TECHNICAL NOTE

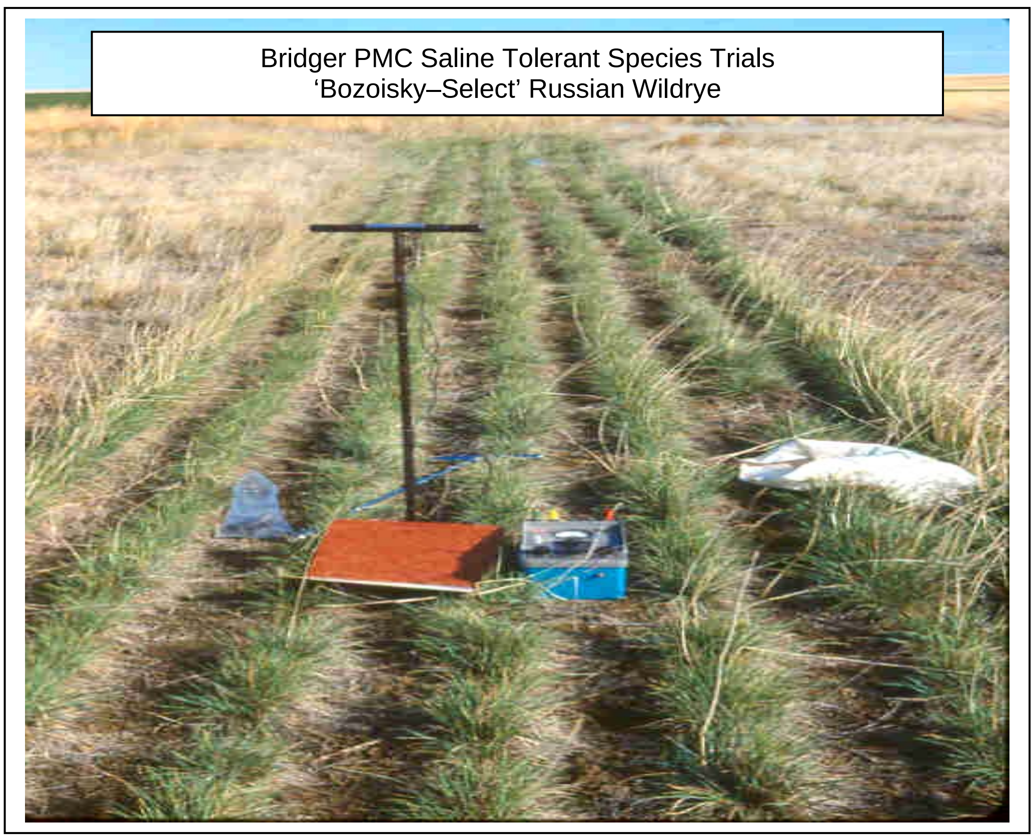
USDA-Natural Resources Conservation Service
Boise, Idaho – Salt Lake City, Utah

TN PLANT MATERIALS NO. 9A **OCTOBER 2009 REVISION**

PLANTS for SALINE to SODIC SOIL CONDITIONS

Dan Ogle, Plant Materials Specialist, NRCS, Boise, Idaho
Loren St. John, Manager, Plant Materials Center, NRCS, Aberdeen, Idaho

This Technical Note provides information on: characterization of saline and sodic soils; effect of salinity on plants; management of salinity problems; planting in saline-sodic soils; and species selection for salt affected areas. Tables provide data on common plants that grow in salt affected areas, recommended species and seeding rates for saline-sodic soils, relative salt tolerance of selected grasses, forbs, legumes and rangeland shrubs and relative salt tolerance of selected windbreak and buffer planting(s) trees and shrubs.



PLANTS for SALINE to SODIC SOIL CONDITIONS

Salt tolerance is the relative ability of a plant to endure the effects of excess salts in the soil rooting medium in order to produce a satisfactory stand or yield. The mode of tolerance can vary. Most plants avoid salinity, some evade or resist salinity, and a few actually tolerate salinity.

Salt avoidance is usually accomplished by limiting germination, growth and reproduction to specific seasons of the year when salt concentrations are lower, by growing roots into non-saline soil layers or by limiting salt uptake. Salt evasion can be achieved by accumulating salts in specific cells or by secretion of excess salts. Salt tolerance is attained only in plants in which the protoplasm functions normally and endures a high salt content without apparent damage.

