TECHNICAL NOTES

U.S. DEPARTMENT OF AGRICULTURE NATURAL RESOURCES CONSERVATION SERVICE

Plant Materials No. 26 (Revised)

Bridger, Montana
October 1, 1996

PLANT MATERIALS FOR SALINE-ALKALINE SOILS

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 into 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. Sugar beets, a species with a relatively 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 again as low as in earlier growth stages.

Salinity Measurement

Salinity is the concentration of dissolved mineral salts present in water and soil on a unit volume or weight basis. The major solutes comprising dissolved mineral salts are the cations Na^+ (sodium), Ca^{2+} (calcium), Mg^{2+} (magnesium), and K^+ (potassium); and the anions Cl^- (chloride), SO_4^{2} (sulfate), HCO_3 (bicarbonate), CO_3^{2} (carbonate), and NO_3 (nitrate). 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) (%). Salinized soils are classified as saline (EC >4, Exchangeable Sodium Percentage (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" soil samples for measurement of the electrical conductivity. 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 that grow on salt-affected soils.

Table 1. Native plants and introduced weeds commonly found on salt-affected soils in Montana and Wyoming.

Scientific Name	Common Name	Level of Salinization
Rumex crispus	curly dock	
Iva axillaris	poverty weed	
Kochia scoparia	kochia	moderate
Poa arida	plains bluegrass	
Spartina gracilis	alkali cordgrass	
Elymus trachycaulus	slender wheatgrass	
Atriplex patula var. *hastata*	spear saltbush	high
Poa juncifolia	alkali bluegrass	
Sporobolus airoides	alkali sacaton	
Hordeum jubatum	foxtail barley	
Sarcobatus vermiculatus	greasewood	
Distichlis stricta	inland saltgrass	
Puccinellia airoides	Nuttall's alkaligrass	very high
Triglochin maritima	shore arrowgrass	
Salicornia rubra	red glasswort	
Suaeda depressa	seepweed	

Salinity Effect on Plants

Soil salinity can affect plant growth both physically (osmotic effect) and chemically (nutrition effect and/or toxicity). Depression of the external osmotic potential by high salt concentrations tends to narrow the gap between the soil (external) and plant cell (internal) water potentials. At high salinities, the soil 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. 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 (caused by a perched water table resulting from clay hardpans or shale subsoil), 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 utilization of existing soil moisture, the prevention of additional water moving into the system and/or site drainage. 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 diminish the saturation of sub-soils. The use of deep-rooted perennial crops will also retard or prevent moisture movement into affected areas. On irrigated sites, irrigation water management is critical. Irrigation timing, duration, and the disposal of waste water all influence the movement of soil salts.

Soil amendments such as gypsum ($CaSO_4$), calcium chloride dihydrate ($Ca\ Cl_2$-$2H_2O$), 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 effect 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, reduce evaporation from the soil surface, and protect emerging seedlings.

The planting depth for most forage species should be at 0.25 to 0.5 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 are placed below the highest concentration of salts on the soil surface. Sprigs can also be planted on small acreage 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 greatest 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 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.

Species compatibility needs to be considered when developing a seed mixture. 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#/acre 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, 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 its most favored condition. 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 in which Altai wildrye will be on the drier end and Shoshone on the wetter end. Complicated mixtures are impractical because of inter-specific competition and varied salt tolerance of the different species.

If a site is becoming too wet to traverse with equipment and the soil salinity is low to moderate, Garrison creeping foxtail is suggested. This species thrives on such a site and, once established, will tolerate some increase in the soil-salinity level.

Shoshone beardless wildrye and 'NewHy' hybrid wheatgrass can be established in relatively high levels of soil salinity, and both species are able to spread by rhizomes to fill in the stand or spread into adjacent areas with higher salinity where they were unable to initially establish from seed.

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
Leymus multicaulus	beardless wildrye	Shoshone	180,000	7
Thinopyrum ponticum	tall wheatgrass	Alkar, Largo, Jose,	79,000	14
Leymus angustus	Altai wildrye	Prairieland, Pearle, Eejay	80,000	13
Elytrigia repens X *Pseudoroegneria spicata*	hybrid wheatgrass	NewHy	135,000	8
Elymus trachycaulus	slender wheatgrass	Pryor	130,000	8
Festuca arundinacea	tall fescue	Kenmont, Fawn, Goar, Alta	240,000	6
Psathyrostachys juncea	Russian wildrye	Bozoisky-Select, Swift Mankota, Vinall	170,000	7
Pascopyrum smithii	western wheatgrass	Rosana, Rodan, Walsh	95,000	8
Alopecurus arundinaceus	creeping foxtail	Garrison, Retain	720,000	3
Agropyron cristatum	crested wheatgrass	Fairway, Ephraim Douglas	200,000	6
A. cristatum X A. desertorum	crested w.g. hybrid	Hycrest	152,000	7
Agropyron desertorum	desert wheatgrass	Nordan, Summit	188,000	7
Agropyron sibericum	Siberian wheatgrass	P-27, Vavilov	163,000	7

Salt, Electrical Conductivity (ED, mmho/cm)

By Mark Majerus (1996). USDA Natural Resources Conservation Service, Bridger Plant Materials Center, Bridger, MT.

