Response of Selected Wildflower Species to Saline Water Irrigation

Genhua Niu and Denise S. Rodriguez
Texas AgriLife Research Center at El Paso, Texas A&M University System, 1380 A&M Circle, El Paso, TX 79927

Cynthia McKenney
Department of Plant and Soil Science, Texas Tech University, Lubbock, TX 79409

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; Sali et al., 2007; Shiilo 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 (ψs) 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 (MgSO₄·7H₂O), and calcium chloride (CaCl₂) at 87:8:5 (weight ratio) to
the nutrient solution. The nutrient solution was prepared by adding 0.5 g L⁻¹ of 20N–8P–16K of Peter’s 20-20-20 (The Scotts Company LLC, Allentown, PA) to tap water. The EC of tap water was 0.8 dS m⁻¹ and the major ions in the tap water were Na⁺, Ca²⁺, Mg²⁺, Cl⁻, and SO₄²⁻ at 184, 52.0, 7.5, 223.6, and 105.6 mg L⁻¹, respectively. The composition of the treatment saline solutions was similar to the reclaimed municipal effluent of the local water utilities. These EC levels were chosen based on the assumption the salt tolerance of the wildflower plants differed and their EC thresholds, which led to significant growth reduction and foliar salt damage, were within the selected treatment salinity range. The EC levels of reclaimed water, varied with locations and water sources, ranges from 1.0 to 1.9 dS m⁻¹. Saline solutions were prepared in 100-L tanks with confirmed EC levels for each treatment. Plants were irrigated with nutrient (control) or one of the saline solutions at 1 L per container whenever the substrate surface started to dry. Irrigation frequency depended on species (biomass) and climatic conditions. Saline solution irrigation started on 21 Apr. and ended on 3 June (45 d). At treatment initiation, plain zinnia had an average of six leaves; Hooker’s evening primrose had ≈10 leaves, whereas mealy cup sage was ≈20 m height. The temperatures in the greenhouse were maintained at 25.3 ± 1.8 °C (mean ± SD) during the day and 22.0 ± 2.0 °C at night. The daily light integral (photosynthetically active radiation) was 15.8 ± 2.6 mol m⁻² d⁻¹.

**Measurement (greenhouse experiment).** On termination, shoots were harvested and dry weight (DW) was determined after being oven-dried at 70 °C until constant weight was reached. To quantify the salt accumulation, leachate was collected twice, 3 and 5 weeks after the treatment, and the EC of leachate was determined using an EC meter (Model B-173; Horiba, Ltd., Japan). To analyze tissue Na⁺ and Cl⁻ concentrations, four shoot samples per treatment were randomly collected, washed three times with deionized water, and oven-dried at 70 °C. Dried tissue was ground to pass a 40-mesh screen with a stainless Wiley mill (Thomas Scientific, Swedesboro, NJ) and the samples were submitted to the Soil, Water, and Air Testing Laboratory of New Mexico State University (Las Cruces, NM) for Na⁺ and Cl⁻ analyses. Na⁺ concentrations were determined by EPA method 200.7 [U.S. Environmental Protection Agency (EPA), 1983] and analyzed using an Inductively Coupled Plasma/Acmission Emission Spectrophotometer Trace Analyzer (Thermo Jarrell Ash, Franklin, MA). Cl⁻ was determined by EPA method 300.0 (U.S. EPA, 1983) and analyzed using an Ion Chromatograph ( Dionex, Sunnyvale, CA).