Salt tolerance of plants varies greatly during plant development and different growth phases of the plant. Sugar beets, a species with fairly high salt tolerance during vegetative growth, is more sensitive to salinity during germination than corn, which is salt-sensitive during growth. The salt tolerance of barley during grain production is half as low as compared to its tolerance during vegetative growth stages.

Characterization of Saline and Sodic Soils

Salt-affected soils may contain excess soluble salts (saline soils), excess exchangeable sodium (sodic soils), or both (saline-sodic soils). Salt affected soils commonly contain a mixture of cations of sodium, calcium, magnesium and potassium and anions of chloride, sulfate, bicarbonate, carbonate and sometimes borate and nitrate. When the total salt, individual salt or combination of salts in the soil is high enough to retard plant growth, injure plant tissue, and/or decrease yields, the soil is referred to as salt affected. Western states have mostly saline soils with some saline-sodic soils and only isolated occurrences of sodic soils.

The original source of all salts in the soil is weathered bedrock and ancient saline sea-bottoms, although it is rare for sufficient salts to have accumulated in place from these sources. The major factor responsible for the formation of salt-affected soils is the redistribution of salts within the soil, with water as the primary carrier. Where rainfall is high, most salts are leached out of the soil. In arid regions, the salt levels accumulated in soils can be very high because of limited or reduced leaching. However, not all soils in arid regions are salt-affected because the soil parent materials are not contributing sources of salts. Indirect sources of salts include irrigation water coming from saline sources or saline water from groundwater wells.

The total concentration of ions in the soil water usually has more influence in affecting plants than the precise composition of the solution. Salinity is expressed in a number of ways: equivalents per liter (mol/l), milligrams per liter (mg/l) which equates to parts per million (ppm), electrical conductivity (EC) which is measured in decisiemens per meter (dS/m) or millimhos per centimeter (mmhos/cm) and total dissolved solids (TDS) (%). Soil surveys generally determine salinity by measuring the electrical conductivity (EC) of the soil solution and are expressed in millimhos/cm (mmhos/cm).

Saline soils are often referred to as “white alkali” because of the white salt crust that forms on the soil surface. Saline soils are characterized by the following: EC > 4, Exchangeable Sodium Percentage (ESP) < 15, and pH < 8.5. Saline soils can be easily reclaimed by application of sufficient water to promote leaching of salts beyond the root zone.

Sodic soils are often referred to as “black alkali” or “slick spots” because of the dissolved organic matter in the soil solution. Sodic soils are characterized by the following: EC < 4, ESP > 15, and pH > 8.5. The exchangeable sodium causes soil particles to disperse, resulting in decreased pore space within the soil and increased soil crusting. The loss of permeability due to less pore space can severely restrict water movement into the root zone resulting in plant stress from lack of water. Crusting can severely affect seedling emergence. Reclamation of sodic soils involves the application of gypsum or sulfur, leaching of salts, special tillage operations or a combination of these measures.

Saline-sodic soils having properties of both saline and sodic conditions are characterized by the following: EC > 4, ESP > 15, and pH < 8.5. Properties of saline-sodic soils are generally similar to those of saline soils; however, "black alkali" sodic conditions can be a problem if excess soluble salts are leached without addressing the excess sodium. Reclamation of saline-sodic soils is the same as sodic soils to ensure that excess salts and sodium are removed.

The soil salinity level can best be determined by taking soil samples in the upper 6 inches of the soil profile and measuring the electrical conductivity. Plants growing on the site can also provide an indication of the severity of salinization.

This table lists some of the more common plants that grow on salt affected soils

Common Name	Scientific Name	Tolerance Level
Black greasewood	*Sarcobatus vermiculatus*	
Inland saltgrass	*Distichlis stricta*	
Nuttall's alkaligrass	*Puccinellia nuttalliana*	
Beardless wildrye	*Leymus triticoides*	Very High
Shore arrowgrass	*Triglochin maritima*	
Red glasswort	*Salicornia ruba*	
Seepweed	*Suaeda depressa*	
Pickleweed	*Salicornia spp.*	
Alkali cordgrass	*Spartina gracilis*	
Slender wheatgrass	*Elymus trachycaulus*	
Saltbush species	*Atriplex spp*	
Winterfat	*Krascheninnikovia lanata*	
Alkali bluegrass	*Poa juncifolia*	High
Alkali sacaton	*Sporobolus airoides*	
Foxtail barley	*Hordeum jubatum*	
Cinquefoil species	*Potentila spp*	
Curley dock	*Rumex crispus*	
Povertyweed	*Iva axillaries*	
Kochia	*Kochia scoparia*	
Plains bluegrass	*Poa arida*	Moderate
Western wheatgrass	*Pascopyrum smithii*	
Thickspike wheatgrass	*Elymus lanceolatus*	

