Utah State University Extension
electronic publishing

Salinity and Plant Tolerance

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March 2000 AG-SO-03

Introduction

Soil salinity is a measure of the total amount of soluble salt in soil. As salinity levels increase, plants extract water less easily from soil, aggravating water stress conditions. High soil salinity can also cause nutrient imbalances, result in the accumulation of elements toxic to plants, and reduce water infiltration if the level of one salt element—sodium—is high. In many areas throughout Utah, soil salinity is the factor limiting plant growth.

Salt-affected plants are stunted with dark green leaves which, in some cases, are thicker and more succulent than normal. In woody species, high soil salinity may lead to leaf burn and defoliation. High salinity causes alfalfa yield to decrease while the leaf-to-stem ratio increases, influencing forage quality. Grasses also appear dark green and stunted with leaf burn symptoms.

Salinity tolerance is influenced by many plant, soil, and environmental factors and their interrelationships. Generally, fruits, vegetables, and ornamentals are more salt sensitive than forage or field crops. In addition, certain varieties, cultivars, or rootstalks may tolerate higher salt levels than others. Plants are more sensitive to high salinity during seedling stages, immediately after transplanting, and when subject to other (e.g., disease, insect, nutrient) stresses.

Climate and irrigation also influence salinity tolerance. As soil dries, salts become concentrated in the soil solution, increasing salt stress. Therefore, salt problems are more severe under hot, dry conditions than under cool, humid conditions. Increasing irrigation frequency and applying water in excess of plant demand may be required during hot, dry periods to minimize salinity stress.

Sources of Soil Salinity

Salts are a common and necessary component of soil, and many salts (e.g., nitrates and potassium) are essential plant nutrients. Salts originate from mineral weathering, inorganic fertilizers, soil amendments (e.g., gypsum, composts and manures), and irrigation waters. An additional, important source of salts in many landscape soils comes from ice melters used on roads and sidewalks. The addition of virtually any soluble material will increase soil salinity. It is only when salts are present in relatively high amounts that plant growth is adversely affected.

Salinity Measurement

Soil salinity is determined by measuring the electrical conductivity of solution extracted from a water-saturated soil paste. Salinity is abbreviated as EC_e (Electrical Conductivity of the extract) with units of decisiemens per meter (dS/m) or millimhos per centimeter (mmhos/cm). Both are equivalent units of measurement and give the same numerical value. The Utah State University Soil Testing Lab charges $5.00 per sample to test for soil salinity. This is a small investment relative to the cost of seed and vegetation planted in fields and landscapes.

Managing Soil Salinity

In principle, soil salinity is not difficult to manage. The first requirement for managing soil salinity is adequate drainage, either natural or man-made. Determine salinity level by collecting a representative soil sample to a 12 inch depth and having it analyzed by a lab. If the salinity level is too high for the desired vegetation (see attached tables), remove salts by leaching the soil with clean (low salt) water. Application of 6 inches of water will reduce salinity levels by approximately 50%, 12 inches of water will reduce salinity by approximately 80%, and 24 inches by approximately 90%. The manner in which water is applied is important. Water must drain *through* the soil rather than run off the surface. Internal drainage is imperative and may require deep tillage to break up any restrictive layer impeding water movement. Sprinkler irrigation systems generally allow better control of water application rates; however, flood irrigation can be used if sites are level and water application is controlled. Test another soil sample after leaching the site to determine whether salinity level is now suitable for planting.

Plant Responses to Soil Salinity

Table 1 describes general plant responses to different soil salinity ranges. Due to economic and/or environmental limitations (e.g., inadequate drainage), it may not be possible to leach salt from soil. In these situations, select plants that are tolerant of the salinity level in soil. Tables 2 through 8 describe the salt tolerances of common agricultural, horticultural, and ornamental plants grown in Utah. Tolerance values should be used as a guide when selecting vegetation. Varietal differences and environmental conditions may make plants more or less salt tolerant than indicated in the tables.

For harvested crops, threshold values indicate soil salinity levels where plants begin to experience yield-reducing effects. Above the threshold, salinity levels associated with expected yield losses of 10%, 25% and 50% are indicated. Ornamental plants are grouped according to their relative salinity tolerance (low, medium or high) with EC_e ranges indicated for each category. With the exception of turf, relatively little research has been done on landscape and ornamental plant salinity tolerance. Most research conducted on ornamentals has addressed tolerance to salt spray deposited on foliage. A high tolerance to salt spray, however, may indicate a high tolerance to salinity in the root zone.

