

Plant Materials for Saline-Alkaline Soils

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Salt Tolerance

The salt tolerance of a plant can be defined as the plant's capacity to endure the effects of excess salt in the medium of root growth. The mode of tolerance can vary, i.e., most plants avoid salinity, some evade or resist salinity, and a few others actually tolerate it. Salt avoidance is usually accomplished by limiting germination, growth, and reproduction to specific seasons during the year, by growing roots in nonsaline 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 different phases of growth and development. Sugarbeet, a species with relatively high salt tolerance during vegetative growth, is more sensitive to salinity during germination than corn, which is salt-sensitive during growth. Salt tolerance of barley is twice as low during grain production as in earlier growth phases.

Salinity Measurement

Salinity is the concentration of dissolved mineral salts present in waters and soils on a unit volume or weight basis. The major solutes comprising dissolved mineral salts are the cations sodium (Na), calcium (Ca), magnesium (Mg) and potassium (K), and the anions chloride (Cl), sulfate (SO₄), bicarbonate (HCO₃), carbonate (CO₃), and nitrate (NO₃). Salinity is expressed in a number of ways: mol/l (equivalents per liter), mg/l (ppm), electrical conductivity EC (dS/m or mmhos/cm) and total dissolved solids (TDS, %). Salinized soils are classified as: **saline** (EC >4, ESP <15), **saline-alkaline** (EC >4, ESP >15) and **alkaline/sodic** (EC <4, ESP >15). Montana and Wyoming have mostly saline soils with some saline-alkaline and only isolated occurrences of 'black alkali' or sodic soils.

The soil salinity level can best be determined by taking 0 to 6-inch soil samples for measurement of EC. Plant material growing on the site can also be used as an indicator of the severity of salinization. Table 1 lists some of the more common plants which grow on salt affected soils.

Table I. Native plants and introduced weeds commonly found on salt-affected soils in Montana and Wyoming.

Scientific Name	Common Name	Level of Salinization
<i>Rumex crispus</i>	curly dock	
<i>Iva axillaris</i>	poverty weed	
<i>Kochia scoparia</i>	kochia	moderate

<i>Poa arida</i>	plains bluegrass	
<i>Spartina gracilis</i>	alkali cordgrass	
<i>Elymus trachycaulus</i>	slender wheatgrass	
<i>Atriplex patula</i> var. <i>hastata</i>	spear saltbush	high
<i>Poa juncifolia</i>	alkali bluegrass	
<i>Sporobolus airoides</i>	alkali sacaton	
<i>Hordeum jubatum</i>	foxtail barley	
<i>Sarcobatus vermiculatus</i>	greasewood	
<i>Distichlis stricta</i>	Inland saltgrass	
<i>Puccinellia airoides</i>	Nuttall's alkaligrass	very high
<i>Triglochin maritima</i>	shore arrowgrass	
<i>Salicornia rubra</i>	red glasswort	
<i>Suaeda depressa</i>	seepweed	

Salinity Effect on Plants

Soil salinity can affect plant growth both physically (osmotic effect) and chemically (nutritional effect and/or toxicity). Depression of the external osmotic potential by high salt concentrations tends to narrow the gap between the external and internal water potentials. At high salinities, the external osmotic potential may be depressed below that of the plant cell water potential, resulting in osmotic desiccation. The reduction in the osmotic potential of the growth medium has long been held to be the primary cause, directly and indirectly, of the adverse effects of salinity on plant growth and survival. The 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 diminishes 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 membranes. The nutritional deficiencies and toxicities of plants can be characterized by necrosis (tip burning or marginal scorch), chlorosis (turning yellow in color), and abscission (premature dropping).

Management of Salinity Problems

Soil salinity problems can result from dryland saline seeps, improper drainage or water management on irrigated soils, or cultivation of naturally saline soils. Soil salinity is strongly linked to water movement through the soil profile. When sub-soil moisture containing salts moves upwards and evaporates, salts are precipitated at or near the soil surface. The solution to salinity problems lies in the prevention of upward salts movement; this requires such actions as drainage, utilization of existing soil moisture, and/or the prevention of additional water moving into the system. Drainage by tiling or ditching is generally not advised because of the potential for both surface and ground water contamination. Changes in cultural practices can be effective. Replacement of crop-fallow cropping systems with flex-cropping or continuous cropping will utilize available soil moisture and prevent the saturation of sub-soils. The use of deep-rooted perennial crops will also retard or diminish moisture movement into affected areas. On irrigated sites, irrigation water management is critical. Irrigation timing, duration and the disposal of wastewater all influence the movement of soil salts.

Soil amendments such as gypsum (CaSO_4), calcium chloride dihydrate ($\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$), and sulfuric acid (H_2SO_4) have been used for the reclamation of saline-alkaline soils. These amendments generally involve the replacement of exchangeable Na^+ with Ca^{++} . 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 penetration.