Effect of Salinity on Plants

Soil salinity can affect plant growth both physically (osmotic effect) and chemically (nutritient and/or toxicity effect). As the salt content of the soil increases, it becomes more difficult for plants to take up water. Sensitive plants appear drought-stricken even at fairly low levels of salt concentration. There is usually a progressive decline in growth and yield (production) as salinity levels increase. The slower growth caused by salts may cause forage to be tougher and less palatable. This has been observed in tall wheatgrass and tall fescue. Some plants are affected by salinity more at one stage of development than at another. Barley and wheat are affected during early seedling growth but not as much during germination or at later growth stages. Even when salinity decreases the plant size of barley and wheat up to 50%, little to no decline in grain yields have been noted. Corn, alfalfa and bean yields decrease almost proportionally to the decrease in plant size. Germinating sugar beets die when the salinity level is high, but mature plants are very tolerant of the same salinity level.

Yield reductions are not always comparable for individual species. For example, crested wheatgrass yields are reduced 25% at 10 mmhos/cm, while tall wheatgrass yields are reduced only 10% at the same level. Yet, yields of both species are reduced about 50% at 20 mmhos/cm. Salinity problems are more severe under hot and dry conditions than under cool and humid conditions for almost all plants.

Occasionally the interaction of various salts further influences the effect of total salts. High concentrations of calcium ions in the soil solution may prevent the plant from absorbing enough phosphorus, potassium or other essential ions. Other ions may affect the uptake of calcium ions.

High concentrations of specific ions can cause disorders in mineral nutrition. For example, high sodium concentrations may cause deficiencies of other elements, such as potassium and calcium, and high levels of sulfate and chloride diminish the rate of nitrate absorption. Specific ions such as sodium and chloride may have toxic effects on plants, reducing growth or causing damage to cells and cell membranes. This is commonly characterized by leaf tip burning, leaf margin scorch, chlorosis (turning yellow), and premature leaf drop. Chlorosis deficiencies can sometimes be corrected with chelated iron or sulfur fertilizers.

Management of Salinity Problems

Soil salinity is strongly linked to water movement through the soil profile. When sub-soil moisture, containing salts, moves upward and evaporates, salts are precipitated at or near the soil surface. Soil salinity problems can result from improper land management practices. Dry cropland systems where crop-fallow is used to store soil moisture sometimes result in a condition known as saline seep where excess stored soil moisture is perched on an impermeable soil layer (commonly clay hardpans or shale subsoil) and then flows to an area where it surfaces and evaporates leaving salts behind on the soil surface. Improper irrigation water management can result in similar salinity problems. The solution to salinity problems lies in the prevention of upward salt movement. This may require cropping and management systems to capture and utilize excess soil moisture through perennial cropping rather than crop-fallow systems, selection of deep rooted crop species such as alfalfa or installation of drainage systems in order to prevent soil moisture and salt movement through the soil

Salts can be leached out of the soil if the soil is deep, permeability is good and there is no water table near the surface. A good water source and good soil drainage are necessary for effective salt leaching. It may be necessary to tile a field, dig drainage ditches or pump out the ground water to provide the necessary drainage. Adequate water must be applied to drain through the rooting depth of the planned crop. Continuous ponding is not effective in removing salts and uses excessive amounts of water. **Caution: Care should be taken to ensure compliance with wetland rules and regulations and to avoid contamination of ground water and surface water sources.**

Seedbed preparation and irrigation management can reduce the effects of salts. Sloping beds with seed rows between the peaks or flat double row beds with a salt wick peak in the center can cause salts to migrate away from the planted area. In addition the crowns of peaked areas can be knocked away from seeded rows following pre-irrigation to remove salts that have accumulated. Under furrow irrigated conditions, planting every other row and then irrigating every other row, will help push salts toward the non-irrigated furrow and away from the seeded row.