**Shadehouse experiment.** Seeds of wildflowers were sown on 2 Feb. 2010 into 406-cell flats filled with Sunshine Mix No. 5 (SunGro Hort.). To improve the germination, flats were covered with aluminum foil and placed into cold storage at 5 °C for 3 to 6 weeks depending on species and were placed back on greenhouse benches when seedling emergence occurred. Seedlings were transplanted to larger cells (vol. 26 mL) on 26 Mar. and 9 Apr., depending on species, and grown in the greenhouse. On 29 Apr., seedlings were transplanted to 2.6-L containers filled with Sunshine Mix No. 4 (SunGro Hort.). On 6 May, a slow-release fertilizer, Osmocote 14.0N–6.1P–11.6K (4-month release time; Scotts-Sierra Hort. Products, Marysville, OH), was applied to all plants at 13 g per pot and Marathon (OHP, Inc., Mainland, PA) was applied at 1 teaspoon per pot. On 7 May, plants were moved to a shadehouse with 25% light exclusion and were irrigated with tap water until saline solution treatments were initiated on 20 May. At treatment initiation, chocolate daisy and Mexican hat had an average of 14 leaves, Hooker’s evening primrose had ≈20 leaves, and mealy cup sage and lemon horsemint were 20 to 30 cm in height.

**Saline solution treatments (shadehouse experiment).** Saline solutions with an EC of 0.8 (tap water, control), 2.8, 3.9, 5.5, and 7.3 dS m⁻¹ were prepared by adding calculated amounts of sodium chloride (NaCl), magnesium sulfate (MgSO₄·7H₂O), and calcium chloride (CaCl₂) at 87:8:5 (weight ratio) to tap water. The preparation of saline solutions and irrigation method were similar to those in greenhouse experiment except for the base solution in which tap water was used in this experiment because a fertilizer injector was not available in the shadehouse. The outdoor climatic conditions during the shadehouse experiment period were: average daily air temperatures at 28.5 ± 2 °C, relative humidity at 19.8% ± 7.3%, solar radiation at 29.5 ± 2.6 MJ m⁻² d⁻¹, and four instances of rainfall with a total of 68 mm recorded by an on-site weather station.

**Measurements (shadehouse experiment).** Foliar salt damage was rated by giving a visual score based on a criterion referenced scale from 0 to 5, where 0 = dead, 1 = over 90% foliar damage (salt damage: burning, necrosis, and discoloration), 2 = moderate (50% to 90%) foliar damage, 3 = slight (less than 50%) foliar damage, 4 = good quality with minimal foliar damage, and 5 = excellent with no foliar damage. The foliar salt damage rating did not consider the plant size. For example, a score of 5 was given to a plant if no salt damage was visible, although the plant was more compact compared with the control.

**Leaf Ψₛ** was determined as described in Niu and Rodriguez (2006a) and Niu et al. (2010). Specifically, leaves were sampled from the middle section of the shoots in the early morning at the end of the experiment, washed in deionized water and dried with a paper towel, sealed in a plastic bag, and immediately stored in a freezer at –20 °C until analysis. Frozen leaves were thawed in a plastic bag at room temperature before sap was pressed out with a Markhart leaf press (LP-27; Wescor, Logan, UT) and analyzed using a vapor pressure osmometer (Vapro Model 5520; Wescor).

**Survival percentage** was calculated as follows: number of surviving plants at the end of the experiment/total number of plants × 100%. Shoot DW, leachate EC, and shoot Na⁺ and Cl⁻ were determined with the same methods as described in the greenhouse experiment.

**Experimental design and statistical analysis.** Both experiments followed a split-plot design with salinity of irrigation water as the main plot and species subplots with 10 replications. All data were analyzed by a two-way analysis of variance using PROC GLM. When the main effect was significant, linear regression was performed using PROC REG. To determine the differences among salinity levels on plant growth, Student-Newman-Keuls multiple comparisons were performed. All statistical analyses were performed using SAS software (Version 9.1.3; SAS Institute Inc., Cary, NC).

