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GROWTH AND PHYSIOLOGY OF SALICORNIA BIGELOVII TORR. AT SUBOPTIMAL SALINITY

FELIX AYALA[1] AND JAMES W. O'LEARY[2]

Department of Plant Sciences, College of Agriculture, University of Arizona, Tucson, Arizona 85721

Salicornia bigelovii Torr. plants were grown in 5, 200, or 600 mol m^{-3} NaCl, representing suboptimal, optimal, and supraoptimal salinities, respectively. Shoot fresh and dry mass of plants grown at optimal salinity were more than 2× higher than those grown at the other two salinities. In spite of the comparable growth reductions at sub- and supraoptimal salinities, the physiological responses, and presumably the causes of the growth reductions, were not the same at those two salinities. Water and osmotic potentials of the shoots decreased significantly with increasing salinity, but turgor potentials did not differ significantly among treatments. Differences in photosynthetic rates were not consistent with the differences in growth. Rates were significantly higher in plants grown at 5 mol m^{-3} NaCl when expressed relative to photosynthetic area, but when photosynthesis was expressed relative to the amount of chlorophyll, no significant differences were found among salinities. Stomatal conductance decreased with increasing salinity, resulting in a significantly higher transpiration rate at the lowest salinity than at the other two levels. Dark respiration was not significantly affected by salinity. Sodium concentration in shoots and roots increased with salinity. Potassium, calcium, and magnesium were highly concentrated in shoots and roots of plants grown at 5 mol m^{-3} NaCl. Excessive NaCl, however, induced calcium and magnesium deficiencies in plants grown at supraoptimal salinity.

Introduction

Some of the more extreme halophytes, often called euhalophytes, are capable of growth rates and total biomass productivities at salinity concentrations exceeding that of seawater (O'Leary et al. 1985; Glenn et al. 1991) that equal those of crop plants and other glycophytes grown with fresh water. Euhalophytes and glycophytes are similar in that they both exhibit growth reduction with increasing salinity, but this response differs in two important ways. First, glycophytes in general have reduced growth with all salinities beyond the range of zero to about 50 mol m^{-3}, but euhalophytes typically do not exhibit reduced growth until the salinity exceeds the range of about 100–200 mol m^{-3} (Flowers et al. 1986). Second, in those glycophytes that do not exhibit reduced growth until the salinity exceeds ca. 50 mol m^{-3}, the response curve is flat between that level and zero, but in euhalophytes, growth decreases considerably as salinity decreases from the 100–200 mol m^{-3} range to zero (Greenway and Munns 1980; Munns et al. 1983). That is, those plants have adapted so well to functioning at high salinities that the optimal salinity for maximum growth is in the range of 100–200 mol m^{-3}, and growth is significantly reduced as salinity increases or decreases beyond that range. A substantial amount of research has addressed the response of both glycophytes and halophytes to supraoptimal salinity, but comparatively little attention has been devoted to the question of why those plants that are highly adapted to salinity have lost the ability to grow as well at salinities lower than 100–200 mol m^{-3}. Answers to that question would contribute to increasing our understanding of how plants have adapted to highly saline environments and would also provide helpful insight into determining which physiological processes should be targeted in attempts to improve genetically the ability of crop plants to tolerate higher salinities.

Salicornia bigelovii Torr. is a succulent, C_3 annual species that occurs in coastal estuaries and is, arguably, the most salt tolerant vascular plant. It has been reported to have maximum growth at about 170–200 mol m^{-3} NaCl (Webb 1966; Weeks 1986). Based on those reports and preliminary studies of our own, we identified 5, 200, and 600 mol m^{-3} NaCl as representative of suboptimal, optimal, and supraoptimal ranges of salinity, respectively. These concentrations gave equivalent reductions in growth at both sub- and supraoptimal salinities and allowed us to compare and contrast the responses to both sub- and supraoptimal salinities. We found that, in spite of the similar growth reductions under those salinities, the physiological responses under those salinities, and presumably the causes of the growth reductions, were very different.

Material and methods

Plants and experimental conditions

Salicornia bigelovii seeds were collected in the autumns of 1991 and 1992 from plants growing in Estero Morúa, a coastal estuary located 7.5 km east of Puerto Peñasco, Sonora, Mexico (31°17′N, 113°24′W). A series of greenhouse experiments was carried out from May 1992 to July 1993. Night temperatures ranged from 15° to 26°C and day temperatures ranged from 26° to 32°C. Photosynthetically active radiation measured at noon ranged from 450 to 1,350 μmol m^{-2} s^{-1}, and

[1]Present address: Unidad Regional Norte Universidad de Sonora, Santa Ana, Sonora, Mexico 84600.
[2]Author for correspondence and reprints.

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