Salt Tolerance of Southwestern Perennial Ornamentals

Technical Report for Grant Number 01-HQ-GR-0113
March 1, 2001 to February 28, 2002

Submitted

March 27, 2003
Water Resources Research Center
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Tucson, AZ 85719

SECTION 1:

TITLE: Salt Tolerance of Southwestern Perennial Ornamentals

SECTION 2.

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CONGRESSIONAL DISTRICT: Fifth District

SECTION 4.

DESCRIPTION INFORMATION

A. Problem and Research Objectives

Water is a limited resource in the arid Southwest. Water demand is increasing for the burgeoning population in Arizona and the Southwest, while water supply is decreasing. The increase in primarily urban population brings with it a steady demand for ornamental plants in nurseries and landscapes. One strategy to stretch the finite ground water resources is reusing or recycling used water or gray water for ornamental plant production or maintenance of plants in the landscape. While generally accepted as a good concept, use of gray water, recycled water or water with higher salinity for irrigation of ornamental plants brings potential problems of increasing soil salinity and possibly causing reduced growth, foliar injury, or death of plants over time. Irrigation water with TDS (total dissolved solids) of up to 1,280 mg/l or an EC (electrical conductivity) of up to 2.0 dS/m is considered acceptable in terms of salinity. However, evaporation without leaching will lead to salt accumulation in the soil and therefore much higher concentrations of salts in the plant root zone. Although many current sources of potable water are of good quality, salinity of pumped groundwater and Colorado River water are expected to increase in the future. In the future, plant production and landscape maintenance will have to rely on irrigation water with higher salinity than current sources.

The plant palette used for landscaping in the Southwest, especially in Arizona, has changed dramatically over the last decade. Mediterranean plants have been replaced by native Southwestern or desert-adapted plants. Many of the most common trees, shrubs, groundcovers, and accent plants were scarcely used until recently and have not previously been tested for salt tolerance. In order to efficiently use water of higher salinity than ground water for irrigation of landscape plants, we need to learn more about salinity tolerance of currently used plants. Areas concerned with using desert-adapted plants for landscaping, decreasing water supply, increasing water demand, and irrigation water with higher salinity in the future are Arizona, New Mexico, Nevada, and the Mojave desert area of California.

The objective of this study was to determine salinity tolerance and ability for osmotic adjustment of selected trees, shrubs, groundcovers, and accent plants recently introduced to landscapes in the Southwest. Three species each of trees, shrubs, groundcovers, and accent plants, with the following attributes were selected for the study: no previous knowledge is available on their salt tolerance, they are widely used across the Southwest, they are readily available from several growers, and they are durable, and long-lived.

B. Methodology

Three species of trees (*Acacia stenophylla*, *Cercidium floridum*, and *Chilopsis linearis*), shrubs (*Calliandra californica*, *Leucophyllum frutescens*, and *Tecoma stans*), groundcovers (*Lantana* 'New Gold', *Verbena rigida*, and *Hymenoxis acaulis*) and accent plants (*Muhlenbergia rigens*, *Dasyliron wheeleri*, and *Nolina microcarpa*) were used in the study. Plants were obtained from a local nursery and tree and shrub liners were transplanted into 5-gal. containers, and groundcovers and accent plants were transplanted into 2-gal. containers on May 15, 2001. Plants were grown in pure silica sand (20 grade) and were irrigated with a fertilizer solution (Peters 20-20-20) containing 50 ppm N (control). The control solution had an EC of 0.6 dS/m and was supplemented with calcium chloride and sodium chloride (1:3 ratio) to reach 2.5, 5.0 or 10.0 dS/m. On July 2, 2001 all treatments other than the control solution received supplemental salts to reach a salinity of 2.5 dS/m. The following week, salinity was increased to 5.0 dS/m for the two higher salinity treatments. On July 16, 2001, salinity of the irrigation solution was increased to 10.0 dS/m for the highest salinity treatment. Plants were irrigated with the salinity treatments for 16 weeks and harvested from November 5 until November 11, 2001.