**Results**

**Greenhouse experiment.** Shoot DW of mealy cup sage and Hooker’s evening primrose decreased at elevated salinity levels compared with the control; however, no differences were found among the elevated EC treatments except for mealy cup sage at EC of 7.3 dS m⁻¹ (Table 1). For plains zinnia, plants grew slowly and no substantial differences in shoot DW among treatments were observed. At an EC of 7.3 dS m⁻¹, all plains zinnia were dead by the end of the experiment. Leachate EC, collected 3 and 5 weeks after the initiation of the treatment (averaged), were 3.53 dS m⁻¹, 7.43 dS m⁻¹, 10.40 dS m⁻¹, 12.64 dS m⁻¹, and 16.63 dS m⁻¹ for treatments of control, EC 2.8, EC 4.1, EC 5.1, and EC 7.3, respectively.

No interactive effect of treatment and species on shoot Na⁺ concentration was found (Table 2). No differences in shoot Na⁺ concentrations among species were found regardless of EC level of the irrigation water. However, both species and treatment interactively

---

Table 1. Dry weight of shoots of three wildflower species irrigated with saline solution at electrical conductivity (EC) of 1.5 (control, nutrient solution), 2.8, 4.1, 5.1, or 7.3 dS m⁻¹ for 45 d (greenhouse experiment).

| Species                  | EC 1.5 | EC 2.8 | EC 4.1 | EC 5.1 | EC 7.3 |
|--------------------------|--------|--------|--------|--------|--------|
| Mealy cup sage           | 19.4 A | 12.7 B | 12.5 B | 10.0 BC| 6.7 C  |
| Hooker’s evening primrose| 35.5 A | 12.9 B | 12.4 B | 11.1 B | 7.5 B  |
| Plains zinnia            | 3.5 A  | 3.3 AB | 3.0 AB | 1.9 B  | 1.4 C  |

*Means with same capitalized letters in the same row (among treatments) were not different tested by Student-Newman-Keuls multiple comparisons at P = 0.05.

*Not measured (dead or not enough replicates).
affected shoot Cl– concentration. Shoot Na+ and Cl– concentrations increased with increasing EC in the irrigation water in all species. For example, in mealy cup sage, Na+ increased from 2.2 mg m–1 in control to 24.5 mg m–1 at EC of 7.3 dS m–1, whereas Cl– increased from 21.4 mg m–1 to 60.4 mg m–1 in control to EC of 7.3 dS m–1. Compared with the other species, Hooker’s evening primrose had higher Cl– concentrations at elevated EC levels.

**Shadehouse experiment.** Among the five species, lemon horsemint did not survive at all elevated salinity levels by the end of the 5-week treatment (Table 3). Plains zinnia was excluded as a result of an insufficient number of seedlings. Eighteen days after treatments, the survival percentages were 60%, 30%, 20%, and 20% for plants irrigated at EC of 2.8, 3.9, 5.5, and 7.3 dS m–1, respectively. For chocolate daisy, the survival percentages were 30% at EC of 5.5 dS m–1 and 7.3 dS m–1 on Day 18. Foliar visual ratings were lowest for lemon horsemint. Chocolate daisy plants had low visual 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 the highest salinity level (Table 3). Hooker’s evening primrose and mealy cup sage had similar low visual ratings at EC of 7.3 dS m–1, whereas Mexican hat plants had high ratings regardless of salinity treatment (Table 4).

Shoot DW of all surviving species decreased linearly as salinity of irrigation water increased, except for chocolate daisy, which was unaffected by salinity (Fig. 1). Chocolate daisy grew slowly during the experimental period with large variations among individual plants and, therefore, no significant differences were observed among the treatments. For mealy cup sage, shoot DW was not different among control, EC of 2.8, 3.9, and 5.5 dS m–1. For Mexican hat and Hooker’s evening primrose, no differences were found in shoot DW between the control and EC of 2.8 dS m–1. According to the linear regression in Figure 1, shoot DW decreased 0.96 g, 1.0 g, and 1.34 g in Mexican hat, mealy cup sage, and Hooker’s evening primrose, respectively, as the salinity of irrigation water increased by 1.0 dS m–1.

