Salt-of-the-Earth Plants — Easing the Pain of Drought

THE DEVELOPMENT OF SUSTAINABLE LANDSCAPES IS BECOMING INCREASINGLY RELIANT ON THE SELECTION OF DROUGHT- AND SALINITY-TOLERANT PLANTS.

By Xiaoya Cai, Genhua Niu, Terri Starman and Mengmeng Gu

Water shortage and poor water quality are critical challenges to gardening and landscaping in many regions of the world and will no doubt continue to challenge our industry. With rapid increases in urban populations and industrial development, the competition for fresh water has increased among agricultural, industrial and municipal water users. Urban landscape irrigation water accounts for 40 to 60 percent of total municipal water use during summer months in the Southwest, and is restricted by many municipalities during drought periods.

Recently, drought has hit areas where water was not an issue historically. In 2007, Georgia's governor declared a drought emergency for the northern third of the state where water supplies were rapidly shrinking during a drought of historic proportions. In 2011, Texas had the driest year on record. Currently, the horticulture industry in California is suffering significantly from a drought.

Due to the limitation for future water uses, many city municipalities have established watering restrictions and emergency response plans. For example in Frisco, Texas, there are four stages of the Drought and Emergency Response Plan in the city's water management plan, including: 1) reduce city government water use for landscape irrigation; 2) water twice a week (or less) on two assigned days, but not between the hours of 10 a.m. and 6 p.m.; 3) water once a week (or less) on the assigned days; and 4) prohibit the irrigation of new landscape, and other landscape watering, except that with soaker hoses, drip/bubbler systems or hand-held hoses.

Another way of conserving fresh water is to use alternative water sources, such as reclaimed water, which is highly treated wastewater effluent. Reclaimed water is becoming more commonly used to irrigate landscapes and agricultural crops in some states. The salt levels and composition of salts in reclaimed water vary from place to place and by treatment method, but the salinity level is usually two to three times higher than drinkable water. Ions commonly found in reclaimed water are sodium (Na) and chloride (Cl) — both of the elements in common table salt — and many trace elements such as nitrogen (N), phosphorus (P), magnesium (Mg) and calcium (Ca). By using reclaimed water, plants can serve as a "bio-filtration system" because, to some extent, plants can use these ions as nutrient elements. Reclaimed water is cheaper than potable water. However, reclaimed water needs a separate delivery system from potable water, which may add extra cost initially.

Figure 1. The exclusion of white powder (salt) in Blue Plumbago 'Escapade Blue' at EC of 7.0 dS/m.

Soil and Water Salinity Measurement

Nearly all waters contain dissolved salts and trace elements. The term salinity is used to describe the "saltiness" or the dissolved salt content of water or soil. Major individual chemical constituents found in water and saline soils include positively charged cations (Na^+, K^+, Ca^{2+}, Mg^{2+}, NH_4^+, H^+) and negatively charged anions (Cl^-, HCO_3^-, CO_3^{2-} NO_3^- and SO_4^{2-}), and they may cause deleterious effects in sensitive plants such as leaf necrosis and leaf edge burn. High soil salinity is usually caused by low-quality irrigation water, poor drainage, climate (low rainfall, high evapotranspiration, etc.), sea water intrusion and road-side de-icing salts.

The salinity of water or a soil extract can be measured by electrical conductivity (EC) with various types of EC meters. The unit of measure is dS/m or mmhos/cm or mS/cm (1 mmhos/cm = 1 mS/cm=1 dS/m). Electrical conductivity meters will measure all electrically charged ions in the water or soil extract. The higher the salt content in the soil extract or water, the greater the flow of electrical current and therefore the higher the reading on the scale of the EC meter. Fresh water has an EC less than 0.8 dS/m. Tap water EC varies by location. For example, the tap water EC is 0.8 to 1.1 dS/m in El Paso, while it is 0.7 dS/m in College Station, Texas. Reclaimed water EC also varies with location, water source and treatment method. Sea water has an EC ranging from 37 to 62 dS/m. The EC thresholds that plants can tolerate vary with species and even with cultivars but general ranges occur. In general, at EC of 0 to 2 dS/m, only very sensitive plants are affected, at EC of 2 to 4 dS/m (saline soil) sensitive plants are affected and at EC of 4 to 8 dS/m (sodic soil) most crops are affected.

Drought and Salinity Tolerance

Some plant species or cultivars naturally have the ability to tolerate drought and salt better than other species or cultivars. Drought-tolerant plants usually have some unique external characteristic that makes them resistant to loss of water or gives them the ability to take up water from greater depths in the soil. These characteristics can include small leaves, leaves with thick cuticles or fine hairs or deep tap roots. Some plants tolerate drought through internal mechanisms. For example, succulents and cacti have the ability to store water in their leaves or stems. Salinity-tolerant plants have the ability to withstand the effects of high salinity without significant adverse effects. For example, plumbago 'Escapade Blue' has the unique salinity tolerant mechanism of being able to exude salts from cells on the undersides of its leaves (Figure 1).