Irrigation was supplied by one or two drip emitters on the surface of the sand for the two-gallon and five-gallon containers respectively. Irrigation was provided at approximately two hour intervals during daylight hours to prevent water stress of plants. Runoff was collected and recycled for 7 days after which all solutions were discarded and fresh ones were prepared. EC and nitrate were measured daily and irrigation solutions were adjusted to their respective salinity treatments daily. Figure 1 shows the EC of the irrigation solutions throughout the experiment. The experiment was located at the Campus Agricultural Center of the University of Arizona on Campbell Avenue in Tucson, Arizona. Plants were grown on elevated benches in full sun. Each of the twelve species was grown under four salinity treatments with 6 replications. The experiment was arranged in a completely randomized block design.

At the end of the experiment, tree height and caliper at 2.5 cm above the media were measured. Plant height and two canopy widths, for which the average was calculated, were measured at the end of the experiment for the other nine species. Visual symptoms of foliar injury, stunted growth, and branch dieback were noted on a weekly basis. Shoot and root dry weights were determined at the end of the experiment. Biomass of dead plants at the end of the experiment was also recorded and is included in the analysis. Plant water potential and osmotic potential were measured during October 2001. Water potential was measured with a pressure chamber and osmotic potential was measured with an osmometer. Osmotic potential of *Cercicium floridum* and *Muhlenbergia rigens* could not be obtained, because we were unable to extract cellular sap from the tissue. Shoot tissue was ground and analyzed for Na and Cl. Data was analyzed with the statistical package SAS.

Principal Findings and Significance

A. Biomass and canopy size

Biomass and canopy size results are summarized in Tables 1 and 2. Photographs of the plants before dry weight determinations are shown in Figure 2.

Tree species

Growth response of the three tree species to increasing salinity ranged from salt tolerant for *Acacia stenophylla,* greater biomass production at intermediate salinity treatments for *Cercidium floridum*, and salt sensitive for *Chilopsis linearis* 'Rio Salado' (Table 1). Root/shoot ratios of tree species was little or not affected by the salinity treatments (Table 1). Shoot, root, and total biomass (Table 1) as well as caliper and height (Table 2) of *A. stenophylla* were not affected by salinity treatments. *A. stenophylla* never developed visual injury symptoms on the foliage throughout the study period.

Cercidium floridum produced the greatest shoot, root and total dry weight when irrigated with 5.0 dS/m solution (Table 1). Lowest biomass production resulted from irrigation with 2.5 dS/m solution, and was approximately one third of that produced by plants irrigated with 5.0 dS/m. Biomass production of plants treated with 0.6 dS/m or 10.0 dS/m irrigation solution did not differ from either of the other treatments. Caliper and height correspond to the biomass results (Table 2). No visual injury symptoms were observed on *C. floridum* plants throughout the study.

Chilopsis linearis 'Rio Salado' growth response indicates sensitivity to higher salinity treatments. Shoot biomass production was reduced under the 5.0 dS/m treatment compared to control and 2.5 dS/m treatment (Table 1). The 10.0 dS/m treatment further reduced both shoot and root biomass to less than 25% of the low salinity treatments. Caliper and height measurements confirm biomass data (Table 2). Fist signs of apical leaf wilting and leaf burning on *C. linearis* 'Rio Salado' appeared within two weeks of the onset of the 10.0 dS/m treatment. Symptoms progressed to defoliation and branch dieback from the tips of branches to the base. Within 8 weeks of the onset of the salinity treatments, plants under the 5.0 dS/m treatment started to show marginal burn on apical leaves. Within 10 weeks of treatment onset, plants irrigated with 10 dS/m solution were 80-90% defoliated and had died back severely, plants irrigated with 5 dS/m solution exhibited more leaf burning and mild defoliation, and plants irrigated with 2.5 dS/m solution showed mild leaf burning. These symptoms persisted until completion of the study.

Shrub species

The shrub species also differed in their tolerance to the salinity treatments. Shoot, root, and total biomass production, root/shoot ratio, and canopy size of *Leucophyllum frutescens* were not affected at the $p<0.05$ significance level (Table 1, 2). However, the means show a trend of approximately 50% lower biomass production for plants irrigated with 10.0 dS/m solution versus those irrigated with 0.6 dS/m solution. Although none of the plants developed foliar symptoms of injury throughout the experiment, growth response of plants was too variable to conclude that *L. frutescens* is tolerant to irrigation with solutions of up to 10.0 dS/m.