Table 1. General guidelines for plant response to soil salinity.

Salinity (EC_e, dS/m)	Plant response
0 to 2	mostly negligible
2 to 4	growth of sensitive plants may be restricted
4 to 8	growth of many plants is restricted
8 to 16	only tolerant plants grow satisfactorily
above 16	only a few, very tolerant plants grow satisfactorily

Table 2. Salinity tolerance of common field crops grown in Utah.

Crop	Threshold value	Yield loss		
		10%	25%	50%
	-------------------------------- EC_e (dS/m)	----------------------------		
Barley	8.0	9.6	13.0	17.0
Beans (field)	1.0	1.5	2.3	3.6
Canola	2.5	3.9	6.0	9.5
Corn (grain)	2.7	3.7	6.0	7.0
Oats (grain)	5.2	6.7	9.0	12.8
Rye (grain)	5.9	7.7	12.1	16.5
Safflower	5.3	8.0	11.0	14.0
Sorghum	4.0	5.1	7.1	10.0
Sugarbeets	6.7	8.7	11.0	15.0
Sunflower	2.3	3.2	4.7	6.3
Triticale (grain)	6.1	8.1	12.0	14.2
Wheat	4.7	6.0	8.0	10.0

Table 3. Salinity tolerance of common forages grown in Utah.

Crop	Threshold value	Yield loss 10%	Yield loss 25%	Yield loss 50%
	------------------------------- EC_e (dS/m) -------------------------------			
Alfalfa	2.0	3.4	5.4	8.8
Barley (forage)	5.3	7.4	9.5	13.0
Beardless Wild Rye	5.0	10.0	14.0	20.0
Bermuda Grass	6.9	8.5	10.8	12.0
Birdsfoot Trefoil	4.0	6.0	7.5	10.0
Brome, Meadow	3.0	4.0	6.0	8.0
Brome, Smooth	2.5	3.1	4.0	5.0
Clovers (Berseem)	1.5	3.2	5.9	10.3
Clovers (Strawberry)	5.0	8.0	10.0	12.0
Clovers (Alsike, Ladino, Red)	1.3	2.3	3.6	5.7
Corn (silage)	1.8	2.7	6.8	8.6
Field Peas	1.3	2.0	3.1	4.9
Harding Grass	4.6	5.9	7.9	11.0
Newhy/Hoffman	4.8	6.4	8.0	16.0
Lovegrass	2.2	3.2	5.0	8.0
Meadow Foxtail	1.3	2.0	3.5	6.5
Oats (forage)	2.6	3.2	4.1	6.8
Orchard Grass	1.5	3.1	5.5	9.6
Perennial Ryegrass	5.6	6.9	8.9	12.0
Rye (forage)	2.5	3.5	5.1	7.2
Sweet Clover	4.0	6.0	7.5	10.0
Sudangrass	2.8	5.1	8.6	14.0
Tall Fescue	3.9	5.8	8.6	15.0
Timothy	2.0	2.7	3.8	5.0
Triticale (forage)	6.1	8.1	10.4	13.6
Vetch (spring)	3.0	3.9	5.3	7.6
Crested Wheatgrass	3.5	6.0	9.8	12.0
Tall Wheatgrass	7.5	9.9	13.0	19.0

Table 4. Salinity tolerance of common vegetables grown in Utah.

Crop	Threshold value	Yield loss 10%	25%	50%
	---------------------------------- EC_e (dS/m) ----------------------------------			
Asparagus	5.0	8.0	11.0	13.0
Beans	1.0	1.5	2.3	3.6
Beets	5.3	8.0	10.0	12.0
Broccoli	2.7	3.5	5.5	8.2
Cabbage	1.8	2.8	4.4	7.0
Cantaloupe	2.2	3.6	5.7	9.1
Carrot	1.0	1.7	2.8	4.6
Cauliflower	2.7	3.5	4.7	5.9
Celery	1.8	3.5	5.8	10.1
Corn, Sweet	1.7	2.5	4.0	6.0
Cucumber	2.5	3.3	4.4	6.3
Lettuce	1.3	2.1	3.2	5.2
Onion	1.2	1.8	2.8	4.3
Peas	0.9	2.0	3.7	6.5
Pepper, Bell	1.3	2.2	3.3	5.1
Potato	1.7	2.5	3.8	5.9
Radish	1.2	2.0	3.0	8.0
Spinach	3.7	5.5	7.0	8.0
Squash/pumpkins	3.9	4.9	5.9	7.9
Sweet Potato	1.5	2.4	3.8	6.0
Tomato	2.5	3.5	5.0	7.6
Turnips	0.9	1.9	3.1	4.9
Watermelon	2.0	2.5	3.5	4.5

Table 5. Salinity tolerance of common fruit and nut crops grown in Utah.