There are two types of salinity tolerance in plants. One is the tolerance to salinity in irrigation water applied to the root zone which is the focus of this article. The other is tolerance to "salt spray", i.e. when saline water is sprayed (e.g. through sprinkler irrigation or natural ocean water spray) directly on foliage and twigs of plants. Generally

Table 1. Drought tolerant annuals, perennials and groundcovers, woody plants, and garden roses from evaluations at the Texas AgriLife Experiment Station in El Paso and at Texas A&M University in College Station, Texas.

Annuals	Perennials and Ground Covers	Woody Plants	Garden Roses
Angelonia 'Serena Lavender Pink'	Blanket Flower	Afghan Pine	Pink Drift
Angelonia 'Senena Purple'	Blue Princess Verbena	Aleppo Pine	RADrazz (Knockout)
Angelonia 'Senena White'	Garden Verbena	Chinese Elm	Red Drift
Angelonia 'Serenita Raspberry'	Homestead Verbena	Oleander	
Blue Plumbago 'Escapade Blue'	Honeysuckle	Pinon Pine	
Helenium 'Dakota Gold'	Lantana 'New Gold'	Texas Sage	
Licorice 'Silver Mist'	Malvaviscus	White Pine	
Petunia 'Baby Duck Yellow'	Mealycup Sage 'Henry Duelberg'		
Petunia 'Mirage Rose'	Mexican Bush Sage		
Petunia 'Spreading'	Purple Ice Plant		
Petunia 'Tidal Wave Silver'	Purple Lantana		
Purslane 'Toucan Hot Mix'	Rosemary		
Vinca 'Titan'	Yarrow		

Table 2. Salt-tolerant annuals, perennials and groundcovers, woody plants, ornamental peppers, ornamental grasses, and garden roses from evaluations conducted at the Texas AgriLife Experiment Station in El Paso and at Texas A&M University in College Station, Texas.

Annuals	Perennials and Groundcovers	Woody Plants	Ornamental Peppers	Ornamental Grasses	Garden Roses
Angelonia 'Serena Lavender Pink'	Blanket Flower	Afghan Pine	Black Pearl	Eulalia 'Sarabande'	Belinda's Dream
Angelonia 'Senena Purple'	Blue Princess Verbena	Aleppo Pine	Calico	Fountain Grass	Climbing Pinkie
Angelonia 'Senena White'	Garden Verbena	Chinese Elm	NuMex Cinco de Mayo	Fountain Grass 'Hameln'	Mrs. Dudley Cross
Angelonia 'Serenita Raspberry'	Homestead Verbena	Oleander	NuMex Easter	Fountain Grass 'Rubrum'	New Dawn
Blue Plumbago 'Escapade Blue'	Honeysuckle	Pinon Pine	NuMex Centennial	Maiden Grass 'Adagio'	Reve d'Or
Helenium 'Dakota Gold'	Lantana 'New Gold'	Texas Sage	NuMex April Fool's Day	Maiden Grass 'Gracillimus'	Sea Foam
Licorice 'Silver Mist'	Malvaviscus	White Pine	NuMex Hallowen	Maiden Grass 'Arabesque'	
Petunia 'Baby Duck Yellow'	Mealycup Sage 'Henry Duelberg'		NuMex Twilight	Petite Banded Miscanthus	
Petunia 'Mirage Rose'	Mexican Bush Sage		NuMex St. Patrick's Day	Variegated Japanese Silver Grass	
Petunia 'Spreading'	Purple Ice Plant		NuMex Valentine		
Petunia 'Tidal Wave Silver'	Purple Lantana				
Purslane 'Toucan Hot Mix'	Rosemary				
Vinca 'Titan'	Yarrow				

speaking, plants can tolerate higher levels of salinity in irrigation water to the roots than "spray" water.

High soil or water salinity applied to plants actually causes a reaction much like drought stress does by preventing the movement of water and nutrients from soil into roots. Therefore, symptoms of drought or salt damage on plants will look similar and include stunted growth, browned leaves and smaller flowers.

Both drought and salinity tolerance are highly species/cultivar dependent. It should not be assumed that a drought-tolerant species or cultivar is also salinity tolerant. For example, zinnias perform fairly well in an arid landscape and they flower all summer long with a low level of irrigation. However, they cannot tolerate high salinity in the soil or irrigation water. Similarly, penstemons and rudbeckias are drought tolerant, but they are not salinity tolerant. Desert Willow is extremely drought tolerant but only moderately salinity tolerant. Rose 'Belinda's Dream' is salinity tolerant, but it is only moderately drought tolerant.

At Texas A&M, we are evaluating which plant species and cultivars are drought and salinity tolerant in the greenhouse and field plots in College Station and El Paso. In the greenhouse drought tolerance studies, plant growth, flowering characteristics and visual quality are compared and evaluated by withholding irrigation to create

Figure 2. The responses of purple ice plant and blue plumbago to EC of 0.8, 3.2, 6.4, and 12.0 dS/m after 2, 6, and 11 weeks of irrigation.

drought stress or irrigating based on moisture sensors to maintain a constant drought level. In the field drought tolerance studies, the irrigation amount and frequency were controlled in each bed to create different levels of drought stress. Then plant growth, visual quality and other physiological parameters are compared and evaluated among species and cultivars to determine their drought tolerance.

