Salinity Tolerance of Cacti and Succulents

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Abstract

The salinity tolerance of golden barrel cactus (Echinocactus grusonii), ocotillo (Fouquieria splendens), saguaro cactus (Carnegiea gigantea), and Gentry's agave (Agave parryi truncata) was tested. Plants were irrigated with a solution of EC 0.6, 5.0, 10.0, and 15.0 dS/m. Duration of treatments were 18 weeks for saguaro and 26 weeks for the other three species. In general, fresh weight, dry weight, and moisture content decreased with increasing salinity levels, with the exception of saguaro dry weight which was not affected by the treatments, and ocotillo moisture content which increased with increasing salinity. Runoff was collected three times during the experiment and indicated that ion uptake was higher for barrel cactus than the other three species. EC of runoff averaged for all dates and species showed an increase of 17%, 54%, 46%, and 64% over the salinity treatment solutions of 0.6, 5.0, 10.0, and 15.0 dS/m, respectively.

Introduction

Salinity is a problem in many arid regions of the world, including the Southwestern United States. Deteriorating water quality exposes cacti and succulents in urban landscapes to increasing salinity conditions. Unless higher leaching fractions are used, salts will accumulate in the root zone of plants when irrigation water of higher salinity is used. In addition, with drought becoming a common occurrence each year in the arid southwest, it is possible that water restrictions will be imposed in response to drought emergencies, which will cause potential issues of both salinity and drought for plants in urban landscapes.

Large numbers of cacti and succulents are already established in Southwest landscapes and many more are planted each year in the rapidly increasing urban developments. Although these plants are generally considered tolerant to drought, no data exists as to their salinity tolerance. It is well established that drought tolerance and salinity tolerance have different mechanisms and therefore tolerance to one stress does not confer tolerance to another. With the likelihood of increasing soil and water salinity in the Southwest, it seems prudent to obtain knowledge regarding the salinity tolerance of commonly planted cacti and succulents. The objective of this research was to determine the salt tolerance of four species of succulents and cacti and to determine ion concentration in runoff.

Materials and Methods

Golden barrel cactus (*Echinocactus grusonii*), saguaro cactus (*Carnegiea gigantea*), ocotillo (*Fouquieria splendens*), and Gentry's agave (*Agave parryi truncata*) were transplanted into 2-gallon (5.4 L) containers with a mix of sand and pumice (50/50 vol.). Plants were grown outdoors in full sun at the Campus Agriculture Center of the University of Arizona in Tucson, Arizona from May to November 2006. Duration of treatments were 18 weeks for saguaro and 26 weeks for the other three species. Plants were irrigated with a fertilizer solution containing 50 ppm N augmented with a 3:1 ratio of sodium chloride and calcium chloride to obtain salinity levels of EC 0.6, 5.0, 10.0, and 15.0 dS/m. Eight replicate plants per species were assigned to each salinity treatment. Plant dry weight, moisture content of shoots and mineral tissue analysis were determined at the end of the experiment. Runoff was captured and analyzed three times at 7-week intervals.

Results

Dry weight of shoots, moisture content, and osmolality of each species were affected differently by increasing salinity (significant interaction between EC treatment and species). Agave shoot dry weight decreased most followed by ocotillo when plants were grown at 5 dS/m compared to 0.6 dS/m (Fig. 1). For both species, small declines in shoot dry weight resulted from further increases in salinity. Saguaro and barrel cactus shoot dry weight was not significantly affected by increasing salinity. Root dry weight of ocotillo decreased dramatically followed by agave in a pattern similar to shoot dry weight. Root dry weight of saguaro increased with increasing salinity.

Ocotillo had the lowest moisture content and the highest osmotic potential among the four species (Fig. 2). Osmotic potential was unaffected by increasing salinity, while moisture content increased at higher EC levels. In the three other species, osmotic potential increased and moisture content decreased with greater salinity. Osmotic adjustment in shoots was not evident in ocotillo, while it seemed to be the primary mechanism for the other three species to tolerate the higher osmotic potential in the root zone.

Concentrations of sodium and chloride in shoot tissue were affected by an interaction between species and salinity treatment (Fig. 3). Barrel cactus sequestered the ions in greatest amounts, followed by saguaro. Agave and ocotillo relied on exclusion of sodium and chloride although concentrations increased with increasing salinity in the irrigation water.

