce, little-leaf linden, Chinese ‘Pfitzer’ juniper and Japanese euonymus. These species are commonly used in local residential landscapes. All trees and shrubs were planted level with the natural grade of the surrounding soil after watering and settling had occurred. Plants were allowed to establish before treatment watering began in May 1996.

Three irrigation treatments, designated high-, medium- and low-quality water, 15, 80 and 120 mg Na/liter respectively, were replicated three times. Irrigation with these three treatments was achieved using an automatic sprinkler valve, operated from a pump timer, which supplied only potable water to the control treatment and a blend of potable and Utah Lake water from the canal for the other two treatments. Weekly analysis of canal water determined sodium content, which was used to determine the blending ratio for the following week. This analysis allowed regulation of the system to maintain a consistent sodium level. Other canal analyses made weekly during the growing season in 1996 and 1997 were pH, EC, total dissolved solids, sodium absorption ratio, HCO_3, $CaCO_3$, B, SO_4, PO_4, NO_3, NH_4 and K. In 1997, Cl was analyzed in both potable and canal water. pH was determined using a model 720A Orion pH meter. Electrical conductivity of water samples was measured in ds/m by using a Beckman conductivity bridge. A HACH conductivity/total dissolved solids meter was used to determine total dissolved solids. Concentrations of K, Na, Ca and Mg were determined in the water samples by following the procedure for determination of these ions as outlined in USDA Handbook 60 using a Perkin Elmer 5000 Atomic Absorption Spectrophotometer (13). NH_4 and NO_3 were determined using steam distillation (11). The HACH DR/3000 spectrophotometer was used to determine bicarbonate and calcium carbonate (alkalinity), boron, sulfate, phosphate and chloride in water samples (6).

Average new growth on each tree and shrub was measured during October 1996 and 1997 by randomly measuring the length of new growth on 8 to 10 branches. Shrub heights and widths were measured both in May and October 1996 and 1997, from the central leader for the height and from widest points across in an east-west direction for the width. Tree heights were not measured. Tree branch diameter was measured using calipers at the beginning and end of each growing season on a tagged branch at a specific location indicated by a ring marking around the branch circumference. An average measurement of leaf area for each deciduous tree was also determined with a Li-Cor 3000 area meter using 10 randomly selected leaves per tree.

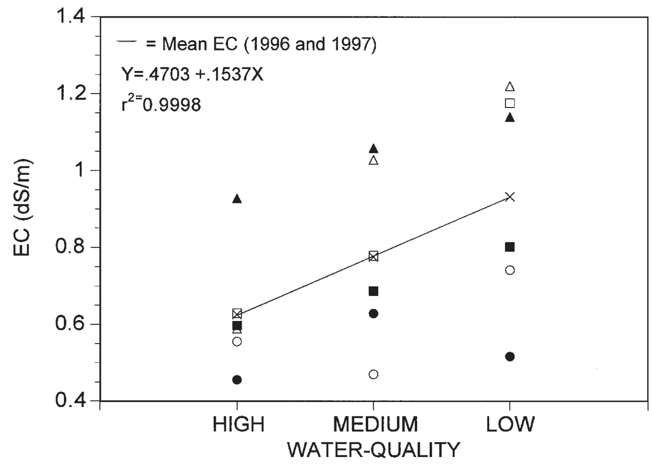

Fig. 1. EC (dS/m) of soils irrigated with high-, medium- and low-quality water at six collection dates: May ’96); July ’96 '; Oct. ’96 +; May ’97 #; July ’97 !; and Oct. ’97 %. Mean represents 3 replications.

To quantify the effects of the treatment on plant appearance, plants were ranked on a scale of 1 to 10 with a score of 10 indicating plants of highest quality. The criteria used in scoring included necrosis, chlorosis, leaf color, leaf turgor, tip die back, misformed leaves, leaf size, leaf loss and disease. Rank scores of plants grown in medium- and low-quality water were compared with those irrigated with high-quality water and means were separated using Fishers LSD.

In 1996, soils were sampled in May, July and September and in 1997, in May, July and August to 30 cm (12 in) depths. Soils were air-dried and ground to pass through a 2 mm sieve before lab analyses were performed according to the procedure outlined in *Soil Sampling and Methods of Analysis* for preparation of soils (3). Saturated pastes were prepared and extracts obtained from the saturated pastes were used to measure both electrical conductivity (EC), with a Beckman conductivity bridge, as well as soluble Na, Ca and Mg (3), used in calculating the adjusted sodium absorption ratio (adj R_{Na}) (2). Herein, SAR will be used in references to adj $R_{Na.}$ To measure Na, Ca and Mg, an atomic absorption spectrophotometer was used in 1996 and an IRIS Plasma Spectrometer was used in 1997. Linear regression analysis was done to show correlation of both SAR and EC for soils in each water-quality treatment over time as well as for EC between treatments.

