R-584 Rev.

SEPTEMBER 1985

Forages for Salt-Affected Soils

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Salt-affected soils are those soils which have high levels of soluble salts and/or sodium in excess of the limits which can be tolerated by crops. Soils with excess soluable salts are referred to as SALINE SOILS. Those soils with excess sodium are referred to as ALKALI (SODIC) SOILS. Soils which contain both high levels of soluble salts and sodium are called SALINE-ALKALI SOILS.

Perennial forages, especially grasses, possess the highest tolerance to saline-alkali soil conditions. The tolerance of a particular crop to saline and/or alkali soil conditions determines its potential to produce a satisfactory yield. REMEMBER - if desirable native plants will not grow on saline and/or alkali soils (Fig. 1), it is unlikely that seeded grasses and legumes will become established.

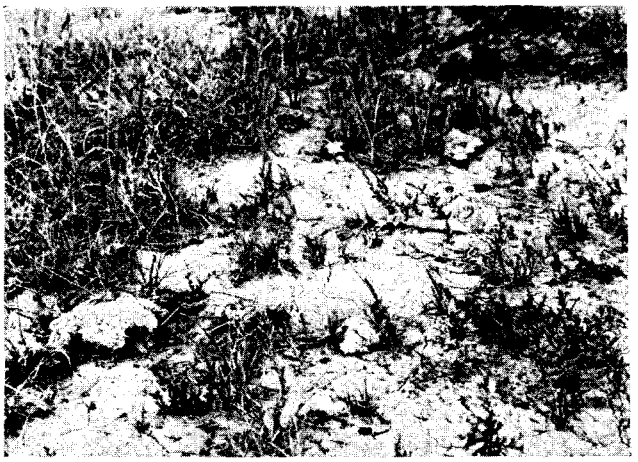

Figure 1. Problem soil area showing only very tolerant native plants growing. Note areas that are vegetated.

Soils with adequate internal drainage under natural conditions generally do not become salt-affected. In well-drained soils, soluable salts are transported by a net downward movement of water in the soils. Soils may become salt-affected (Fig. 2) if there is a net upward movement of water from a shallow water table, from ground water seepage or from saline water overflow which evaporates leaving a salt deposit on the surface.

Plants may grow and produce well when grown on moderately salt-affected soils provided soil moisture remains high. Soils with high soil moisture levels will have a lower concentrations of salts in the soil-water solution. The salts are more concentrated in dry soils and interfere with water uptake (Fig. 3) by plant roots. Excess salts in soil may affect plant growth in several ways. They include the following soil-water-plant relations.

- Limits uptake of water
- Limits uptake of nutrients

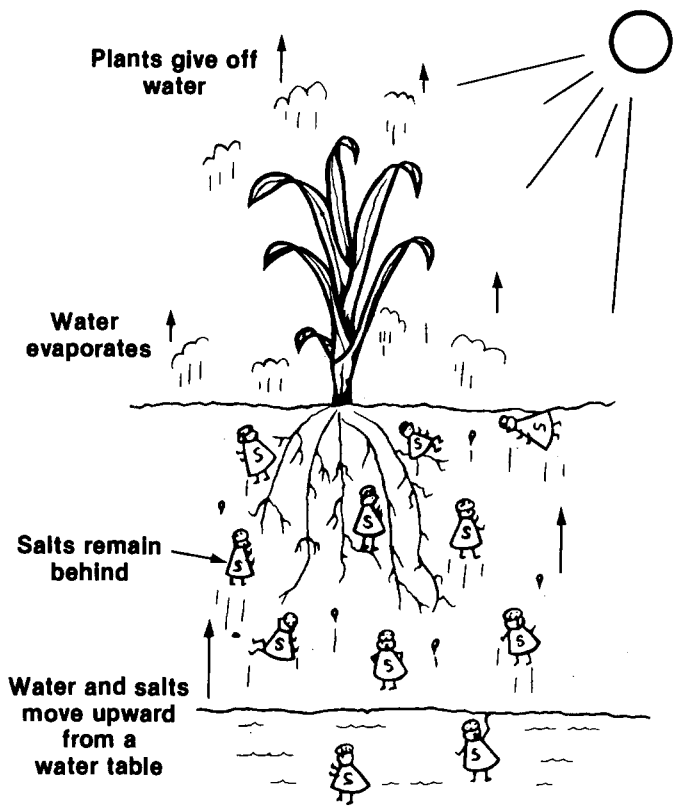

Figure 2. Poor internal drainage and high water table permits salts to build up in crop root zone.