In the greenhouse salinity tolerance studies, salt tolerant plants are determined by irrigating plants with treatment solutions at different salinity levels. For example, purple ice plant and hardy blue plumbago were irrigated with four levels of salinity (EC=0.8, 3.2, 6.4 and 12.0 dS/m) (Figure 2). Purple ice plant looked more succulent and dark green as salinity levels increased, and they had acceptable growth at EC of 12.0 dS/m (Figure 2). Hardy blue plumbago had acceptable growth at EC of 3.2 dS/m, and most plants died after 12 weeks of irrigation at EC of 12 dS/m (Figure 2). In the field salinity tolerance study, tap water was used as the control, and saline solutions were stored in the big tanks at different salinity levels. During and at the end of the growing season, plant growth and visual quality were assessed.

After evaluating the plant growth and physiological responses under drought and salt stresses, drought- and salinity-tolerant plants are selected for sustainable landscape development (Table 1 and 2). For example, angelonia 'Lavender Pink' plants did not show any foliar salt damage after three months of irrigation with saline water, but they were compact with smaller growth at higher salinity (Figure 3). Similar responses were seen in vinca 'Titan' (Figure 3).

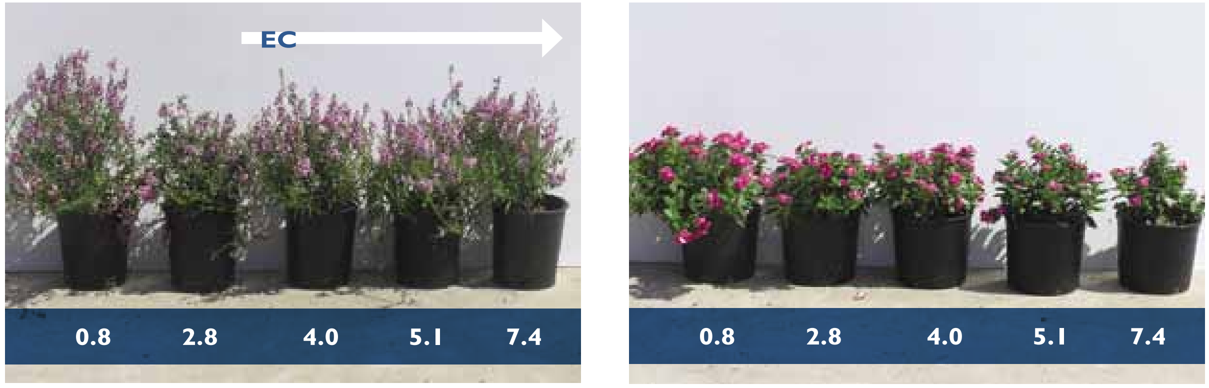

Figure 3. The responses of angelonia 'Lavender Pink' (top) and vinca 'Titan' (bottom) irrigated with water at elevated EC levels (0.8, 2.8, 4.0, 5.1, and 7.4 dS/m).

Landscape Salinity Management

Many factors could affect plant salinity tolerance in landscapes, such as irrigation methods, soil types and environmental conditions (e.g. temperature, wind, relative humidity, precipitation, and ground water level). Better landscape salinity management should start with proper plant selection. Salinity-tolerant plants should be the primary plants grown if salt levels are high in soil extract EC tests or if reclaimed water is chosen as a sustainable alternative to potable water for irrigation. Regardless of salinity tolerance, it should be cautioned that all plants need to be well-watered for initial establishment in the landscape.

Although most plants tolerate irrigation salinity up to 2.0 dS/m, soil salinity could be much higher due to salt accumulation. Vigilance in site assessment with the use of an EC meter to measure salt levels in the soil and water is important to prevent salt accumulation. In addition, an irrigation system for landscape needs to apply enough water to leach salts through the landscape's root zone. Although sprinkler irrigation is the most common method of irrigating landscapes, sprays of salty water onto leaves directly may cause foliar salt injury even at lower salinity levels. A simple adjustment to sprinkler heads to direct the flow of water below the leaf canopy of plants can help to prevent this type of foliar injury. If possible, installing or converting the current irrigation system to drip irrigation and appropriate use of drip provides the most efficient use of water in the landscape and there is no danger of salt spray to landscape plants.

Summary

Overall, the selection of drought- and salinity-tolerant plants is becoming increasingly important for the development of sustainable landscapes. Before planting, it is important to diagnose a potential salinity problem by determining the salt concentration in irrigation water and soil. High salt concentrations are directly toxic to plants, causing problems with foliage discoloration, leaf drop, and root damage. For better salinity management, reclaimed water could be blended with high-quality potable water, together with the implementation of a drainage program to leach excess salts from the root zone. g

Xiaoya Cai is PhD graduate student and Tom Slick Fellow, Genhua Niu (gniu@tamu.edu) is associate professor, Terri Starman (tstarman@tamu.edu) is professor, and Mengmeng Gu (mgu@tamu.edu) is assistant professor and extension specialist at Texas A&M University.