Results and Discussion

There was a predictable increase in soil salinity as water-quality declined (Fig. 1). There was also a significant, predictable increase in soil salinity during the growing season

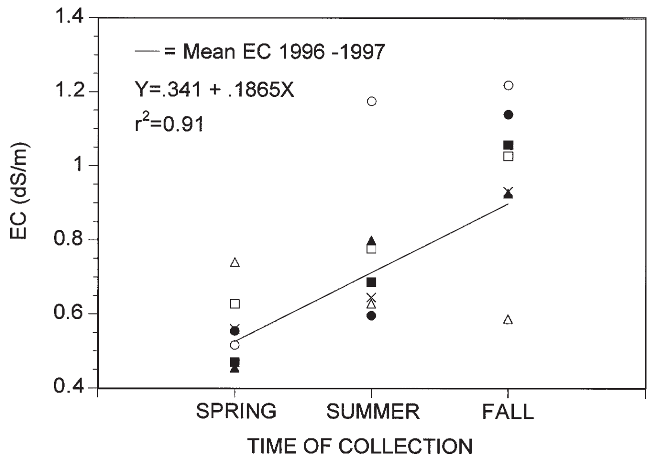

Fig. 2. **Seasonal change in EC (dS/cm) for soils collected in spring, summer and fall irrigated with high-), #; medium- ', !; and low-quality +, % water in 1996 and 1997, respectively. Mean represents 3 replications.**

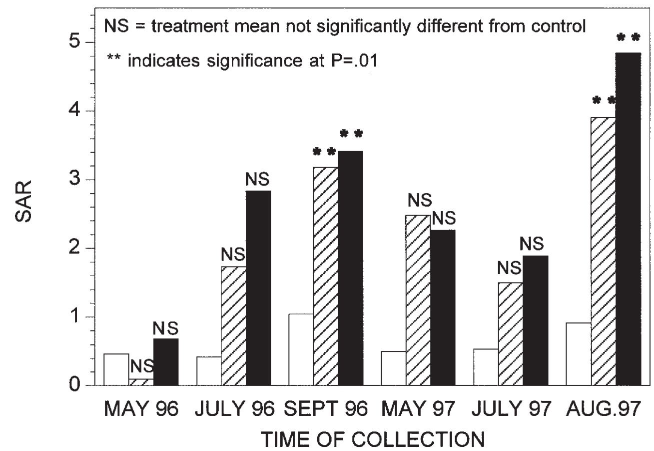

Fig. 3. **Adj R Na, expressed as SAR, of soils irrigated with high- ▭; medium- ▨; and low- ■ quality water. ANOVA done within species. Means separated using Fishers LSD. * indicates P = 0.05.**

(Fig. 2). However, after two years of irrigation, salt build-up would not be considered high and could be easily managed by leaching. Between 1996 and 1997, winter precipitation was sufficient to leach the salts from the soils and re-establish low salinity by the next season (Figs. 1 and 2).

Increases in SAR with use of medium- and low-quality water over the two years of this study provide reason for concern (Fig. 3). By fall of both years, soils receiving medium- and low-quality water showed high SAR values compared to soils receiving high-quality water. Although these levels are not currently deleterious, they cause serious concern because they represent a five- and seven-fold increase for fall 1996 and fall 1997, respectively, compared with SAR calculated in spring 1996 for soils irrigated with high-quality water. Unlike EC, SAR in spring 1997 did not return to original spring 1996 levels. It is possible that, if these rates of deterioration continued, this soil could become sodic within four years.

Irrigation treatments did not adversely affect new growth of any of the twelve species (Fig. 4). Conversely, honey locust, when irrigated with medium- and low-quality water, and ash, barberry and Austrian pine, when irrigated with medium-quality water, had significantly more new growth than control plants. Since the amount of new growth is a good indication of the plant's ability to tolerate salinity (4, 7, 9), low-quality water, with [Na] as high as 120 mg/liter and salinity levels up to 2.1 ds/m, could be recommended for use on all species studied based on new growth effects.

Possibly more important to many producers or residential water-users than the effects of low-quality water on growth, are its effects on plant appearance (1, 8). Based on this parameter, medium-quality water, containing up to 80 mg Na/liter and with salinity levels as high as 0.98 ds/m, could be recommended for use on all 12 species since rank scores of plants grown using medium-quality water were not different from control plants (Fig. 5). Using waters of this quality would provide an excellent alternative to using potable water for irrigation, as plants would appear equally attractive. Similarly, appearance of most plants when irrigated with low-quality water would be indistinguishable from those watered with high-quality water. Only ash, linden, euonymus and yew