Leachate salinities were pooled from species because species did not affect leachate EC. The average EC of leachate measured in the middle of the experiments were 3.8, 7.1, 11.8, 14.6, and 16.2 dS m–1 for treatments of EC 0.8 (control), 2.8, 3.9, 5.5, and 7.3 dS m–1, respectively.

Leaf ψw in the control was highest in lemon horsemint among the five species, indicating this species had the lowest in osmotic adjustment (Table 5). Because no plants of lemon horsemint survived, there was no data of ψw to compare with other species. Generally, leaf ψw decreased at higher salinity treatments (EC 5.5 and 7.3 dS m–1) in Mexican hat, mealy cup sage, and Hooker’s evening primrose. In the surviving plants of chocolate daisy, Mexican hat, and mealy cup sage, no differences in ψw were found among control, EC of 2.8, and 3.9 dS m–1.
Shoot Na⁺ and Cl⁻ concentrations in all surviving species increased with increasing EC of the irrigation water (Table 6). At EC of 5.5 dS·m⁻¹ and 7.3 dS·m⁻¹, Hooker’s evening primrose, Mexican hat, and mealy cup sage had similar shoot Na⁺ and Cl⁻ concentrations.

Among the species in the control, shoot Na⁺ was higher in chocolate daisy compared with those in lemon horsemint and Hooker’s evening primrose, whereas no differences were found in Cl⁻ in the control among species. All species had similar shoot Cl⁻ concentrations except at EC of 2.8 dS·m⁻¹ and 3.9 dS·m⁻¹ in which Hooker’s evening primrose had higher Cl⁻ concentrations compared with other species, which agreed with the results in the greenhouse experiment.

**Discussion**

Shannon and Grieve (1999) defined the salt tolerance of crops as the inherent ability of plants to withstand the effects of high salt concentrations in the root zone or on the leaves without a significant adverse effect. For ornamental plants, tolerance of salt stress can be assessed based on survival rate, with or without foliar salt damage or the degree of foliar salt damage, and growth. Aesthetic appearance is more important in ornamental plants than maximum growth and researchers used visual ratings to compare relative salt tolerance among tested species (Cameron et al., 2004; Fox et al., 2005; Zollinger et al., 2007). According to these criteria, lemon horsemint was no doubt the most sensitive species among the six followed by chocolate daisy. Mexican hat was the most tolerant, and Hooker’s evening primrose and mealy cup sage performed similarly. Although not included in the shadehouse experiment, plains zinnia did not survive when irrigated with saline solution at EC of 7.3 dS·m⁻¹ in the greenhouse experiment, which may indicate less tolerance to salinity compared with mealy cup sage and Hooker’s evening primrose. It is recommended to further confirm the tolerance of this species.

In a separate study, several cultivars of *Z. marylndica* and *Z. maritima*, which performed well in landscapes under semiarid climate conditions (high heat and drought stresses), were not tolerant to salinity (Niu et al., 2012). Interestingly, the most tolerant Mexican hat and the most sensitive lemon horsemint have similar native habitats: prairie, plains, meadows, pastures, savannahs, and roadsides, according to the Native Plant Database (2012).

The salinity threshold of irrigation water is usually different from the soil salinity threshold. This is because salts accumulate in the root zone, which depends on irrigation leaching fraction, salinity of the irrigation water, irrigation frequency and amount, and substrate or soil property. In the situation of a container study, salt accumulation can be quantified by monitoring leachate salinity.