Planting in Saline-Alkaline Soil

The optimum time to seed a forage or cover crop in saline-alkaline soils is late fall (mid-October to December) or during a snow-free period during the winter. The seed should be in the ground so that it can take advantage of the diluting affect of early spring moisture. Germination and emergence can also be improved with light, frequent irrigations in early spring. As with the planting of any forage crop, seedbed preparation is critical. With low to moderate salinity, a firm weed-free seedbed is recommended. With higher salinity levels, particularly when a high water table is involved, a fallow condition may not be the best seedbed. If existing vegetation and weeds are chemically eradicated, the remaining desiccated roots and stems improve moisture infiltration and percolation, reduces evaporation from the soil surface, and protects emerging seedlings.

The planting depth for most forage species should be 1/4 to 1/2 inch (5-10 mm). A double disk drill equipped with depth bands will ensure optimum seed placement. An alternate method of establishing forage grasses in saline-alkaline soils is sprigging. This method involves the planting of rhizomes at a depth of 3 to 4 inches (7 to 10 cm). Specialized equipment for digging and planting sprigs is commercially available. Plants can be established by sprigging at slightly higher salinity levels than by seeding; as the rhizomes are more salt-tolerant than seedlings and they are being placed below the highest concentration of salts of the soil surface. Sprigs can also be planted on small acreages with a tree planter. Once established these rhizomatous grasses will continue to spread and establish themselves. The availability of a sprig source in close proximity of the planting site, transportation costs, and equipment availability are the biggest limitations to this establishment method.

Species Selection/Compatibility

It is impractical to recommend a universal mixture of forage species that will cover all potential variables of a planting site. Species not only vary in their salt tolerance, but also in their ability to withstand a high water table or droughty conditions. Figure 1 lists several major crops, forage species, and native grasses, ranking their threshold and maximum salt tolerance. Because of the variability in climatic, edaphic and site conditions these are average numbers that show the expected salt tolerance of the different species relative to each other.

Some species have very good seedling vigor. These species 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 plant stand after 4 to 5 years. Slender wheatgrass also develops rapidly, often producing seedheads the establishment year. Although slender wheatgrass establishes quickly, providing cover and stability to the site, this species characteristically begins to deteriorate after 3 to 4 years and often will totally relinquish itself to other long-lived species in a mix. If slender wheatgrass is included in a mix, it should be seeded at a rate of 2 pounds/A or less to avoid initial competitiveness. Both Russian wildrye and tall

fescue are slow to develop and do not have aggressive, seedlings. If either one of these grasses are the desired species, then they should be seeded by themselves.

If gradients of soil salinity and/or soil moisture are present, mixtures can be designed so that each species will dominate in the conditions it favors the most. A mixture of 'Garrison' creeping foxtail, 'Rosana' western wheatgrass, and 'Shoshone' beardless wildrye will sort themselves out along a wet salinity gradient with Garrison on the mildly saline end of the gradient and Shoshone on the most saline end of the gradient. A mixture of Altai wildrye and Shoshone beardless wildrye will sort themselves along a moisture gradient such that Altai wildrye will be on the drier end and Shoshone on the wetter end. Complicated mixtures are generally impractical because of interspecific competition and varied salt tolerance of the different species.

Seed of a variety of forage grasses (Table 2) is commercially available, with seed supply of the most salt tolerant species such as beardless wildrye (Shoshone) and hybrid wheatgrass ('Newhy') often in short supply.

Table 2. Commercially- available cultivars for planting in saline-alkaline soils in the Northern Great Plains and Southern Canadian Prairie Provinces.

Scientific Name	Common Name	Adapted Cultivar	Seeds/lb.	Seeding Rate
<i>Leymus multicaulus</i>	beardless wildrye	Shoshone	180,000	7
<i>Thinopyrum ponticum</i>	tall wheatgrass	Alkar, Orbit, Jose, Largo	79,000	14
<i>Leymus angustus</i>	altai wildrye	Prairieland, Pearl, Eejay	80,000	13
<i>Elytrigia repens</i> X				
<i>Pseudoroegneria spicata</i>	hybrid wheatgrass	Newhy	135,000	8
<i>Elymus trachycaulus</i>	slender wheatgrass	Pryor, Revenue, San Luis, Primar	130,000	8
<i>Festuca arundinacea</i>	tall fescue	Kenmont, Fawn, Goar, Alta	240,000	6
<i>Psathyrostachys juncea</i>	Russian wildrye	Bozoisky-Select, Swift, Mankota, Vinall	170,000	7
<i>Pascopyrum smithii</i>	western wheatgrass	Rosana, Rodan, Walsh	95,000	8
<i>Alopecurus arundinaceus</i>	creeping foxtail	Garrison, Retain	720,000	3
<i>Agropyron cristatum</i>	crested wheatgrass	Hycrest, Parkway, Ephraim, Douglas	200,000	6
<i>Agropyron desertorum</i>	desert wheatgrass	Nordan, Summit	188,000	7
<i>Agropyron sibiricum</i>	Siberian wheatgrass	P-27, Vavilov	163,000	7

[\(Top\)](#)