Saline areas with a high water table can not be entered with heavy equipment during much of the year. It is very important that weed control and seedbed preparation are performed. Weed competition and heavy residue are the biggest obstacles in seeding and establishing plant materials on wet saline sites. It is also very important to take advantage of organic matter (plant litter), particularly if salinity/sodicity is associated with a high water table. The growing plants act as a biological pump, keeping the water table far enough below the surface to decrease evaporation and salt deposition on the soil surface. The roots and stems of plants that have been controlled chemically (herbicides), assist with soil structure, infiltration and percolation of moisture through the soil profile. Mechanical tillage can destroy organic matter and soil structure, retards infiltration and may cause salt accumulation on the soil surface. An ATV four-wheeler equipped with spray equipment can enter wet sites earlier in the spring than heavy equipment and may be the best alternative to control weed competition and maintaining soil structure.

Every saline site is unique in the kind and amount of salt, soil type, available moisture and climatic conditions. Most soil amendments will not correct a high salt concentration problem. A proper soil analysis (0-6 inches) will help determine the nature of the problem and if soil amendments can be recommended. Soils with an EC greater than 25 mmhos/cm or Sodium Adsorption Ratios (SAR) in excess of 12 in high salinity soils, or 25 in low saline soils, should not be seeded until amendments, leaching or drainage when possible have reduced the hazard. Insufficient leaching after the use of a soil amendment may make a salinity problem worse.

Soil amendments such as gypsum, calcium chloride dehydrate and sulfuric acid have been used for reclamation of saline-sodic soils. These amendments generally involve the replacement of exchangeable sodium with calcium. For amendments to be effective, the displaced sodium must be leached out of the plant rooting zone. This is not always possible because of water availability and/or poor drainage from the salinized site. However, even without leaching, amending with gypsum will reduce surface crusting and improve moisture infiltration into the soil.

Planting in Saline-Sodic Soils

The optimum period to complete seedings for forage and cover type species in wet-saline soils is late fall (mid October to December) or during a snow-free period during the winter. The seed should be in the ground before the next growing season so that it can take advantage of the diluting effect of early spring moisture on salt concentrations. Under irrigated situations, germination and seedling emergence can be improved with light – frequent irrigations during initial establishment.

Seedbed preparation is critical. With low to moderate salinity, a tilled, firm, weed-free seedbed is recommended. With high to very high salinity levels, particularly when a high water table is involved, tillage may not be possible or provide the best seedbed. Under these conditions, vegetation and weeds should be controlled chemically. The soil structure will remain intact and the desiccating stems and roots will improve conditions for moisture infiltration into the soil, reduce evaporation from the soil surface, and protect emerging seedlings. Planting depth for most species should be about ¼ to ½ inch.

An alternate method of establishing grasses in saline-sodic soils is sprigging. Sprigging involves the planting of rhizomes over an area at a 3 to 4 inch depth. Specialized equipment for digging and planting sprigs is commercially available. Sprigs can also be planted with a tree planter. Plants can be established by sprigging at slightly higher salinity levels than by seeding because the rhizomes are more salt tolerant than seed and seedlings and are placed below the highest concentration of salts that form near the soil surface. Once established, rhizomatous grasses will spread and fill in vacant spaces. The availability of a source of sprigs in close proximity of the planting site, transportation costs, and equipment availability are the greatest limitations to this establishment method.

Species Selection

A salinity-sodicity soil assessment must be made prior to selection of site treatment alternatives. It is impractical to recommend a universal mixture covering all variables at potential planting sites. Species not only vary in their salinity tolerance, but also their ability to withstand a high water table or more droughty conditions.

Most species can be seeded by themselves or in combination with additional adapted species. Species compatibility needs to be considered when developing a seed mixture. Some species have very good seeding vigor; develop rapidly, often at the expense of other species in the seed mixture. It is recommended that tall wheatgrass be planted by itself, as it will completely dominate a planting after 4 to 5 years. Slender wheatgrass also develops rapidly, often developing seedheads the establishment year. Although slender wheatgrass establishes quickly, providing cover and stability to the site, this species is short-lived and begins to decline after 2 to 3 years relinquishing itself to longer lived species in the mix. Slender wheatgrass should be seeded in species mixtures at a rate of about 1- 2 pounds per acre to avoid competitiveness with other species in the mixture. Both Russian wildrye and tall fescue are slow to develop and are not aggressive seedlings. If these species are desired, they should generally be planted by themselves or in alternate rows.