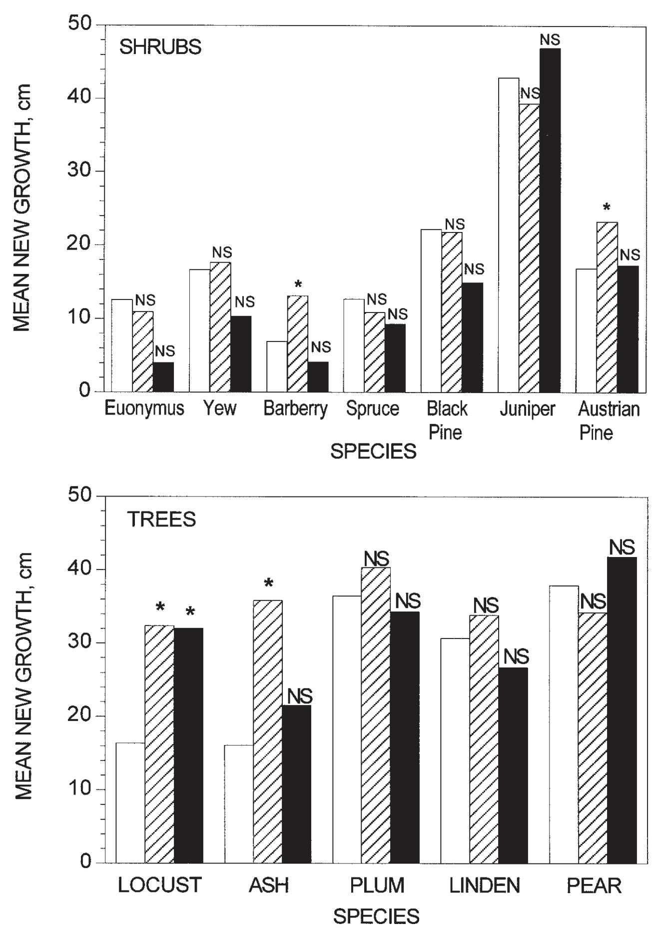

Fig. 4. **Mean new growth of shrubs and trees during both 1996 and 1997 when irrigated with high- ▭; medium- ▨; and low- ■ quality water. ANOVA done within species. Means separated using Fishers LSD. * indicates P = 0.05.**

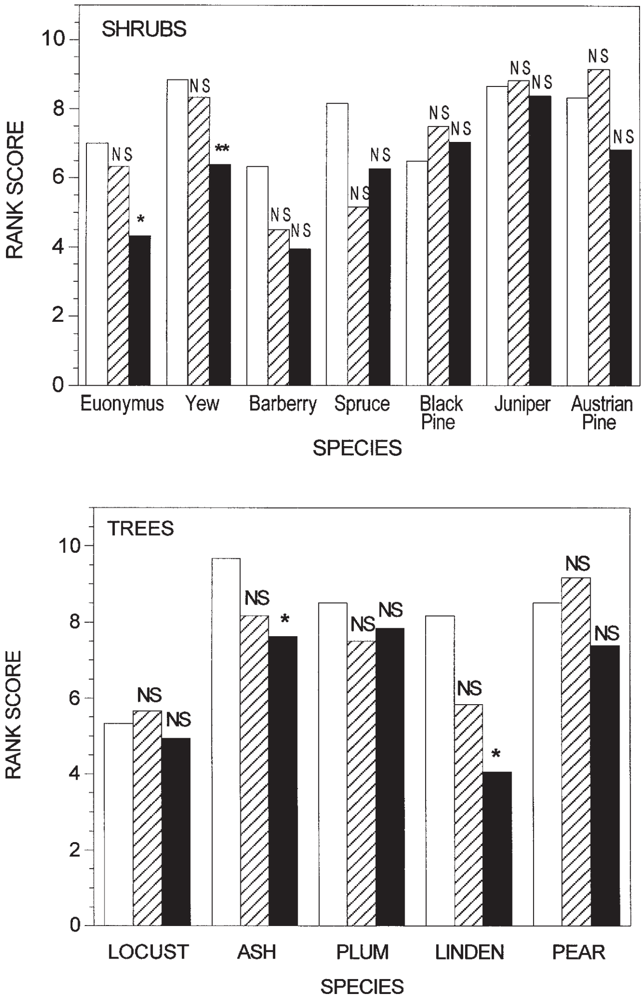

Fig. 5. Mean rank scores of shrubs and trees irrigated with high- ☐; medium- ▨; and low-quality ■ water during 1996 and 1997. ANOVA done within species. Fishers LSD used to separate means. Means represent 3 replications. * and ** show P = 0.05 and P = 0.01 respectively.

plants watered with low-quality water scored significantly lower in their appearance than control plants (Fig. 5). Mean rank scores for these plants irrigated with low-quality water were 7.6, 4.1, 4.3 and 6.4 respectively, compared to rank scores of 9.7, 8.2, 7.0 and 8.3 for ash, linden, euonymus and yew respectively, grown using high-quality water. Irrigation with low-quality water would probably not be suited for these plants as all of them suffered noticeable leaf loss, severe necrosis and chlorosis as well as a dirty, white residue on shrub plants whose leaves were exposed to water directly from the low-profile sprinklers.

In summary, irrigating with medium-quality water having salinity levels as high as 0.98 ds/m and containing up to 80 mg Na/liter would be acceptable for watering woody landscape plants when high-quality water is not available. Irrigation with low-quality water could be recommended for use on all species except ash, linden, euonymus and yew.

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