Chemical composition of runoff at the three dates was similar and was affected by species and salinity treatment (Table 1). Runoff was increasingly concentrated when irrigation with higher salinity was supplied. EC of runoff averaged for all dates and species showed an increase of 17%, 54%, 46%, and 64% over the salinity treatment solutions of 0.6, 5.0, 10.0, and 15.0 dS/m, respectively. Barrel cactus had lower concentrations of sodium, chloride, calcium in runoff and lower EC compared to the other three species. These ions may have been used for osmotic adjustment in barrel tissue.

Conclusions

• Ocotillo was most sensitive to increasing salinity among the four species tested. Root and shoot dry weight decreased 40% and 47%, respectively when salinity increased from 0.6 dS/m to 5 dS/m. Plants showed no evidence of osmotic adjustment. Mineral analysis of shoot tissue and runoff suggest that ocotillo relies on exclusion of ions with increasing salinity in irrigation.

• Agave was sensitive to increasing salinity and shoot and root dry weights decreased approximately one third when plants were exposed to irrigation with EC of 5 dS/m compared to 0.6 dS/m. Osmotic adjustment appears to be a mechanism of agave based on increasing osmotic potential, decreasing shoot moisture content, and increasing sodium and chloride in shoot tissue.

• Both saguaro and barrel cactus were tolerant of all levels of salinity, and saguaro roots responded positively in root growth to increasing salinity. Cacti relied on osmotic adjustment based on the increased osmotic potential, higher concentration of sodium and chloride in the shoot tissue, and for barrel cactus, lower concentration of ions in the runoff.

Table 1. Chemical composition of runoff collected at three dates from plants irrigated with saline irrigation

Salinity (dS/m)	Ca (ppm)	Cl (ppm)	Na (ppm)	EC (dS/m)
0.6	48	24	43	0.7
5	280	2153	1028	7.7
10	569	4776	2347	14.6
15	922	7129	3524	24.6
Species				
Agave	452	3607	1789	12.0
Barrel	429	3206	1552	10.8
Ocotillo	476	3641	1830	12.3
Saguaro	446	3519	1705	12.1