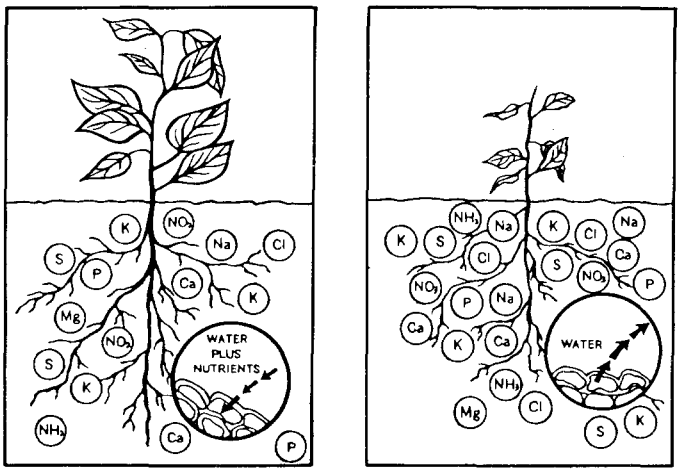

Figure 3. Healthy Plant **Injured Plant**

Healthy plant - Normal levels of soluble salts in soil solution. Roots are actively taking up water and essential nutrients.

Injured plants - Excessive amounts of soluble salts in soil solution. Water is being removed from plant roots causing plant to wilt and possibly die.

- Removal of water from plant roots
- Reduced activity of soil microorganisms
- Increased surface crusting
- Restricted root penetration
- Reduced intake of water into soil
- Reduced aeration of soil

A soil test is the best way to determine the severity of the soluble salt and/or sodium problem in soils. The level of soluble salts in soil is expressed in terms of electrical conductivity (EC) — millimohos per centimeter (mmhos/cm). The influence of soil salinity on plant growth is greater on coarse-textured soils than on medium and fine-textured soils. Coarse-textured soils hold less moisture per foot of depth than medium and fine-textured soils. Therefore, at the same soil salinity level, coarse-textured soils will have a greater concentration of soluble salts in the soil-water solution than heavier soil textures. The soil salinity class for soils based on textural groupings is provided in Table 1. Note that when an electrical conductivity (EC) reading of from 2.0 to 4.0 mmhos/cm is obtained that a coarse-textured soil is strongly salt-affected, medium-textured soils are moderately salt-affected and fine-textured soils are only slightly salt-affected.

The pH level of a soil indicates whether the soil is acidic or basic (Table 2). A soils with a pH level below 6.6 is considered acid, 6.6 to 7.3 near neutral and 7.4 and above is basic.

Soils rated strongly basic will usually be difficult to revegetate because they often contain excess levels of sodium. In most situations the problem cannot be correted economically. A major problem of sodic or alkali-affected soils is severe surface cursting which slows water intake and restricts emergence of forage crop seedlings.

SALT-AFFECTED SOILS ARE BEST USED FOR HAY and PASTURE. Forage production potential depends on the level of salts in the soil and the salt tolerance of grass and legume species selected for the site. In general, perennial grasses are more tolerant to saline-alkali soil condition than legumes. Grass species which possess a high level of drouth tolerance grow best on salt-affected soils.

Table 2. Soil pH levels and the relative degree of acidity.

Soil pH	Relative degree of acidity
5.5 or less	Strongly acid
5.6 - 6.0	Moderately acid
6.1 - 6.5	Slightly acid
6.6 - 7.3	Neutral
7.4 - 7.8	Mildly basic
7.9 - 8.4	Moderately basic
8.5 or more	Strongly basic

SALT TOLERANCE of FORAGES

The salt tolerance of a particular forage crop determines its potential to produce a satisfactory yield at levels of salinity and/or alkalinity not tolerated by other crops. Table 3 provides an estimate of the salt tolerance for a number of perennial grasses and legumes. Species are listed in decreasing order of salt tolerance within each tolerance grouping. For example, moderately salt-tolerant forage species, such as crested wheatgrass, creeping foxtail, intermediate and pubescent wheatgrass and smooth bromegrass, would be expected to establish and produce relatively high yields of quality forage on a moderately salt-affected soil. By comparison, reed canarygrass would do best at the lower level of electrical conductivity (Table 1) for moderately saline soils. A particular species may vary in its tolerance to salts due to differences between individual varieties or strains. As the level of soil salinity approaches the maximum limit for a particular species, forage production will be extremely low provided it can even be established. If barley will not grow on a salt-affected soil, the salinity level is likely strongly to very strongly saline. Very strongly saline soils or