Calliandra californica tolerated irrigation solutions of up to 5.0 dS/m without reductions in biomass (Table 1). Growth of plants irrigated with 10.0 dS/m appeared stunted beginning five weeks after the onset of the treatment and had died within 12 weeks. *C. californica* never developed injury symptoms on leaves.

Tecoma stans responded to increasing salinity levels with a linear decrease in biomass production (Table 1). Height and canopy width were not significantly affected by the treatments (Table 2). Within 2 weeks of the onset of the 10.0 dS/m treatment, lower leaves started to turn yellow and subsequently dried. A week later the symptoms progressed from the base of the plant upward, and first symptoms of leaf chlorosis were observed in plants irrigated with 5.0 dS/m and 2.5 dS/m solutions. Plants irrigated with 10.0 dS/m solution were defoliated within 8 weeks of treatment onset and had died four weeks later. Plants irrigated with 5.0 dS/m solution lost most of their lower leaves, while those irrigated with 2.5 dS/m solution suffered from mild chlorosis and leaf abscission. Minor chlorosis was observed on lower leaves of plants irrigated with 0.6 dS/m solution, and can be attributed to shading and natural ageing of the vigorously growing plants.

Accent plants

Muhlenbergia rigens produced the greatest biomass among all experimental species (Table 1). Shoot and root dry weights and plant height were progressively reduced when plants received irrigation solutions of 5.0 dS/m or greater (Table 1, 2). Root/shoot ratio was greatest for plants irrigated with 0.6 dS/m solution and smaller for all other treatments. Drying leaf tips developed within three weeks of irrigating plants with solutions of 2.5 dS/m or higher, but were most pronounced and developed most rapidly for the higher salinity treatments.

Biomass production of *Nolina microcarpa* was not affected by salinity treatments, although canopy height was reduced for plants irrigated with the two higher salinity treatments compared to the 0.6 dS/m and 2.5 dS/m treatments (Table 1, 2). Plants had been transplanted from 1-gal. containers to 2-gal. containers and appeared to grow very little during the experimental period. However, plants irrigated with the 5.0 or 10.0 dS/m solution showed no more leaf tip burn than the ones irrigated with the lower salinity solutions. A longer period for evaluating the salinity tolerance of *N. microcarpa* seems appropriate due to the slow growth rate of this species.

Dasyliron wheeleri produced the smallest biomass among the experimental plants used in this experiment (Table 1). Although statistical differences were found for biomass between the 2.5 dS/m treatments and the 10.0 dS/m treatment, plant growth during the experimental period was unacceptable from a commercial point of view and from the perspective of evaluating salinity tolerance of this species. It appears that the continuous moisture that was provided to the root system prevented plants to thrive, thus making them unsuitable to be tested under our current experimental protocol. *D. wheeleri* is also known to have a slow juvenile growth rate and therefore should be tested for salinity tolerance for a longer period than 3 months.

Ground covers

Lantana 'New Gold' plants were sensitive to irrigation solutions of 2.5 dS/m which reduced shoot and total biomass by approximately 50%, and root biomass by two thirds compared to plants irrigated with the 0.6 dS/m solutions (Table 1). Defoliation of older leaves on plants irrigated with the 5.0 dS/m and the 10.0 dS/m solution began 8 weeks after the onset of all treatments, while older leaves started to turn yellow on plants irrigated with 2.5 dS/m solutions at that time. When the study was concluded, the highest to lowest salinity solutions caused the following foliar injury symptoms: more than 90% of leaves dropped, 50% of leaves dropped, about 33% of leaves dropped, and no foliar injury symptoms. The decrease in biomass production was primarily due to loss of leaves, as canopy size decreased only significantly for plants irrigated with the 10.0 dS/m solution compared to the other treatments (Table 2).

