

Response of *Zinnia marylandica* Cultivars to Salinity

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Significance to Industry: Zinnias, whose Mexican heritage is reflected in their bright colors, prolific bloom and ability to handle hot, dry summer conditions are one of the most widely cultivated species and is prized among garden ornamentals in the United States (1). As salt-affected land spreads rapidly all over the world, the demand for salt tolerant ornamentals increases. With the rapidly increasing population and industrial development, the availability of fresh water is limited. Alternatively, reclaimed water plays an important role in irrigating landscapes (2,3). Therefore, selecting plant varieties with greater tolerance to salt stress is of increasing importance. This study investigated the response of six zinnia cultivars to elevated salinity. The results, based on growth and survival rate, indicated that the selected *Zinnia* cultivars are moderately sensitive to salt stress.

Nature of Work: Seeds of the *Zinnia (Zinnia marylandica)* cultivars, 'Zahara Yellow', 'Zahara White', 'Zahara Scarlet', 'Zahara Rose Starlight', 'Zahara Fire', and 'Zahara Coral Rose' were sown on 13 Aug. 2009 into 72-cell trays filled with a Sunshine Mix No. 5 (SunGro Hort., Bellevue, WA) and placed under a misting bench. Seedlings were transplanted on 31 Aug. to 4-inch plastic pots filled with Sunshine Mix No. 4 (SunGro Hort.). Plants were grown in the greenhouse and sub-irrigated with nutrient solution until treatments were initiated on 8 Sept. During the experimental period, the average air temperature in the greenhouse was maintained at 28.9 ± 2.5 °C (mean \pm standard deviation) during the day and 23.0 ± 0.6 °C at night. The average daily light integral (photosynthetically active radiation) was 16.7 ± 3.9 mol·m⁻²·d⁻¹.

Saline solutions were prepared by adding appropriate amounts of sodium chloride (NaCl), magnesium sulfate (MgSO₄·7H₂O), and calcium chloride (CaCl₂) at 87%, 8%, and 5%, respectively, on a weight basis to a nutrient solution which was made by adding 0.5 g·L⁻¹ of 20N-8.6P-16.7K (Peters 20-20-20; Scotts) to tap water (3). Five salinity levels of 1.4 dS·m⁻¹ (nutrient solution, control), 2.5, 4.0, 6.0, and 8.0 dS·m⁻¹ electrical conductivity (EC) were created. The main ions in the tap water were Na⁺,

Ca^{2+} , Mg^{2+} , Cl^- , and SO_4^{2-} at 184, 52.0, 7.5, 223.6, and 105.6 $\text{mg}\cdot\text{L}^{-1}$, respectively. The composition of saline solutions was similar to that of the reclaimed municipal effluent of the local water utilities. The EC for each treatment was confirmed before irrigation every time. Treatments were initiated on 8 Sept. and ended on 4 Oct. Plants were sub-irrigated as needed. Irrigation intervals varied with treatments and weather conditions.

Upon termination of the experiment, plant height and time to flower were recorded. Shoot DW was determined after oven-drying at 70 °C. The experiment used a split-plot design with irrigation water as the main plot and species as the subplots with 6 replications. Since there was an interaction between treatment and cultivar, data were analyzed separately by cultivar. Treatments at EC of 6.0 $\text{dS}\cdot\text{m}^{-1}$ and 8.0 $\text{dS}\cdot\text{m}^{-1}$ were excluded in the analysis because no plants survived. A two-way ANOVA using PROC GLM was performed. To distinguish the differences among the treatments, Student-Newman-Keuls multiple comparison was performed. All data were analyzed using SAS software (Version 9.1.3, SAS Institute Inc., Cary, NC).

Results and Discussion: Salinity treatment and cultivars had interactive effects on plant height, shoot DW and time to flower, indicating that zinnia responses to salinity differed among cultivars. No plants survived, regardless of cultivar, at EC of 6.0 and 8.0 $\text{dS}\cdot\text{m}^{-1}$. Mortality started to occur around 20 days after initiation of the treatment for all cultivars.