If gradients of soil salinity and/or soil moisture (water tables) are present, mixtures can be designed so each species will dominate in its most favored condition. A mixture of creeping foxtail, western wheatgrass, and beardless wildrye will sort along a wet saline gradient with creeping foxtail on mildly saline, wet end of gradient and beardless wildrye on the most saline, drier end of the gradient. A mixture of Altai wildrye and beardless wildrye will sort along a moisture gradient where Altai wildrye will be on the drier locations. If a site is too wet to traverse with equipment and salinity is low to moderate, creeping foxtail is recommended.

Beardless wildrye, tall wheatgrass, Russian wildrye, and 'Newhy' hybrid wheatgrass are the most salt-tolerant species on moderate to well drained areas. Beardless wildrye, tall wheatgrass, tall fescue and western wheatgrass are the most salt-tolerant species on wet areas (sites where the water table stays within three feet of the surface the entire growing season). Creeping foxtail is moderately salt tolerant and an excellent forage on wet areas when it can be utilized. Russian wildrye, tall wheatgrass, Altai wildrye, forage kochia, fourwing saltbush and winterfat are quite drought-tolerant and perform well on drier saline areas (sites where the water table drops below three feet of the surface during the growing season, or where no water table is present). Crested wheatgrass, Siberian wheatgrass, Russian wildrye, intermediate wheatgrass and pubescent wheatgrass are very drought tolerant and will perform very well in drier low to moderately saline areas. The species listed for drier sites perform best in the 12 to 18 inch annual precipitation areas, but some may be adequate in lower rainfall areas as well. For sites with higher rainfall, wet site or where irrigated species are recommended (see Relative Salt Tolerance of Selected Grass, Forb and Legume Species Table – Wet/Saturated or Irrigated Sites).

Slender wheatgrass performs well on both wet and dry sites, but is relatively short-lived (2 to 3 years). Yellow sweetclover performs well in moderate to low levels of salinity on drier sites, and is also short-lived. These species could be included in mixtures for quick establishment and cover, but they will not persist over the long term. Both species could be considered as interim hay crops while soil amendments are being used or as green manure crops to improve soil tilth and organic matter, thus enabling the establishment of longer-lived species.

There are no commercially available legumes that will establish in very high saline soils. Strawberry clover is the most salt tolerant legume and it can be used only in wet to saturated conditions. The upper limit for establishment of other saline tolerant legumes is about 10 EC (mmhos/cm) or less.

Commercially Available Species for Seeding in Saline-Sodic Soils

Common Name	Cultivar(s)	Tolerance	Seeds/Lb.	Seeding Rate[1]
Beardless wildrye	Shoshone	Very High	150,000	9 lbs/ac[2]
Tall wheatgrass	Alkar, Largo	Very High	78,000	15 lbs/ac
Altai wildrye	Prairieland, Eejay, Pearle	Very High	73,000	18 lbs/ac
Hybrid wheatgrass	NewHy	Very High	139,000	12 lbs/ac
Slender wheatgrass	Pryor, First Strike, Revenue	Very High	135,000	9 lbs/ac[3]
Russian wildrye	Bozoisky II, Mankota	Very High	170,000	9 lbs/ac
Tall fescue	Johnstone, Kenmont, Fawn	High	205,000	8 lbs/ac
Western wheatgrass	Recovery, Rosana, Arriba	High	115,000	12 lbs/ac
Fairway c. wheatgrass	Ephraim, Roadcrest	High	175,000	8 lbs/ac
Crested wheatgrass X	Hycrest II, Hycrest	High	165,000	8 lbs/ac
Standard c. wheatgrass	Nordan, Summit	High	165,000	8 lbs/ac[4]
Siberian wheatgrass	Vavilov II, Vavilov	High	160,000	9 lbs/ac[4]
Forage kochia	Immigrant	High	395,000	3 lbs/ac[5]
Fourwing saltbush	Snake River Plains, Wytana	High	52,000	4 lbs/ac
Winterfat	Northern Cold Desert, Open Range	High	123,000	4 lbs/ac[5]
Strawberry clover	Salina	High	300,000	6 lbs/ac
Creeping foxtail	Garrison	Moderate	750,000	5 lbs/ac
Meadow brome	Regar, Cache, Fleet, Paddock	Moderate	93,000	15 lbs/ac
Smooth brome	Manchar, Lincoln	Moderate	145,000	9 lbs/ac
Pubescent wheatgrass	Luna, Manska	Moderate	80,000	15 lbs/ac
Intermediate wheatgrass	Rush, Oahe, Reliant	Moderate	80,000	15 lbs/ac
Thickspike wheatgrass	Bannock, Critana, Sodar	Moderate	135,000	9 lbs/ac
Yellow sweetclover	Madrid	Moderate	262,000	6 lbs/ac[3]
Cicer milkvetch	Lutana, Monarch, Windsor	Moderate	130,000	11 lbs/ac