Biomass of *Verbena rigida* decreased linearly with increasing salinity treatments (Table 1). Plants irrigated with solutions of 10.0 dS/m showed leaf burn immediately after the onset of treatments, and started to die back from the apical end towards the base within two weeks of treatments. All of those plants were dead after 6 weeks of treatment. Five of the six replicate plants irrigated with the 5.0 dS/m solution were dead at the end of the experiment. Plants irrigated with 2.5 dS/m solution showed leaf burn on apical leaves. Plant height and canopy width were smaller for plants under the two higher irrigation treatments compared to the ones irrigated with 0.6 dS/m or 2.5 dS/m solutions (Table 2).

Hymenoxis acaulis liners established with difficulty and all plants irrigated with 5.0 dS/m or 10.0 dS/m had died after 8 weeks of treatments. It is unclear whether they required a longer establishment period, or are indeed very sensitive to saline conditions in the root zone. Plants irrigated with 0.6 dS/m solution developed into commercially acceptable plants by the end of the experiment, while those under the 2.5 dS/m treatment appeared stunted, but without specific foliar symptoms of injury. Even though biomass and canopy size data has been analyzed and shows that salinity of 2.5 dS/m and greater severely curtailed growth (Table 1, 2), problems with initial establishment only allow a cautious conclusion that *H. acaulis* is very salt sensitive.

B. Na and Cl in shoot tissue

Na and Cl concentration in shoot tissue increased for all plant species with increasing salinity treatments with the exception of Na in tissue of *Cercidium floridum* and *Verbena rigida* (Table 1). The concentration of Na in tissue even under the control treatment varied widely between species and ranged from 188 µg/g dry weight in *Calliandara californica* to 10,536 µg/g dry weight in *Verbena rigida*. Mechanisms of inclusion and exclusion of Na and Cl ions were evident among salt tolerant and salt sensitive species tested in this study.

Glycophytes often respond with exclusion of Na and Cl at the root cell membrane, while includers take up greater amounts of the ions. In this experiment, both exclusion and inclusion of Na and Cl was observed for plants that were tolerant beyond 10 dS/m as well as for those that were damaged at 5.0 or 2.5 dS/m. Species that tolerated 10 dS/m without loss of biomass or aesthetic appearance and seemed to rely on exclusion of Na and Cl were *Acacia stenophylla* and *Cercidium floridum* (Table 1, 3). *Nolina microcarpa* and *Leucophyllum frutescencs* seemed to rely on exclusion of Na, but inclusion of Cl while maintaining aesthetic appeal under the highest salinity treatment. *Muhlenbergia rigens* adapted to greater salinity with inclusion of both Na and Cl.

Calliandra californica and *Chilopsis linearis* had reduced biomass at 5.0 dS/m and 10 dS/m, respectively, seemed to rely on exclusion of Na and Cl, but concentration of these ions increased significantly at 10 dS/m when plants died, indicating the limits of this strategy. *Tecoma stans* and *Verbena rigida* seemed to rely on inclusion of both ions, and sustained damage to leaves even at 2.5 dS/m. *Lantana* 'New Gold' appeared to include Na and exclude Cl, however both ions increased significantly over the control at 2.5 dS/m and concomitantly reduced biomass.

C. Water potential and osmotic potential

Stem water potential (ψ_{wp}) measured during midday 12 weeks after the onset of salinity treatments increased with increasing salinity for four of the ten species measured (Table 4). ψ_{wp} of *Lantana* increased linear with increasing EC. For *Leucophyllum frutescens* ψ_{wp} differed between the control treatment and EC 10, for *Tecoma stans* ψ_{wp} was greatest for EC 10 compared to all other treatments, and for *Chilopsis linearis* ψ_{wp} differed only at EC 2.5 from EC 20 (Table 4).

Osmotic potential (ψ_{osm}) was affected by salinity treatments of four species (Table 4). The salt sensitive species *Lantana* 'New Gold' and *Verbena rigida* responded with an increase in ψ_{osm} to 2.5 dS/m and 5.0 dS/m treatments, respectively. In the salt tolerant species *Acacia stenophylla* ψ_{osm} was highest for the 2.5 dS/m and 5.0 dS/m treatments, and lowest for the control and 10 dS/m treatments. ψ_{osm} of *Leucophyllum frutescens* was highest for EC 10.