Table 1. Electrical conductivity (EC) of the soil and the influence of soil texture on soil salinity class.[1]

Electrical conducivity	Soil Texture		
	Coarse	Medium	Fine
mmhos/cm	Soil salinity class		
0 - 1.0	non to slightly saline	non-saline	non-saline
1.0 - 2.0	moderately saline	slightly saline	slightly saline
2.0 - 4.0	strongly saline	moderately saline	slightly saline
4.0 - 7.0	very strong saline	strongly saline	moderately saline.
over 7.0	very strongly saline	very strongly saline	strongly saline

[1]NDSU test 1:1 soil-water ratio

Table 3. Estimated salt tolerance of forage crops.

Slightly tolerant	Moderately[1] tolerant		Strongly tolerant	Very strongly tolerant
Alfalfa (seedling)	Crested wheatgrass	D	Altai wildrye	Beardless wildrye
White Dutch clover	Creeping foxtail	E	Slender wheatgrass	Tall wheatgrass
Alsike clover	Inter. wheatgrass	C	Western wheatgrass	
Red clover	Pubes. wheatgrass	R	Russian wildrye	
	Smooth bromegrass	E		
	Birdsfoot trefoil	A		
	Sweetclover	S		
	Alfalfa (established)	I		
	Reed canarygrass	N		
		G		
		T		
		O		
		L		
		E		
		R		
		A		
		N		
		C		
		E		

[1] Annual forages including barley, oats, foxtail millet, sudangrass and sorghum possess moderate tolerance..

those with electrical conductivities greater than 6 to 7 mmhos/cm for coarse-textured soils and 10 to 12 mmhos/cm for medium and fine-textured soils, based on the NDSU salinity test, will be very difficult to revegetate unless soil moisture levels are high. If revegetation is attempted, use only the very strongly salt-tolerant grasses.

SOIL TEST

The first step in revegetating salt-affected soil areas is to obtain a soil salinity test. The salinity test will indicate the potential for revegetation of the site and provide a basis for selecting grasses and legumes with adequate tolerance for existing conditions. Follow the usual soil sampling procedures taking at least 20 subsamples per composite sample across the problem soil area. Samples obtained from the 0 to 6, 6 to 12, 12 to 24 and 24 to 36-inch depths will provide an excellent overview of the salt problem within the plant root zone. Select forage species which will tolerate the higher salt concentration in the plant root zone.

SPECIES SELECTION

Grass and legume species for planting on saline-alkali areas should be selected based on their ability to tolerate existing soil condition. In addition, species selected should be adapted to North Dakota. Table 4 provides a listing of the more commonly used grasses and legumes and suggested varieties for use in North Dakota. Additional information on grass and legume varieties may be found in circulars R-794, 'Grass Varieties for North Dakota'; R-681, 'Alfalfa Variety Selection' and R-862, 'Sweetclover Production and Management.'

SEEDBED PREPARATION

Successful establishment of small seeded grasses and legumes requires a firm, weed-free seedbed. A well-prepared seedbed often is difficult because saline-alkali soils often are wet. However, existing vegetation should be controlled by tillage or the use of a non-selective grass and/or broadleaf herbicide. A well-prepared seedbed will be most helpful to obtain a shallow seeding of about ¼ to ½-inch deep.

TIME OF SEEDING

Forage establishment is the most critical phase in managing saline-alkali soils. This is because salt concentrations usually buildup in the surface inch or so of soil due to an upward movement of saline soil

Table 4. Suggested grass and legume varieties for use on saline-alkali soils where adapted.