Plant height for all cultivars decreased as the EC of irrigation water increased, except for 'Zahara Yellow' whose height was similar among the treatments (Fig. 1). Compared to the control, plant height of 'Zahara White', 'Zahara Scarlet', 'Zahara Rose Starlight', 'Zahara Fire', and 'Zahara Coral Rose' at 4.0 $\text{dS}\cdot\text{m}^{-1}$ was reduced by 20.6%, 22.7%, 28.6%, 27.6% and 37.5%, respectively. Shoot dry weight (DW) of all cultivars decreased as EC increased (Fig. 2). At EC of 4.0 $\text{dS}\cdot\text{m}^{-1}$, shoot DWs of 'Zahara Yellow', 'Zahara White', 'Zahara Scarlet', 'Zahara Rose Starlight', 'Zahara Fire', and 'Zahara Coral Rose' were reduced by 52.2%, 49.3%, 53.6%, 50.9%, 55.4% and 57.3%, respectively, compared to control. There was no difference in shoot DW of 'Zahara White' between control and 2.5 $\text{dS}\cdot\text{m}^{-1}$.

No differences were observed in time-to-flower for 'Zahara Yellow', 'Zahara Scarlet', and 'Zahara Rose Starlight' (Fig. 3). For 'Zahara Fire' and 'Zahara Coral Rose', flowering at 4.0 $\text{dS}\cdot\text{m}^{-1}$ was delayed for 3 and 2 days, respectively, compared to control. However, the response of time to flower in 'White' was different. Nevertheless, the difference in time to flower was small and may be insignificant commercially. Elevated salinity reduced flower size in all cultivars but did not affect the number of flowers per plant (data not presented).

A number of bedding plants were found to be moderately tolerant to salinity (4). However, this study indicated that the selected six zinnia cultivars were moderately sensitive to salinity based on their growth response and mortality at EC of 6.0 and 8.0 $\text{dS}\cdot\text{m}^{-1}$. Therefore, these zinnia cultivars should not be used for landscapes with poor-

quality irrigation water or on soil with high salinity. Further study is underway to confirm the results and to determine the salinity threshold of zinnia by irrigating plants from the substrate surface instead of sub-irrigation.

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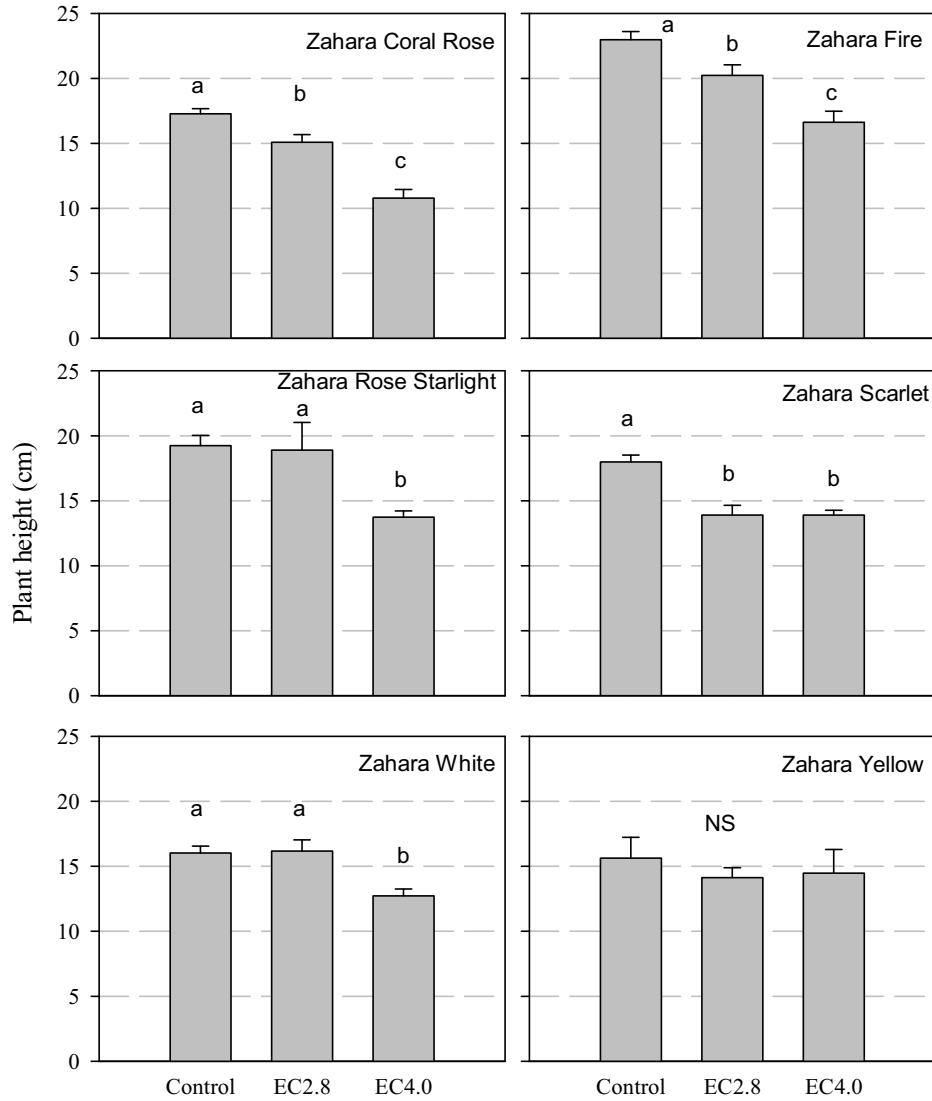