Summary

Twelve species of ornamental plants growing in containers were irrigated for 16 weeks with four solutions with an electrical conductivity of 0.6, 2.5, 5.0, or 10.0 dS/m. The onset of injury symptoms under the four treatments varied by species. Mechanisms of inclusion and exclusion of Na and Cl ions were evident among salt tolerant and salt sensitive species tested in this study. Response of ψ_{wp} and ψ_{osm} to increasing salinity differed among species and were not related to the level of salt tolerance.

The following table provides an overview of salinity tolerance based on the treatments when biomass reduction started and when biomass was reduced to 25% or less of the control or plants had died by the end of the experiment.

Species	**EC (dS/m) when biomass reduction begins**	**EC (dS/m) when biomass $\leq$ 25% of control plants or plants are dead**
Acacia stenophylla	>10.0	>10.0
Cercidium floridum	>10.0	>10.0
Nolina microcarpa	>10.0	>10.0
Muhlenbergia rigens	5.0	>10.0
Leucophyllum frutescens	5.0	>10.0
Calliandra californica	5.0	10.0
Tecoma stans	5.0	10.0
Chilopsis linearis 'Rio Salado'	2.5	10.0
Verbena rigida	5.0	5.0
Lantana 'New Gold'	2.5	10.0

Table 1. Biomass and root to shoot ratio of twelve species of ornamental plants grown for 16 weeks with irrigation water of different salinity.

	EC dS/m	Shoot	Root Dry Weight (g)	Total	Root/shoot Ratio
Acacia stenophylla	0.6	88.2	22.6	110.8	0.26ab
	2.5	124.7	24.8	149.6	0.18b
	5.0	105.2	20.8	126.9	0.29a
	10.0	95.8	19.6	115.4	0.20b
Significance (p-value)		0.06	0.07	0.06	0.04
Cercidium floridum	0.6	134.2ab	40.3ab	174.5ab	0.30
	2.5	90.4b	25.1b	115.6b	0.28
	5.0	242.9a	80.6a	323.5a	0.36
	10.0	180.4ab	57.9ab	238.3ab	0.33
Significance		0.04	0.007	0.02	0.37
Chilopsis linearis	0.6	273.9a	88.5a	362.3a	0.33
'Rio Salado'	2.5	247.1a	106.2a	353.3a	0.43
	5.0	162.9b	66.1ab	229.0b	0.40
	10.0	57.1c	26.7b	83.8c	0.49
Significance		.00001	.001	.00001	0.11
Calliandra californica	0.6	39.3a	14.1a	53.4a	0.38a
	2.5	30.5ab	11.0ab	41.6ab	0.38a
	5.0	34.1ab	12.4ab	46.5a	0.41a
	10.0	0.7b	0.2b	0.9b	0.15b
Significance		0.02	0.02	0.02	0.005
Leucophyllum frutescens	0.6	57.6	5.0	62.6	0.08
	2.5	39.7	2.9	42.6	0.08
	5.0	44.0	2.6	46.7	0.06
	10.0	26.5	1.5	28.0	0.06
Significance		0.27	0.06	0.24	0.09
Tecoma stans	0.6	239.8a	42.2a	281.9a	0.18a
	2.5	197.7ab	29.4a	227.1ab	0.15ab
	5.0	142.1bc	14.5b	156.7bc	0.11b
	10.0	72.6c	9.4b	82.1c	0.13ab
Significance		0.0003	0.0001	0.0001	0.02