[1] These rates are Critical Area Planting (NRCS Standard 342) Pure Live Seed (PLS) seeding rates - 1.5 times normal seeding rates
[2] Beardless wildrye requires over-wintering in soil for seed stratification and must be dormant fall planted
[3] Recommended in mixtures with no more than 1- 2 lbs of slender wheatgrass or 1 lbs of yellow sweetclover per acre
[4] Standard crested wheatgrass and Siberian wheatgrass are more drought tolerant than Fairway or the crested wheatgrass cross
[5] Forage kochia and winterfat should be seeded on the soil surface and pressed into soil. Do not bury seed.

Relative Salt Tolerance of Selected Grass, Forb and Legume Species

The salt tolerances given in this table compare the relative tolerances of various species. It provides an upper salinity limit above which plants will usually not germinate. The production column indicates the level at which yields become affected. Source: Plant Materials for Saline-Alkaline Soils. 1996. USDA, NRCS, Bridger PMC, Montana TN 26. Future research will refine these figures.

	EC (mmhos/cm)		Tolerance
Crop	Production Affected	Upper Limit	Rating
Barley	8	16	High
Sugar beets	7	13	Moderate
Safflower	6	10	Moderate
Wheat	7	8	Low
Oats	4	8	Low
Corn	3	6	Low
Beans	1	2	Low
Forage –Wet/Saturated (water table w/in 3 feet of soil surface) or Irrigated (well drained) Sites			
Beardless wildrye	13	26	Very High
Tall wheatgrass	13	26	Very High
Newhy hybrid wheatgrass	13	26	Very High
Slender wheatgrass	10	22	Very High
Altai wildrye	10	20	Very High
Tall fescue	8	18	High
Western wheatgrass	6	16	High
Strawberry clover	6	16	High
Creeping foxtail	5	12	Moderate
Smooth brome	5	10	Moderate
Meadow brome	4	10	Moderate
Cicer milkvetch	4	10	Moderate
Birdsfoot trefoil	5	8	Low
Orchardgrass	3	8	Low
Reed canarygrass	3	5	Low
Clover (Alsike, Red, Ladino)	3	4	Low
Forage - Dry (10 inch + precipitation and water table below 3 feet of soil surface) Sites			
Russian wildrye	13	24	Very High
Tall wheatgrass (12 inch+)	13	24	Very High
Slender wheatgrass	10	20	Very High
Forage kochia	10	18+	High
Fourwing saltbush	10	18+	High
Winterfat	10	18+	High
Crested wheatgrass	6	14	Moderate
Siberian wheatgrass	6	14	Moderate
Pubescent wheatgrass (11 inch+)	6	12	Moderate
Intermediate wheatgrass (12 inch+)	6	12	Moderate
Yellow sweetclover	5	10	Moderate
Alfalfa (12 inch+)	4	8	Low
Small burnet (14 inch+)	2	3	Low
Native Grasses			
Nuttall's alkaligrass	14	30	Very High
Alkali sacaton	14	26	Very High
Beardless wildrye	13	26	Very High
Alkali cordgrass	12	24	Very High
Alkali bluegrass	12	24	Very High
Slender wheatgrass	10	22	Very High
Plains bluegrass	10	20	Very High
Western wheatgrass	6	16	High
Thickspike/Streambank wheatgrass	6	14	Moderate

Relative Salt Tolerance of Selected Tree and Shrub Species

Source: Tree Planting, Care and Management. 2007. USDA-NRCS. Boise, ID Plant Materials TN No. 43.