Figure 1. Effect of salinity treatment on height of the six selected *Zinnia marylandica* cultivars. Means followed by the same letters are not significantly different as indicated by Student-Newman-Keuls multiple comparison at $P = 0.05$. Vertical bars represent standard errors.

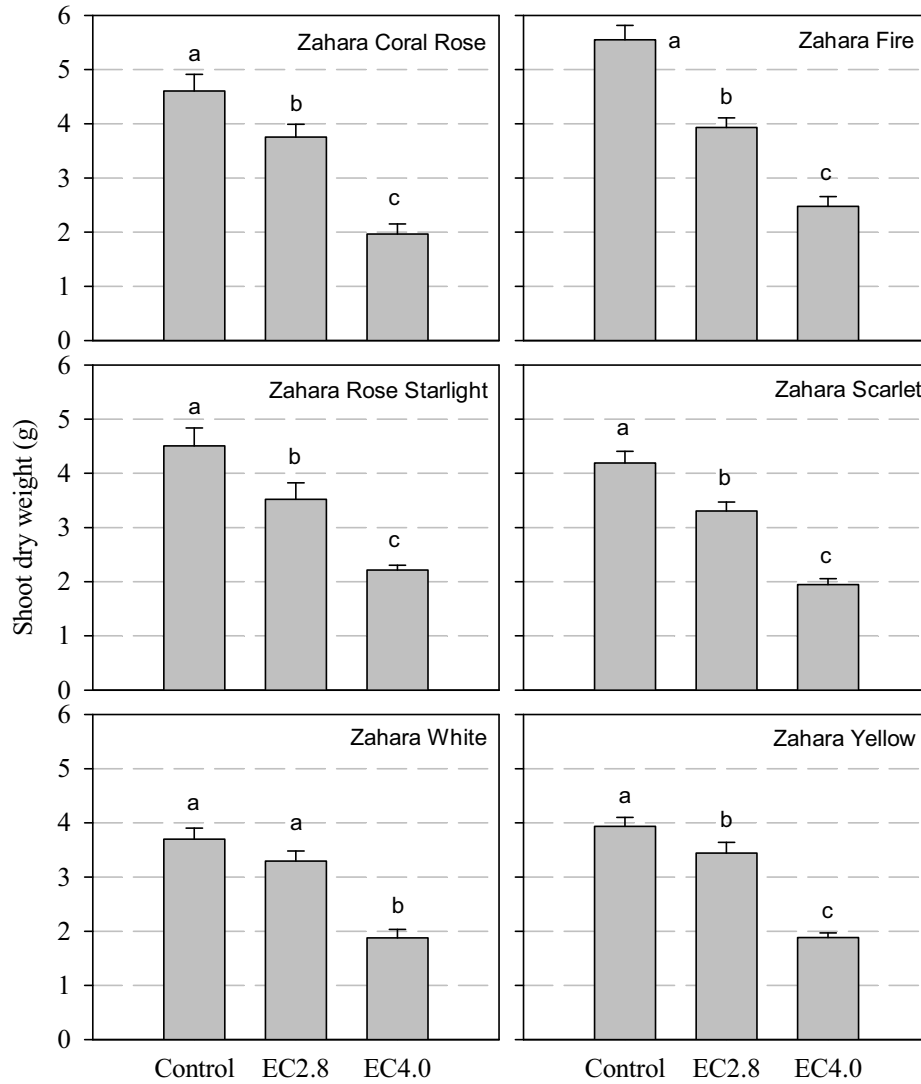


Figure 2. Effect of salinity treatments on shoot dry weight of the six selected *Zinnia marylandica* cultivars. Means followed by the same letters are not significantly different as indicated by Student-Newman-Keuls multiple comparison at $P = 0.05$. Vertical bars represent standard errors.