Table 1 continued

	EC dS/m	Shoot	Root	Total	Root/shoot Ratio
		Dry Weight (g)			
Dasyliron wheeleri	0.6	0.97ab	0.31ab	1.28	0.34
	2.5	1.19a	0.46a	1.66	0.41
	5.0	0.39ab	0.19ab	0.77	0.51
	10.0	0.33b	0.10b	0.86	0.30
Significance		0.02	0.01	0.16	0.16
Muhlenbergia rigens	0.6	647.7a	101.4a	749.2a	0.16a
	2.5	687.0a	54.7a	741.7a	0.08b
	5.0	509.5b	47.0b	556.5b	0.09b
	10.0	295.2c	31.1c	326.3c	0.11b
Significance		0.0001	0.0001	0.0001	0.0001
Nolina microcarpa	0.6	18.9	6.6	25.5	0.35
	2.5	17.1	6.5	23.5	0.37
	5.0	16.7	7.4	24.2	0.44
	10.0	15.1	7.1	22.2	0.45
Significance		0.8	0.95	0.94	0.22
Lantana 'New Gold'™	0.6	168.2a	50.5a	210.3a	0.26
	2.5	83.8b	16.9b	100.7b	0.21
	5.0	85.0b	15.0b	100.0b	0.18
	10.0	46.8b	7.8b	54.7b	0.17
Significance		0.0001	0.0001	0.0001	0.40
Verbena rigida	0.6	104.8a	17.7a	122.5a	0.16
	2.5	75.5ab	8.5ab	84.0ab	0.11
	5.0	56.4bc	5.2ab	61.6bc	0.09
	10.0	23.1c	1.9b	25.1c	0.08
Significance		0.0001	0.01	0.0001	0.16
Hymenoxis acaulis	0.6	24.6a	3.8a	27.8a	0.15
	2.5	5.4b	0.5b	5.8b	0.06
	5.0	4.1b	0.6b	4.7b	0.11
	10.0	--	--	--	--
Significance		0.0003	0.0001	0.0002	0.52

Table 2. Stem diameter of trees and height and canopy width of twelve species of ornamental plants grown for 16 weeks with irrigation water of different salinity.

Species	EC dS/m	Stem Diameter (mm)	Height (cm)	Width (cm)
Acacia stenophylla	0.6	12.5	158.6	-
	2.5	14.5	170.6	-
	5.0	11.5	140.1	-
	10.0	13.6	182.0	-
Significance (p-value)		0.71	0.46	
Cercidium floridum	0.6	15.5ab	103.5ab	-
	2.5	14.1b	81.1b	-
	5.0	19.0a	145.3a	-
	10.0	16.3ab	122.3ab	-
Significance		0.01	0.004	
Chilopsis linearis	0.6	19.0a	136.1ab	-
'Rio Salado'	2.5	18.5a	144.0a	-
	5.0	16.1ab	102.8bc	-
	10.0	11.5a	95.8c	-
Significance		0.001	0.0015	
Calliandra californica	0.6	-	41.6ab	-
	2.5	-	47.2a	-
	5.0	-	48.8a	-
	10.0	-	7.1b	-
Significance			0.03	
Leucophyllum frutescens	0.6	-	47.50	48.6
	2.5	-	45.00	50.1
	5.0	-	44.50	48.4
	10.0	-	38.17	36.2
Significance			0.58	0.19
Tecoma stans	0.6	-	76.1	78.4
	2.5	-	72.0	66.9
	5.0	-	54.5	68.6
	10.0	-	60.83	59.7
Significance			0.36	0.053

Table 2 continued

Species	EC dS/m	Height (cm)	Width (cm)
Dasyliron wheeleri	0.6	20.8a	9.7
	2.5	21.3a	10.0
	5.0	5.0b	3.6
	10.0	8.1ab	3.3
Significance		0.0007	0.01
Muhlenbergia rigens	0.6	112.3a	57.9b
	2.5	122.3a	68.7a
	5.0	96.1b	57.2bc
	10.0	60.8c	50.1c
Significance		0.0001	0.0001
Nolina microcarpa	0.6	57.5a	31.2
	2.5	56.3a	29.7
	5.0	46.8b	28.6
	10.0	40.6b	24.6
Significance		0.04	0.19
Lantana 'New Gold'	0.6	34.1	90.7a
	2.5	23.8	77.1ab
	5.0	30.3	81.4ab
	10.0	32.2	66.1b
Significance		0.12	0.04
Verbena rigida	0.6	28.8a	56.0a
	2.5	29.6a	52.5a
	5.0	24.3a	40.3b
	10.0	13.6b	27.0c
Significance		0.0004	0.0001
Hymenoxis acaulis	0.6	14.0a	22.2a
	2.5	3.1b	4.8b
	5.0	3.1b	5.1b
	10.0	-	-
Significance		0.0001	0.0001

Table 3. Sodium and chloride concentration in leaf tissue of ten species of ornamental plants grown for 16 weeks with irrigation water of different salinity.