Table 5. Leaf osmotic potential (ψₛ) measured at the end of the experiment of five wildflower species irrigated with saline solution at electrical conductivity (EC) of 0.8 (control, tap water), 2.8, 3.9, 5.5, or 7.3 dS·m⁻¹ for 5 weeks (shadehouse experiment).

| Species               | EC = 0.8 | EC = 2.8 | EC = 3.9 | EC = 5.5 | EC = 7.3 |
|-----------------------|----------|----------|----------|----------|----------|
| Chocolate daisy       | −1.59 A b| −1.71 A a| −1.43 A a| −1.72 A | −1.87 A |
| Lemon horsemint       | −1.29 A  |          |          |          |          |
| Hooker’s evening primrose | −1.81 AB bc | −1.76 A a | −2.25 DC c | −2.15 BC a | −2.50 D a |
| Mexican hat           | −1.66 AB bc| −1.76 A a| −1.95 AB b | −2.17 B a | −2.51 C a|
| Mealy cup sage        | −1.92 A c| −2.12 AB b| −2.21 ABC c| −2.33 BC a| −2.53 C a|

*Means with same capitalized letters in the same row (among treatments) were not different; means with same small letters in the same column (among species) were not different tested by Student-Newman-Keuls multiple comparisons at P > 0.05.*

Table 6. Shoot Na⁺ and Cl⁻ concentration of five wildflower species irrigated with saline solution at electrical conductivity (EC) of 0.8 (control, tap water), 2.8, 3.9, 5.5, or 7.3 dS·m⁻¹ for 5 weeks (shadehouse experiment).

| Species              | EC = 0.8 | EC = 2.8 | EC = 3.9 | EC = 5.5 | EC = 7.3 |
|----------------------|----------|----------|----------|----------|----------|
| Chocolate daisy      | 8.4 B a  | 12.8 A a | 12.8 A a |          |          |
| Lemon horsemint      | 3.2 b    |          |          |          |          |
| Hooker’s evening primrose | 2.0 B b   | 2.2 B c | 8.9 A B a | 11.3 A a | 11.6 A a |
| Mexican hat          | 3.8 B ab | 8.3 B ab | 7.4 B a | 19.2 A a | 13.4 A a |
| Mealy cup sage       | 4.3 B ab | 7.8 B b | 17.3 A a | 17.9 A a | 19.6 A a |

| Species              | EC = 0.8 | EC = 2.8 | EC = 3.9 | EC = 5.5 | EC = 7.3 |
|----------------------|----------|----------|----------|----------|----------|
| Chocolate daisy      | 14.4 B a| 25.3 A b | 25.9 A b |          |          |
| Lemon horsemint      | 23.2 a   |          |          |          |          |
| Hooker’s evening primrose | 17.2 C a  | 35.5 B a | 44.3 A a | 46.1 A a | 47.7 A a |
| Mexican hat          | 17.0 C a | 25.2 B a | 24.4 B b | 34.2 A a | 43.0 A a |
| Mealy cup sage       | 11.8 B a| 27.2 A b | 31.2 A b | 36.1 A a | 36.7 A a |

*Means with same capitalized letters in the same row (among treatments) were not different; means with same small letters in the same column (among species) were not different tested by Student-Newman-Keuls multiple comparisons at P > 0.05.*
Kjelgren, R., L. Wang, and D. Joyce. 2009. Water deficit stress responses of three native Australian ornamental herbaceous wildflower species for water-wise landscapes. HortScience 44:1358–1365.

Marozi, A. 2004. Effect of soil salinity on nutrient uptake, growth, and decorative value of four ground cover shrubs. J. Plant Nutr. 27:977–989.

Munn, R. 2002. Comparative physiology of salt and water stress. Plant Cell Environ. 25:239–250.

Munn, R. and M. Tester. 2008. Mechanisms of salinity tolerance. Annu. Rev. Plant Biol. 59:651–681.

Native Plant Database. 2012 (July). <http://www.wildflower.org>.

Wang, L., X. Guo, and A. Harivandi. 2001. Salt tolerance and salt accumulation of landscape species. J. Plant Nutr. 24:1473–1490.

Zollinger, N., R. Koenig, T. Cerny-Koenig, and R. Kjelgren. 2007. Relative salinity tolerance of intermountain western United States native herbaceous perennials. HortScience 42:529–534.