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Soil Salinity, Salt Tolerance, and Growth Potential of Horticultural and Landscape Plants

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Soil salinity

All soils contain some water-soluble salts. Plants absorb essential plant nutrients in the form of soluble salts, but excessive accumulation of soluble salts, called **soil salinity**, suppresses plant growth. Saline or salt-affected soils are common in arid and semi-arid regions. Salts in the soil occur as ions (electrically charged forms of atoms or compounds). Ions are released from weathering minerals in the soil. They may also be applied in irrigation water or as fertilizers, or migrate upward in the soil from shallow groundwater. When precipitation is insufficient to leach ions from the soil profile, salts accumulate in the soil and soil salinity can result.

Poor drainage (the most common cause of soil salinity) and/or poor irrigation water often contribute to soil salinity. As plants absorb soil water or as water evaporates, salts from the water remain in the soil. For this reason, soil salinity will usually be greater than the salinity of the irrigation water used. Improper irrigation management increases the risk of developing soil salinity. To prevent salt buildup, enough water must be passed through the root zone to leach salts from the soil. Keep in mind that some of these salts are also essential plant nutrients. Some salts (i.e. nitrate) may become environmental pollutants if leached into groundwater.

The general effect of soil salinity on plants is called an **osmotic effect**. This means that salts increase the energy with which water is held in the soil. In other words, the soil must be kept wetter to supply the same amount of **plant-available water** as would be present without the salts. Plants then must increase the energy they expend to obtain water from the soil. The plant must use energy to get water that would otherwise be used for growth, flowering, or fruiting. When soil salinity exceeds a plant's tolerance, growth reductions occur. As salt concentration increases, water becomes increasingly difficult for the plant to absorb. A plant can actually die from water stress or drought in a moist soil if the salt concentration becomes high enough.

Other effects of salts on plants are toxicities of specific salts and nutritional imbalances. Some elements, such as sodium, chlorine, and boron, have specific toxic effects on plants. Plants sensitive to these elements may be affected at relatively low salt levels if the soil contains enough of the toxic element. Because many salts are also plant nutrients, high salt levels in the soil can upset the nutrient balance in the plant or interfere with the uptake of some nutrients.

In the soil testing laboratory, soil salinity is estimated by extracting the solution (water containing ions) from a saturated soil sample and measuring the ability of the solution to conduct electricity. This solution is called the saturation extract. The greater the concentration of ions or salts in the saturation extract, the more electricity the solution will conduct. The electrical conductivity of the saturation extract is often referred to by the abbreviation EC_e. Salinity is expressed in deciSiemens/meter (dS/m) or millimhos/centimeter (mmhos/cm); both are equivalent units of electrical conductivity. The higher the EC_e, the more salts are in the soil.

Plant responses

Symptoms of salt injury in plants resemble drought. Both conditions are characterized by water stress (wilting)

and reduced growth. Severe injury caused by prolonged exposure or high salinity results in stunted plants and tissue death. Reduced growth caused by salinity is a progressive condition that increases as salinity increases above a plant's tolerance threshold.

Plants vary in their response to soil salinity. Salt-tolerant plants (plants less affected by salinity) are better able to adjust internally to the osmotic effects of high salt concentrations than salt-sensitive plants. Salt-tolerant plants are more able to absorb water from saline soils. Salt-sensitive plants have a limited ability to adjust and are injured at relatively low salt concentrations. Many horticultural and landscape plants are classified as sensitive or moderately sensitive to soil salinity. Relative salt-tolerance classifications of some of these plants are given in Table 1. Table 1 should not be considered a comprehensive listing of plants adapted to Wyoming. The plants listed are offered as representative of a salt tolerance group. The plants listed can be used to determine the salt tolerance of closely related plants or plants adapted to similar sites. The tolerance ratings in Table 1 are to be interpreted only as a guide in making comparisons among plants and apply generally from late seedling stage to maturity.

Specific plant tolerances are affected by climate, soil conditions, cultural practices, and variety selection. During cool weather when plant transpiration demands are low, salt injury will be less than during hot, dry weather. There is wide variation in salt tolerance among varieties or rootstocks of some species.

Salt tolerance during germination and emergence, though not well defined, is often less than that given for mature plants. A good example is beets. Beets, a moderately tolerant plant, are more sensitive at germination than corn, a moderately sensitive plant. Practices to reduce salinity in the seed zone, such as leaching before planting and planting on the sides of sloping beds, can be used to improve germination and emergence.

For ornamentals, size and appearance are the important criteria for determining salt tolerance. Comparisons based on growth reductions may not be completely applicable. In some cases, tolerances are based on the premise that reduced growth may be acceptable as long as plants appear healthy and attractive.

Table 2 lists salinity ranges expected to give a specified growth or yield level for each relative tolerance group listed in Table 1. Because plants within a class vary in salinity tolerance, a range of values are given for each class. Table 2 should be used in conjunction with a soil-test report. A University of Wyoming soil-test report gives a salt estimate (electrical conductivity, EC_e) that can be used to select appropriate plants for your soil. Many laboratories in the western United States routinely perform soil-salinity tests.