Species	**EC dS/m**	**Na (µg/g)**	**Cl (µg/g)**
Acacia stenophylla	0.6	1101b	6838b
	2.5	1381b	12070a
	5.0	2351a	13023a
	10.0	2471a	13264a
Significance (p-value)		0.0001	0.01
Cercidium floridum	0.6	1123	635c
	2.5	2215	3680bc
	5.0	2696	6144ab
	10.0	2705	8392a
Significance		0.07	0.0006
Chilopsis linearis	0.6	614b	3441b
'Rio Salado'	2.5	964b	10609ab
	5.0	1121b	11083ab
	10.0	6600a	20064a
Significance		0.0127	0.0334
Calliandra californica	0.6	188a	785a
	2.5	555a	2766ab
	5.0	763a	5516b
	10.0	67411b	166360c
Significance		0.0001	0.0001
Leucophyllum frutescens	0.6	743b	4833c
	2.5	1623b	13639bc
	5.0	3678ab	21892ab
	10.0	6468a	30944a
Significance		0.006	0.0001
Tecoma stans	0.6	3046b	5135c
	2.5	3596b	12631bc
	5.0	5254b	19412b
	10.0	12247a	30547a
Significance		0.0001	0.0001

Table 3 continued

Species	EC dS/m	Na (µg/g)	Cl (µg/g)
Muhlenbergia rigens	0.6	1520d	11127b
	2.5	8780c	31777ab
	5.0	14059b	43809a
	10.0	20726a	51954a
Significance		0.0001	0.0004
Nolina microcarpa	0.6	451c	5263c
	2.5	1063c	7954c
	5.0	3187b	14413b
	10.0	5391a	22943a
Significance		0.0001	0.0001
Lantana 'New Gold'	0.6	4317c	8300c
	2.5	10686b	32253b
	5.0	12891ab	39109ab
	10.0	17120a	43305a
Significance		0.0002	0.0001
Verbena rigida	0.6	10536	11164c
	2.5	7250	35295b
	5.0	12047	53944a
	10.0	13441	41532ab
Significance		0.0613	0.0001

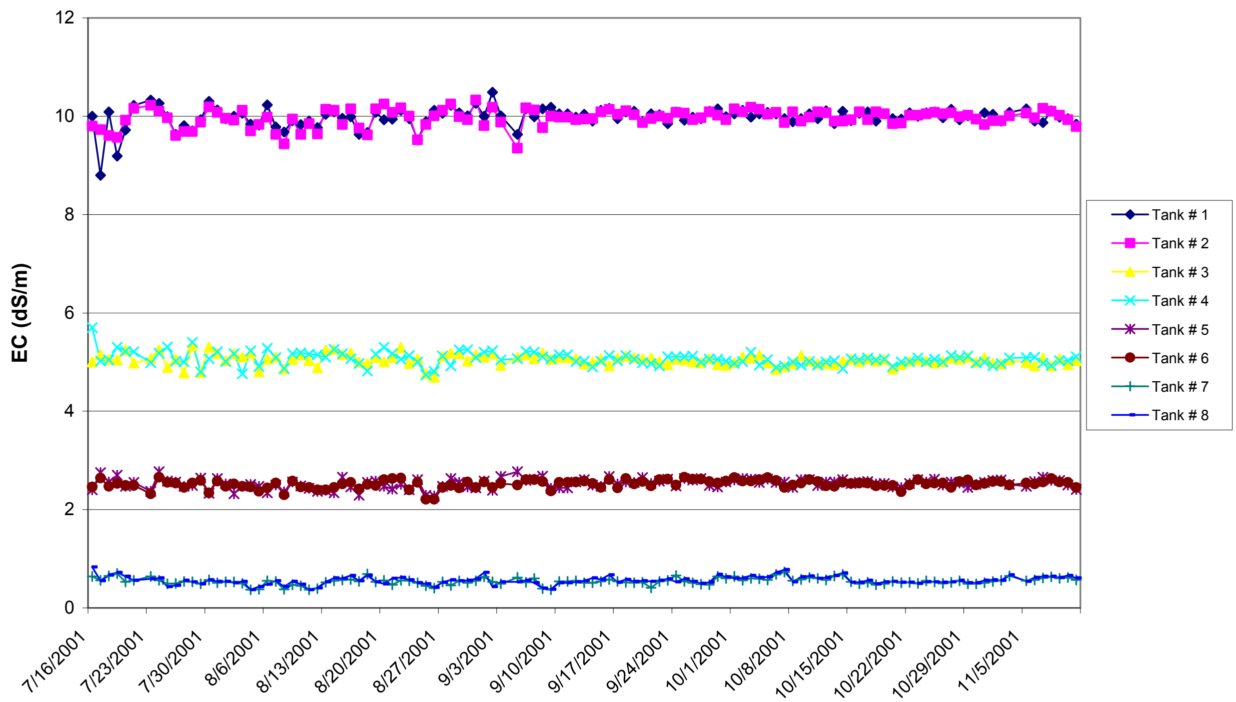
Table 4. Water potential and osmotic potential of ten species of ornamental plants grown for 16 weeks with irrigation water of different salinity.