Species	EC (mmhos/cm) Upper Limit	Tolerance Rating
Trees and Shrubs		
Ash, Green	12	Moderate
Aspen, Quaking	3	Slight
Boxelder*	3	Slight
Buckthorn, Sea	15	Moderate
Buffaloberry, Silver	14	Moderate
Cherry	3	Slight
Chokecherry	9	Low
Cotoneaster*	3	Slight
Cottonwood	3	Slight
Crabapple	3	Slight
Current, Golden	13	Moderate
Dogwood	3	Slight
Douglas-Fir	3	Slight
Elm, American	3	Slight
Elm, Siberian*	13	Moderate
Fir, Balsam	3	Slight
Hawthorn	13	Moderate
Honeysuckle, Freedom*	9	Low
Juniper, Rocky Mountain	12	Moderate
Larch, Siberian	9	Low
Lilac, Common	12	Moderate
Linden, Little Leaf	3	Slight
Mountain-Ash	3	Slight
Pine, Austrian	11	Moderate
Pine, Ponderosa	12	Moderate
Pine, Scotch	9	Low
Plum, American	3	Slight
Poplar, Hybrid	3	Slight
Rose	3	Slight
Russian Olive**	14	Moderate
Siberian Peashrub	13	Moderate
Silverberry*	15	Moderate
Spruce, Blue	9	Low
Sumac, Skunkbush	12	Moderate
Viburnum	3	Slight
Walnut, Black	3	Slight
Willow, Laurel	3	Slight

* Potentially invasive – species has ability to spread under proper environmental conditions

** Due to very invasive tendencies Russian olive is not recommended in Idaho plantings

Tree and Shrub species differ in the stages at which they are most sensitive to salinity. Generally trees and shrubs are most sensitive during establishment. To partially avoid this sensitive period, older bare root stock and/or potted trees and shrubs are recommended for plantings in saline-alkaline soils.

Plant stress related to salinity may be evident at levels lower than those listed in table. The listed values generally refer to the level at which major portions of a population show considerable mortality, reduced biomass or reduced growth rates. Trees and shrubs appear less salt tolerant when grown in a hot, dry climate than a cool, humid climate.

Select species that are the most tolerant to salinity and that also meet the landowner's objectives. Manage the soil surface around each plant to minimize soil water evaporation and concentration of salts. Practices such as scalp planting and mulching, with either fabric or organic mulches, are effective in keeping the soil surface moist and discouraging salt accumulation near the young establishing tree or shrub.

References

American Society of Civil Engineers. 1990. Agricultural Salinity Assessment and Management. ASCE Manuals and Reports on Engineering Practice No. 71. ASCE, 345 East 47th Street, NY, NY 10017. 619 p.

Ayers, R.S. and D.W. Westcot. 1976. Irrigation Drainage Paper - Water Quality for Agriculture. Food and Agriculture Organizations of the United Nations - Paper 29. Rome, Italy. 97 p.

Bernstein, Leon. 1964. Salt Tolerance of Plants. USDA Information Bulletin 283. ARS. 23 p.

Bernstein, Leon. 1958. Salt Tolerance of Grasses and Forage Legumes. USDA Information Bulletin 194. ARS. 7 p.

Carter, D.L. Salinity and Plant Productivity. Materials presented at Salinity Workshop. USDA-ARS. Snake River Conservation Research Center. April 1988.

Dunn, L.E., W. Bianchi, and L. Thran. 1963. Characteristics and Reclamation of Three Nevada Salt Affected Soils. Agricultural Experiment Station, University of Nevada. 24 p.

Majerus, M. 1996. Plant Materials for Saline-Alkaline Soils. USDA. Natural Resources Conservation Service. Bridger Plant Materials Center. Montana Technical Note No. 26. 5 p.

Montana Interagency Plant Materials Handbook. 1990. Salt Tolerant Plants. Multiple Agencies Extension Publication. pp 9-11.

Ogle, Daniel G. 1994. Salt Tolerant Plants. USDA. Natural Resources Conservation Service. Boise, Idaho. Idaho Technical Note No. 9. 7 p.

Ogle, D. G., L. St. John and C. Stange. 2007. Tree Planting, Care and Management. USDA. Natural Resources Conservation Service. Boise, Idaho. Technical Note No. 43. 30 p.

Robbins, C.W. Salt Problems, What to Look For-What to Test For and What Can be Done for Them. Materials presented at Salinity Workshop. USDA-ARS. Snake River Conservation Research Center. April 1988.

Soil and Water Conservation Districts of Montana. 1978. Saline Seep Plant Materials Program - Final Report. Old West Regional Commission and Montana Department of State Lands. Helena, Montana. 41 p.

Thorup, R.M. 1984. Soil Salinity. Ortho Agronomy Handbook. A Practical Guide to Soil Fertility and Fertilizer Use. The Fertilizer Division. Chevron Chemical Company. pp. 198-200.