Crop	Threshold value	Yield loss 10%	25%	50%
	---------- EC_e (dS/m) ----------			
Apple	1.7	2.3	3.3	4.8
Almond	1.5	2.0	2.8	4.1
Apricot	1.5	2.0	2.6	3.7
Blackberry	1.0	2.0	2.6	3.8
Boysenberry	1.3	2.0	3.0	4.0
Cherries, Sweet and Tart	0.9	1.9	2.2	3.1
Grape	1.5	2.5	4.1	6.7
Nectarines	1.6	2.0	2.6	3.7
Peach	1.7	2.2	2.9	4.1
Pear	1.7	2.3	3.3	4.8
Pecan	1.9	2.5	3.5	4.9
Plum	1.5	2.1	2.9	4.3
Raspberry	1.0	1.4	2.1	3.2
Strawberry	1.0	1.3	1.8	2.5
Walnut	1.7	2.3	3.3	4.8

Table 6. Salinity tolerance of selected flowers grown in Utah.

Low tolerance	Moderate tolerance	High tolerance
EC_e less than 2.0 dS/m*	**EC_e = 2.0 to 3.0 dS/m***	**EC_e = 3.0 to 4.0 dS/m***
China Aster	Carnation	Rose
Geranium	Poinsettia	
Lily	Chrysanthemum	
Gladiolus		
Gardenia		
Azalea		

*Approximate tolerance ranges. *Very little* research has been done on the salinity tolerance of flowers.

Table 7. Salinity tolerance of common turfgrasses grown in Utah. The following represents electrical conductivity levels at which the species begin to show a reduction in growth and quality.

Low tolerance	**Moderate tolerance**	**Mod. to High tolerance**	**High tolerance**
EC_e = less than 3.0	**EC_e = 3.0 to 6.0**	**EC_e = 6.0 to 9.0**	**EC_e = 9.0 to 12.0**
Kentucky bluegrass	Fairway crested wheatgrass	Tall fescue	Alkaligrass
Annual bluegrass	Creeping red fescue	Bermudagrass	
	Chewings fescue		
	Hard fescue		
	Perennial ryegrass		
	Creeping bentgrass		
	Blue grama grass		
	Buffalograss		
	Zoysiagrass		

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Acknowledgments

Salinity and Plant Tolerance is a revision of the earlier publication titled *Salinity and Crop Tolerance* authored by J. Kotuby-Amacher, J. Jurinak, V. P. Rasmussen, D. W. James and R. W. Whitesides.

Table 8. Salinity tolerance of ornamental and shade trees grown in Utah.

Low tolerance	Moderate tolerance	High tolerance
EC_e less than 2 dS/m*	**EC_e = 2 to 3 dS/m***	**EC_e = 3 to 4 dS/m***
Alders	Boxelder	Maples (Norway, Hedge)
Beech	Ohio Buckeye	Honeylocust
Norway Spruce	Catalpas	Cottonwoods
Giant Sequoia	Birchs (River, White)	Ash (European, Green, White)
Dawn Redwood	Kentucky Coffeetree	Flowering Crabapple
Scots/Scotch pine	Ginkgo	Poplars
Japanese Arborvitae	London Planetree	Goldenraintree
Maples (Sugar, Red)	Hackberry	Horsechestnut
Filbert/Hazel	Hawthorn	Joshua Tree
Littleleaf Linden	American Holly	Tamarack
American Linden	Silver Linden	Paper Birch
Eastern Redbud	Magnolia	Willows
European Hornbeam	Firs	Junipers/ E. Redcedar
Yellow-Poplar	Mountainash	European Larch
	Oaks (Bur, Gambel, Shingle)	Locust (Black, Idaho, New Mexico)
	American Sycamore	Austrian Pine
	Walnut (Black, English)	Chinese Date
	Blue Spruce	Baldcypress
	Pines (Bristlecone, Limber, Lodgepole, S.W. White, Ponderosa, Pinyon)	Oaks (English, Northern Red, White)
	Spruce (Englemann, White)	

*approximate tolerance ranges.

For a more complete listing of ornamental tree tolerances to salinity and other conditions, see the Utah State University Extension Bulletin #HG460, Selecting and Planting Landscape Trees.