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Response of Selected Wildflower Species to Saline Water Irrigation

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***Abstract*. Wildflowers are good candidates for water-wise landscapes because many of them are drought-tolerant after establishment. Little information is available regarding whether these herbaceous wildflowers are tolerant to salt stress. Container experiments were carried out in a greenhouse and a shadehouse under semiarid climate conditions to investigate the salt tolerance of six native wildflowers: *Salvia farinacea* (mealy cup sage), *Berlandiera lyrata* (chocolate daisy), *Ratibida columnaris* (Mexican hat), *Oenothera elata* (Hooker's evening primrose), *Zinnia grandiflora* (plains zinnia), and *Monarda citriodora* (lemon horsemint). In the greenhouse experiment, mealy cup sage, Hooker's evening primrose, and plains zinnia were irrigated with a saline solution with an electrical conductivity (EC) of 1.5 (control, nutrient solution), 2.8, 4.1, 5.1, or 7.3 dS·m^{-1} for 45 days. All plants survived except for plains zinnia at EC of 7.3 dS·m^{-1}. Shoot dry weights decreased as EC of irrigation water increased for all three species. In the shadehouse experiment (second year), plants of all species (plains zinnia was not included) were irrigated with saline solutions at EC of 0.8 (control, tap water), 2.8, 3.9, 5.5, or 7.3 dS·m^{-1} for 35 days. Plants were fertilized with slow-release fertilizer in the shadehouse experiment. After 5 weeks of treatment, all plants of lemon horsemint in the elevated salinity treatments, regardless of EC levels, were dead. The visual foliar salt damage rating was lowest for lemon horsemint. Chocolate daisy had low survival percentages and low foliar ratings at EC of 5.5 dS·m^{-1} and 7.3 dS·m^{-1}. For the other three species, survival percentages were 80% and 90% at EC of 7.3 dS·m^{-1}. Hooker's evening primrose and mealy cup sage had similar low foliar visual ratings at EC of 7.3 dS·m^{-1}, whereas Mexican hat plants had high foliar visual ratings regardless of salinity treatment. All species had similar high uptake of Na^+ in shoots, whereas Hooker's evening primrose had slightly higher Cl^- concentrations compared with other species. Based on these results, lemon horsemint was most sensitive to salinity stress followed by chocolate daisy. Hooker's evening primrose and mealy cup sage were moderately tolerant and may be irrigated with low salinity water at EC of less than 3.9 dS·m^{-1}. Mexican hat was the most tolerant among the six species.**

Water quantity and quality are critical global issues. As the urban population increases, the competition for high-quality water among agriculture, industry, and domestic water users is becoming progressively intense. Water consumption in urban landscape irrigation increases with urban population expansion (Kjelgren et al., 2000; Qian et al., 2005). Using alternative water sources such as municipal reclaimed water to irrigate urban landscapes can significantly conserve potable water. Municipal reclaimed water is the only water source that increases with population growth (Qian et al., 2005). Many regions with water shortage problems have started to use municipal reclaimed water (also called recycled water) to irrigate golf courses, school yards, and landscapes (Fox et al., 2005; Gori et al., 2000; Jordan et al., 2001; Wu et al., 2001) and for agricultural and horticultural crop production (Dobrowolski et al., 2008; Safi et al., 2007; Shillo et al., 2002). However, reclaimed water frequently contains high salt levels that may cause damage or even death to sensitive plants if not managed properly. Therefore, screening and identifying salt-tolerant landscape plants is urgently needed to expand the use of alternative and reclaimed water for landscape irrigation and nursery production.

Soil salinity is typically high in arid and semiarid regions where temperatures are high and rainfall is low. Irrigation with poor-quality water exacerbates the soil salinity. Typical plant responses to soil salinity include reduced shoot and root growth rates, decreased leaf or shoot number (Munns, 2002), decreased gas exchange rates, foliar salt damage, and even death as salinity increases (Munns and Tester, 2008; Niu and Cabrera, 2010). The degree of these negative responses depends on species and the level of the salinity. Many researchers worldwide have conducted studies on salt tolerance of landscape plants in the past years (e.g., Fox et al., 2005; Gori et al., 2000; Jordan et al., 2001; Marosz, 2004; Niu and Cabrera, 2010; Niu and Rodriguez, 2006a, 2006b; Tanji et al., 2008; Wu et al., 2001; Zollinger et al., 2007). These studies indicate a wide range of salt tolerance existing among different species and cultivars within the same species.

Wildflowers are popular plants in water-wise, low-maintenance landscapes. Planting wildflowers in landscapes could reduce mowing costs and improve soil erosion and soil stabilization (Bretzel et al., 2009). Planting wildflowers in landscapes also increases aesthetic appearance by increasing diversity in colors and vegetation. Herbaceous wildflowers dominate meadows in arid regions of Australia and the western United States (Beran et al., 1999; Kjelgren et al., 2009; Pérez et al., 2010). However, little information is available on the salt tolerance of these herbaceous wildflowers.

To introduce wildflowers in landscapes where poor-quality water with high salinity may be used for irrigation, this study aimed to examine the growth and physiological [osmotic potential (ψ_S) and ion uptake] responses of six native wildflowers to a range of salinity levels in both greenhouse and shadehouse environments under semiarid conditions. The selected wildflowers included were *Salvia farinacea* (mealy cup sage), *Berlandiera lyrata* (chocolate daisy), *Ratibida columnaris* (Mexican hat), *Oenothera elata* (Hooker's evening primrose), *Zinnia grandiflora* (plains zinnia), and *Monarda citriodora* (lemon horsemint). All these species are native to North America and thrive in well-drained soils with full sun conditions in southwestern United States and northern Mexico (Stubbendieck et al., 2003).

Materials and Methods

Greenhouse experiment. Seeds of selected wildflowers were sown in mid-Jan. 2009. Because three species (chocolate daisy, Mexican hat, and lemon horsemint) did not germinate with an insufficient number of seedlings, they were dropped from the greenhouse experiment. Uniform seedlings of the other three wildflower species, mealy cup sage, Hooker's evening primrose, and plains zinnia, were transplanted on 14 Apr. to 2.6-L containers filled with Sunshine Mix No. 4 (SunGro Hort., Bellevue, WA). A week after transplanting, saline water irrigation treatment was initiated.

Saline solution treatments (greenhouse experiment). Saline solutions at EC of 1.5 (nutrient solution, control), 2.8, 4.1, 5.1, and 7.3 dS·m^{-1} were created by adding calculated amounts of sodium chloride (NaCl), magnesium sulfate ($MgSO_4 \cdot 7H_2O$), and calcium chloride ($CaCl_2$) at 87:8:5 (weight ratio) to

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