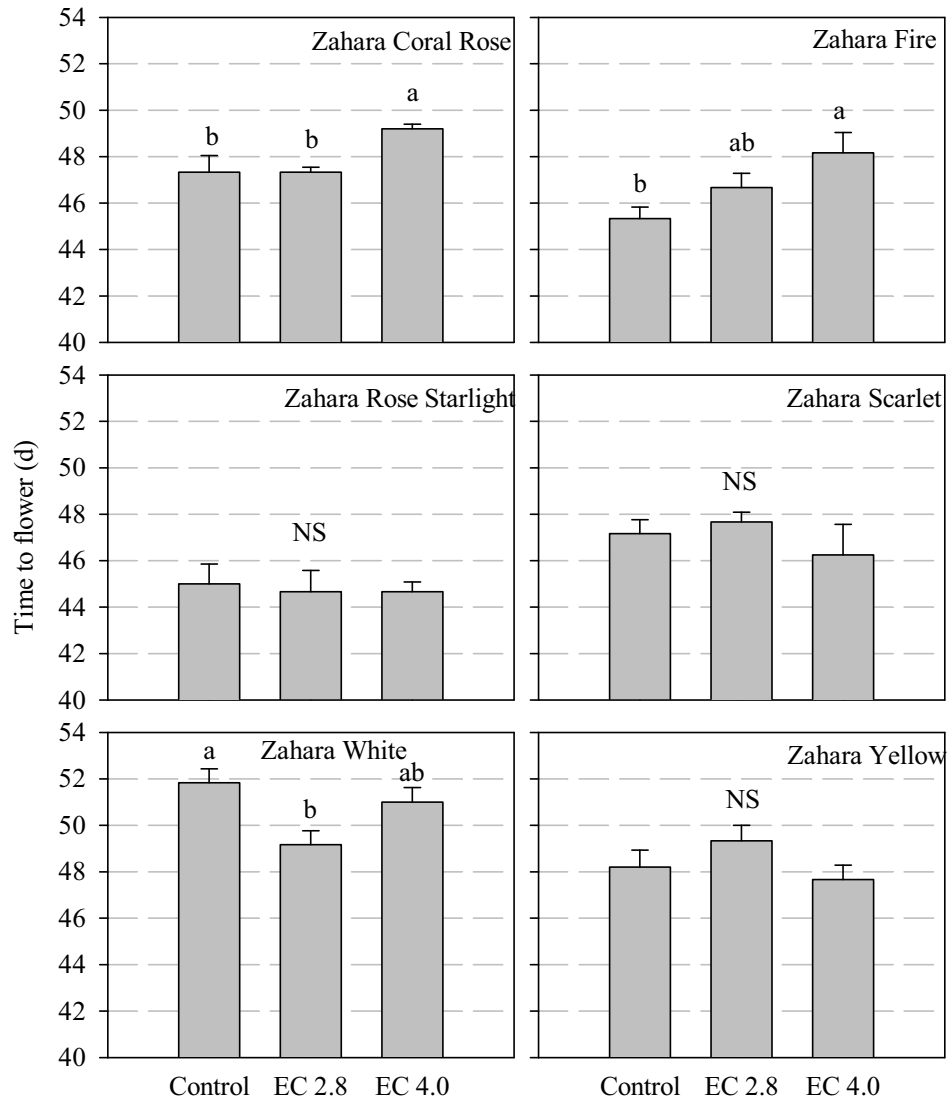


Figure 3. Effect of salinity treatments on days-to-flower of the six selected *Zinnia marylandica* cultivars. Means followed by the same letters are not significantly different as indicated by Student-Newman-Keuls multiple comparison at $P = 0.05$. Vertical bars represent standard errors.