salinity. At low salinity, however, leaf expansion rates, turgor pressure, and photosynthetic rates are maintained while growth declines, suggesting that other factors must also limit growth potential. Species like alkali bulrush that exclude mineral salts use a considerable proportion of their photosynthetic products for osmotic adjustment, and this process must certainly compete with growth. Like related species, alkali bulrush may accumulate sugars under stress, and this may explain its desirability for herbivores. In contrast, pickleweed utilizes soil salts rather than photosynthetic products for osmotic adjustment, accounting for much of its stimulated growth under salinity — and its salty taste.

Alkali bulrush and pickleweed thus show that halophytes differing greatly in physiology and in vegetative and reproductive growth patterns can grow in equally saline soils. Rapid growth rates during periods of low soil salinity and greater plant height, combined with vegetative propagation from spreading rhizomes and tubers, probably allow alkali bulrush to compete successfully with the more salt-tolerant pickleweed. Better understanding of the diverse adaptations of halophytes to salinity should aid agriculturists in selecting for increased salt-tolerance in existing cultivated species, and perhaps in the development of new crops.

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Salt tolerance of mesquite

Wesley M. Jarrell **Ross A. Virginia**

California's native mesquite grows primarily in areas of shallow ground water where temperatures are rarely below 24°F. Many of these areas have naturally occurring saline surface or subsurface soils — up to 88 dS/m (about 56,300 mg/L) in the saturation extract. Root systems of mesquite, including the native species, *Prosopis glandulosa* var. *torreyana*, are well adapted for growth in areas where the plant must rely primarily on ground water. Another species, *Prosopis tamarugo*, native to the Atacama Desert of Chile, where average annual rainfall is less than ½ inch, relies wholly on groundwater derived from snow and rain in the Andes Mountains.

Over the past several years, mesquite varieties have been considered as sources of biomass for firewood, forage, and energy generation, but these trees are not likely to replace conventional crops where water and soil quality are good. On marginal lands, however, especially where moderately saline groundwater or surface water is available, salt-tolerant woody species may be grown without competing with agronomic crops for resources.

In research to learn the extent of this plant's salinity tolerance, we took soil samples from a field site of native mesquite near the Salton Sea. The surface soil had an electrical conductivity in the saturation extract as high as 20 dS/m (salinity of about 12,800 mg/L). This surface zone, down to 20 or 24 inches, was heavily rooted with fine absorbing roots, even though average annual rainfall on the site is less than 3 inches. The groundwater, at about a 16-foot depth, had an electrical conductivity of 2.8 dS/m (about 1,800 mg/L). Based on soil samples taken in 1-foot increments down to the water table, we found there tended to be a bulge in concentration (up to 12 dS/m — 7,700 mg/L) between 3 and 6 feet above the water table. Fine roots generally occurred within 3 feet of the water table, with electrical conductivities as high as 5 dS/m (3,200 mg/L) in this zone.

To further define mesquite's sensitivity to groundwater salinity, we started seedlings in the greenhouse in 6-foot-tall polyvinyl chloride columns containing sandy loam soil. The bottom 4 inches of soil were kept saturated with one of three simulated groundwaters based on 0.5, 1, or 2 times the field groundwater composition: 1.7, 2.8, or 5.5 dS/m (about 1,000, 1,800, or 3,500 mg/L). Plants were grown for 10 months and then harvested. At harvest, average weights of the 2.8 and 5.5 dS/m plants were 80 and 45 percent, respectively, of the 1.7 dS/m plants' weight. In the most highly salinized zone 12 inches above the water table, electrical conductivity exceeded 29 dS/m (18,500 mg/L) in the high-salt treatments.

Total nitrogen accumulated through symbiotic nitrogen fixation by the tree also decreased with increasing salinity: nitrogen in the 2.8 and 5.5 dS/m treatments was 83 and 44 percent, respectively, of that in the 1.7 dS/m treatment. Active nodules occurred even in the most highly salinized zone.

Mesquite appears able to survive and even flourish in soils more saline than 20 dS/m (12,800 mg/L), if the tree can obtain water from a portion of the root zone with lower salinity. The roots can apparently continue to extract water from soil with salinities greater than 28 dS/m (17,900 mg/L). Further research is required to determine how long salts can accumulate in the subsaturated zone above the water table before growth is seriously decreased or the plant dies. It is apparent, however, that the trees rapidly produce substantial amounts of biomass, using low-quality, saline waters, relying on nitrogen fixation with little or no soil or fertilizer nitrogen.

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Mesquite flourishes in soils of greater than 12,800 mg/L salt, if its roots can obtain water of lower salinity.