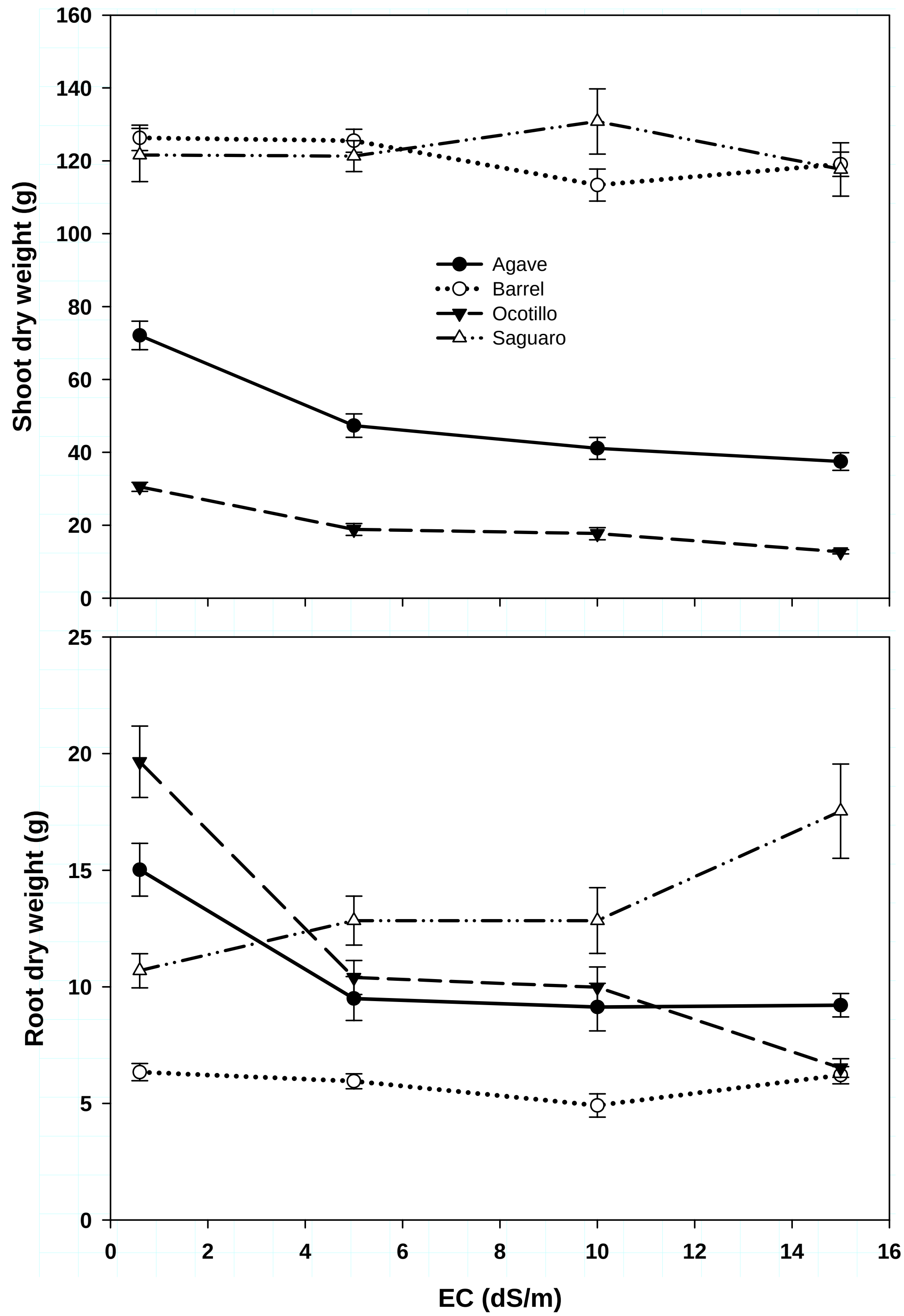

Fig. 1. Shoot and root dry weight of plants grown under four levels of saline irrigation

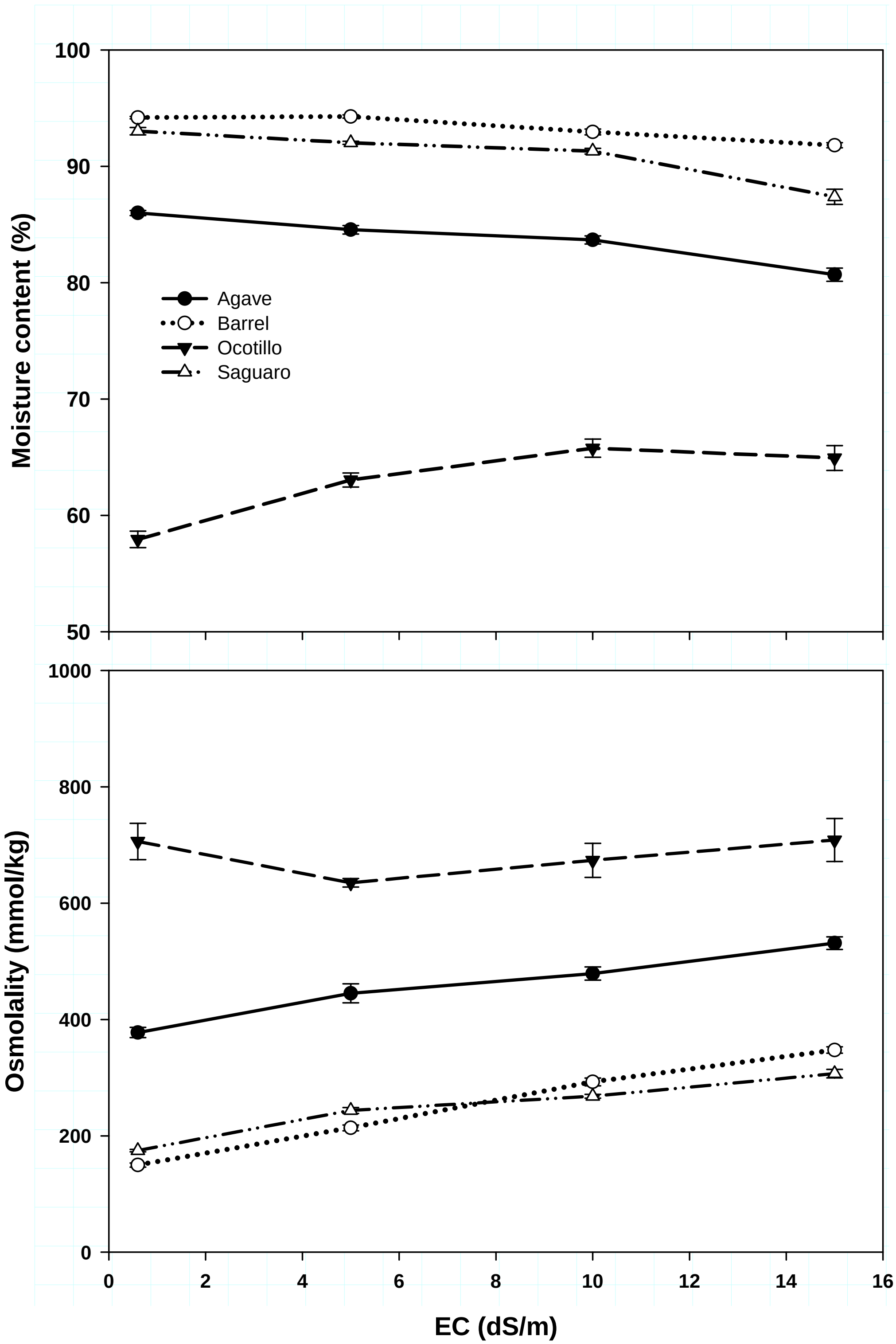

Fig. 2. Osmotic potential and moisture content in shoots of plants grown with saline irrigation