Common Name	Varieties and/or comments
LEGUMES	
Alfalfa	Plant only winterhardy varieties, numerous varieties available. Seedling alfalfa not tolerant to salts. Established plant exhibit moderate tolerance.
Sweetclover	Goldtop, Norgold, Madrid and Yukon are yellow-blossom varieties. Use only in mixtures on moderately salt affected soils.
GRASSES	
Creeping foxtail	Use the variety Garrison. Creeping foxtail does not germinate rapidly in moderate to high saline-alkali soil. Requires good soil moisture for germination. Tolerates flooding very well.
Smooth bromegrass	Use any available variety. Possesses only moderate tolerance to salts.
Wheatgrass:	
Crested	Fairway and Nordan most readily available varieties. Possesses moderate tolerance to salts.
Intermediate	Chief, Clarke, Oahe and Slate are accepted varieties. Moderate tolerance to salts.
Pubescent	Mandan 759 and Greenleaf are accepted varieties. Moderate tolerance to salts.
Slender	Primar and Revenue are the only two varieties. Strongly tolerant to salts. Short lived in pure stands. Performance is better on drier sites than other wheatgrasses of similar salt tolerance.
Tall	Alkar, Orbit and Platte are the named varieties. Very strongly tolerant to salts. Performance is best under wet soil conditions.
Western	Rodan, Rosana and Walsh are the adapted varieties. Strongly tolerant to saline-alkali soil conditions. Slow to establish from seed.
Wildrye:	
Altai	Prairieland is the only variety available. Strongly tolerant to salts. Commonly used for late fall pasture.
Beardless	Shoshone is the only accepted variety for North Dakota. Must be dormant-season seeded to break seed dormancy. Very strongly tolerant to salts.
Russian	Vinall is the most readily available variety. Other varieties include Mayak, Sawki and Swift. Primary use is for fall pasture.

water. Soil moisture evaporates at the surface, leaving salts behind. The germinating seed is then exposed to salt concentrations much higher than encountered by roots during later growth stages.

Various studies have shown that seed germination, seedling emergence and stand establishment are the most successful under moist soil conditions. Fall plantings have resulted in better stands than spring plantings. **LATE FALL PLANTING, JUST PRIOR TO FREEZE-UP, IS THE BEST TIME TO PLANT SMALL SEEDED GRASSES AND LEGUMES ON MODERATE TO STRONGLY SALINE-ALKALI SOILS.** Late fall seedings have the seed in the soil ready to germinate early the following spring when soil moisture is usually high. In addition, saline-alkali soils usually are drier in the fall, permitting machinery to cross without difficulty.

FERTILIZATION

Fertilizer applications usually are not required during the establishment year. Studies at the Soil Conservation Plant Materials Center, Bridger, Montana on established stands of beardless wildrye have shown an excellent response to annual fall applications of nitrogen fertilizer. Forage production of beardless wildrye averaged about 4,800 pounds per acre when 50 pounds of actual nitrogen was applied and 7,300 pounds with 100 pounds of nitrogen per acre compared to about 2,700 pounds per acre when not fertilized. If soil phosphorus is very low, an annual application of 20 pounds P_2O_5 per acre annually in combination with the nitrogen will improve the yield of forage.

SEED MIXTURES

Seed mixtures suggested for use on saline-alkali soils are based on the salinity level of the soil. Studies have shown that as the salinity level of the soil increases, seed germination declines and the time required for germination increases. Therefore, seeding rates are increased approximately 30 percent for soils with strongly to very strongly saline ratings. The following are suggested seeding rates for grasses and legumes when seeded individually or in mixtures based on the salinity level of the soil.

SLIGHTLY SALINE

	Lbs PLS/acre
1. Alfalfa	6 to 8
2. Reed canarygrass (wet)	5.0
3. Smooth bromegrass	6.5
Alfalfa	2.0
	8.5
4. Crested wheatgrass	5.0
Alfalfa	2.0
	7.0

MODERATELY SALINE

	Lbs PLS/acre
1. Crested wheatgrass	4.0
Slender wheatgrass[1]	2.0
Alfalfa	2.0
	8.0
2. Smooth bromegrass	6.0
Slendeer wheatgrass[1]	2.0
Alfalfa	2.0
	10.0
3. Creeping foxtail (wet)	6.0

[1] If seed of slender wheatgrass is not available substitute intermediate or pubescent wheatgrass and increase seeding rate to 3.5 lbs PLS per acre.

STRONGLY SALINE

	Lbs PLS/acre
1. Tall wheatgrass	8.0
Slender wheatgrass	1.5
Western wheatgrass	3.5
	13.0
2. Altai wildrye	12.0
3. Russian wildrye	8.0

VERY STRONGLY SALINE

	Lbs PLS/acre
1. Beardless wildrye	12.0
2. Tall wheatgrass	20.0
3. Beardless wildrye	6.0
Tall wheatgrass	10.0
	16.0

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