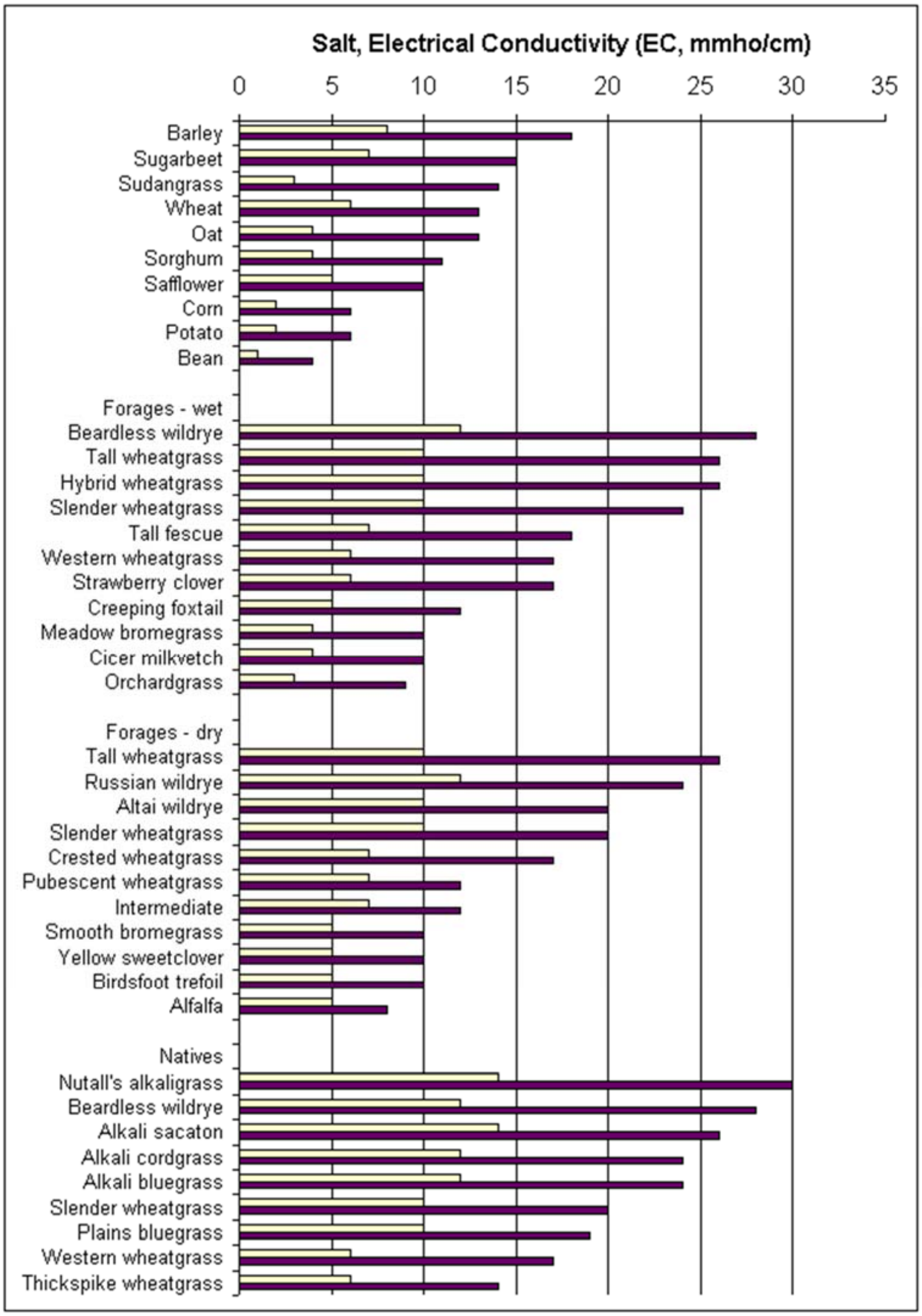

Figure 1. Threshold and maximum salt tolerance levels of various forage and crop species. Top bars denote levels where plant productivity declines, lower bars denote upper limit for plant survival. These values based on composite of research trials at the Bridger PMC (Majerus), U.S. Salinity Laboratory, Riverside, CA (Maas and Hoffman), and the University of Wyoming (Borrelli and Brosz).