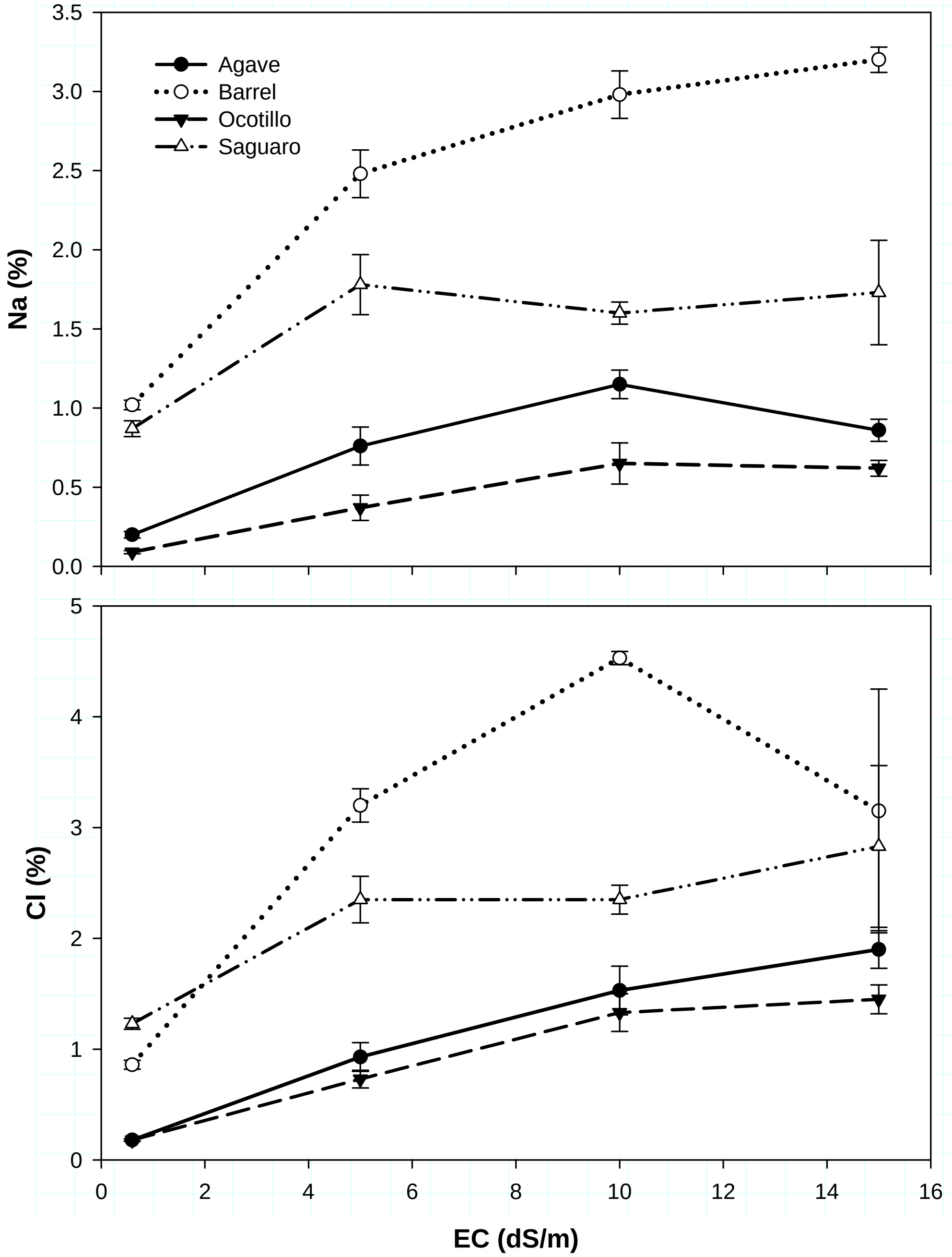

Fig. 3. Sodium and chloride concentration in shoot tissue of plants grown with saline irrigation.