Species	EC dS/m	Water potential (-MPa)	Osmotic potential (-MPA)
Acacia stenophylla	0.6	19.37	0.81 a
	2.5	16.83	1.35 bc
	5.0	17.50	1.65 c
	10.0	20.25	1.00 ab
Significance (p-value)		0.145	0.0003
Cercidium floridum	0.6	20.26	-
	2.5	16.40	-
	5.0	18.93	-
	10.0	17.73	-
Significance		0.215	
Chilopsis linearis	0.6	10.24 ab	2.08
‘Rio Salado’	2.5	7.58 a	2.14
	5.0	9.56 ab	1.97
	10.0	11.50 b	1.88
Significance		0.021	0.611
Calliandra californica	0.6	18.12	0.91
	2.5	17.48	1.15
	5.0	16.37	0.84
	10.0	-	-
Significance		0.770	0.192
Leucophyllum frutescens	0.6	15.52 a	1.67 a
	2.5	16.13 ab	1.38 a
	5.0	17.13 ab	1.65 a
	10.0	22.16 b	2.86 b
Significance		0.089	0.0002
Tecoma stans	0.6	17.31 a	1.93
	2.5	15.22 a	2.21
	5.0	16.80 a	2.14
	10.0	24.50 b	2.56
Significance		0.0300	0.439

Table 4 continued

Species	EC dS/m	Water potential (-MPa)	Osmotic potential (-MPA)
Muhlenbergia rigens	0.6	15.71	-
	2.5	13.60	-
	5.0	13.87	-
	10.0	11.50	-
Significance		0.194	
Nolina microcarpa	0.6	14.40	2.02
	2.5	18.83	2.55
	5.0	19.73	2.22
	10.0	19.30	-
Significance		0.195	0.195
Lantana 'New Gold'	0.6	9.75 a	0.48 a
	2.5	13.58 b	1.34 b
	5.0	15.08 bc	1.60 b
	10.0	16.83 c	1.95 b
Significance		0.0004	0.0041
Verbena rigida	0.6	10.78	1.36 a
	2.5	13.33	1.96 a
	5.0	9.40	3.03 b
	10.0	-	-
Significance		0.214	0.025

Figure 1. EC of irrigation solutions from June 16, 2001 to November 11, 2001. The even tank numbers contain runoff solution, the odd numbers contain solutions that were adjusted or feshly prepared.



SECTION 5. PUBLICATION INFORMATION

1.-5. no publications

6. Other Publications

Schuch, U.K., T. Mahato. 2002. Salt tolerance of Southwestern plant species. Abstract in HortSciences (July 2002 issue)

SECTION 6. STUDENT SUPPORT

None

SECTION 7. NOTABALE ACHIEVEMENTS AND AWARDS

None