To determine the suitability of your soil for a plant salt-tolerance class, find the desired plant class in the left-hand column and the acceptable yield or growth reduction across the top. The point where the desired row and column intersect is the range of the maximum salt estimate at which the chosen plant is likely to produce the acceptable growth level. Compare the salt estimate from your soil-test report to this range. If your soil's salt estimate exceeds this range, either a more tolerant plant should be chosen or a greater growth reduction should be expected.

Example: A homeowner has a soil with a salt estimate of 3.5 dS/m and wishes to grow a small vegetable garden. According to Table 2, at 3.5 dS/m, moderately tolerant plants can be grown with little or no growth or yield reduction; moderately sensitive plants can be grown, but a growth reduction of as much as 25 percent may be observed; sensitive plants may grow but with a growth reduction of up to 50 percent, a level that may not be acceptable. By using Table 1, we find that beans, carrots, and onions (sensitive plants) are probably not good choices for this garden. Broccoli and tomatoes (moderately sensitive plants) can be grown with a modest yield reduction, and beets and zucchini (moderately tolerant plants) will probably not be affected.

Soil salinity is difficult to overcome. Salts can be removed from the soil by leaching if drainage is not restricted. Watering plants more frequently can reduce salt injury. Adverse effects of soil salinity can also be reduced by promoting vigorous growth through good management and adequate fertility. If you suspect soil salinity is a problem, contact your university extension educator. Sometimes, additional soil tests are necessary to identify the exact nature of salinity problems. Your extension educator can help you get more information on soil salinity and how to correct it.

Table 1. Relative salt tolerances of horticultural and landscape plants.*

Woody fruits and trees	Ornamentals, grasses, and groundcovers	Herbaceous fruits, vegetables, and flowers
Sensitive		
Apple	American linden	African violet
Cherry & Prunus *spp*.	Cotoneaster	Bean
Chokecherry	Little leaf linden	Carrot
Currant	Mock orange	Onion
Gooseberry	Oregon grape	Parsnip
Pear	Redtwig dogwood	Strawberry
Plum	Rose	
Raspberry		
Moderately Sensitive		
Aspen	Clematis	Aster
Black locust	Common snowball	Broccoli
Cottonwood	English Ivy	Cabbage
Fir	Honeysuckle	Cantaloupe
Grape	Kentucky bluegrass	Cauliflower
Green ash	Lilac	Celery
Honey locust	Orchardgrass	Corn
Maples (most)	Privet	Cucumber
Poplar	Service berry	Flowers, general
Siberian elm	Wayfaring tree	Gladiolus
Spruce	Yellow sage	Kale
Willow		Lettuce
		Pea
		Pepper
		Potato
		Pumpkin
		Radish
		Spinach
		Squash, scallop
		Tomato
		Turnip
		Watermelon
Moderately Tolerant		
Autumn olive	Blue Grama	Beet
Evergreens, general	Buffalo grass	Carnation
Hackberry	Caragana	Chrysanthemum
Juniper	Crested wheatgrass	Squash, zucchini
Pine	Fine Fescue	
Russian olive	Oleander	
	Perennial ryegrass	
	Potentilla	
	Tall fescue	
	Winged euonymous	
Tolerant		
Tamarix	Alkali grass	Asparagus
	Creeping bentgrass	
	Iceplant	

*This list is only an indication of the salt tolerances of major plant groups. These “indicator” plants can be useful in determining the salt tolerances of closely related plants or plants adapted to similar sites.

Table 2. Soil salinity levels and yield potential of salt-tolerance classes of horticultural and landscape plants.

Relative salt tolerance class	Expected loss of relative growth or yield (%)			
	0	25	50	100
	----------Soil salinity (EC_e†, dS/m)----------			
Sensitive	<1.3	1.4-2.7	2.6-4.2	>8.0
Moderately sensitive	<3.0	2.7-6.3	4.2-9.5	>16.0
Moderately tolerant	<6.0	6.3-10.5	9.5-15.0	>24.0
Tolerant	<10.0	10.5-15.5	15.0-21.0	>32.0

†EC_e is electrical conductivity of the saturated paste extract.

References

Ayers, R.S., and D.W. Westcot. 1985. ***Water quality for agriculture***. Irrigation and Drainage Paper no. 29. Food and Agriculture Organization of the United Nations, Rome.

Bernstein, L. 1980. ***Salt tolerance of fruit crops.*** USDA Agriculture Information Bull. no. 292.

Francois, L.E. 1980. ***Salt injury to ornamental shrubs and ground covers***. USDA Home and Garden Bull. no. 231.

Hayward, H.E., and L. Bernstein. 1958. ***Plant-growth relationships on salt-affected soils.*** Bot. Rev. 128:584-635.

Maas, E.V. 1984. ***Salt tolerance of plants.*** p. 57-75. In Handbook of Plant Science in Agriculture. CRC Press Inc., Boca Raton, FL.

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