JOB SHEET

Salinity and Sodic Soil Management
Oklahoma Conservation Practice Job Sheet 610

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Landowner____

WHAT IS SALINITY AND SODIC SOIL MANAGEMENT?
Salinity and Sodic Soil Management is the management of land, water, and plants to control and minimize accumulations of salts and/or sodium on the soil surface and in the crop root zone.

PURPOSE
Salinity and Sodic Soil Management is used:

- To reduce and control harmful salt concentrations in the root zone
- To reduce problems of crusting, permeability, or soil structure on sodium affected soils
- To promote desired plant growth and to utilize excess water in the root zone in non-irrigated saline seep areas and their recharge areas.

HOW IT HELPS THE LAND
This practice can help reclaim land where salt concentrations have developed on the soil surface and in the plant root zone.

WHERE THE PRACTICE APPLIES
This practice applies to all land uses where the concentration or toxicity of salt limits the growth of desirable plants or where excess sodium causes crusting and permeability problems. This practice also applies to non-irrigated land where a combination of factors such as topography, soils, geology, precipitation, vegetation, land use and cultural/structural practices can increase the extent and concentration of salts in saline seep areas.

WHERE TO GET HELP
For assistance with this practice, contact your local Natural Resources Conservation Service or your local Conservation District office.

APPLYING THE PRACTICE
Saline Soils

Naturally developed saline soils usually represent only small areas of a field but can extend to larger areas. Often, these areas are found in bottomlands which have poor internal drainage and a shallow water table. Other small areas occur on slopes where erosion has exposed saline subsoil. Soil surveys often indicate the location and extent of saline soils.

Capillary rise from the shallow water table carries soluble salts occurring in the soil or bedrock to the surface. The water evaporates on the soil surface and leaves behind salts.

These soils are also frequently wet during cultivation and can become compacted in and around the wet areas. A very thin white crust will develop on the soil surface as the soil dries.

Crop production is reduced in these areas due to the salt accumulation. Seedling plants are very sensitive to water stress which leads to stand reduction. Saline soils generally have a very good soil physical condition throughout the tillage depth. When these soils are not too wet, they are friable, mellow, and easily tilled.

Soil which has been saline for several years will be very fertile and high in N, P, and K. These nutrients build up in salty areas because of limited crop removal over time. Soil pH remains relatively unchanged. Electrical Conductivity (EC) of the soil extract is greater than 4 mmho/cm at 25^{0}C, soil pH is below 9, Sodium Adsorption Ratio (SAR) is less than 13, and Exchangeable Sodium Percentage (ESP) is less than 15. The EC is generally consistent throughout the soil profile.

Alkali (Sodic) Soils

Alkali soils contain excessive amounts of sodium. This can result from excess sodium in the subsoil by mineral weathering or sodium rich water applied to the surface.

Sodium forces the soil particles to separate and causes the soil to disperse. Alkali soils are not friable and mellow like saline soils. Instead alkali soils are greasy when wet, especially if it is fine textured and often very hard when dry. They are often characteristically too wet or too dry for tillage. Therefore, poor seed germination and stand establishment are common because good seedbed preparation is difficult.

The pores in the soil which allow water to infiltrate become plugged with the dispersed clay and organic material. As a result, the subsoil is very dry even though water is ponding on the surface. Plants in the area often suffer water stress and may eventually die from lack of water and oxygen.

Alkali soils will have an ESP greater than 15%, a SAR greater than 13, EC of the soil extract less than 4 mmho/cm at 25^{0}C, and generally a pH greater than 9.

Induced Saline and Alkali Soils

Saline and/or sodic soils can be induced with liquid wastes from saltwater brine released from oil wells.

Saltwater brine is concentrated sodium chloride along with other salts and possibly toxic elements. It can result from seepage of evaporation ponds, leakage from wells and pipelines or from unloading tank trucks at the site.

These sites have soils that are dispersed, have a white crust and are mostly bare of vegetation. Soil erosion is generally active at the site which has exposed the subsoil.

Saline Seeps

Saline seeps are intermittent or continuous saline water sites that discharge at the soil surface. They occur downslope from a recharge area.

Saline areas will develop white crusts on the soil surface as water evaporates from the soil profile during dry periods. Normal crop growth is inhibited due to the salt concentration in the plant root zone. Seed germination and early seedling stages are particularly effected.

Saline soils will have a very good physical condition throughout the tillage zone. The soil will be friable, mellow, and easily tilled. Soil which has been saline for several years is generally very fertile having high N, P, and K soil analysis. These nutrients tend to build up due to the lack of vegetation grown on the site.

Saline seeps have the following characteristics:

- They have been accelerated by dryland farming practices
- They are recent and local in origin
- They develop a white crust on the soil surface
- The water table is within 8 feet of the soil surface (often within 3 ft. of the soil surface)
- Soil Electrical Conductivity (EC) is greater than 4 mmhos/cm at 25^{o}C in the top 6 inches of soil. The soil EC will decrease with soil depth.
- Soil pH is less than 9
- Groundwater salinity is generally 4000 micromhos or greater (2600 ppm soluble salts)

IDENTIFY THE PROBLEM

Saline and alkali soils have similar characteristics and can be confused with each other. Verifying the soil condition present is best done with soil testing.

Problem areas can be evaluated in one of the following ways:

- Have a soil scientist evaluate the site with a salinity meter, or
- Have soil samples tested for salinity at the Oklahoma State University soils lab or any other soils lab using the same testing procedures.

The size of the recharge and seep area will need to be determined by a soil scientist. Recharge areas are generally within 2000 ft. of the saline seep.

Soil samples will be collected in accordance with OSU Fact Sheet 2207 – How to Get a Good Soil Sample. Suspected areas should be sampled separately from the rest of the field. A salinity management analysis will need to be done on the soil sample. This analysis includes results for Na, Ca, Mg, K, B, EC, TSS (total soluble salts), Sodium Adsorption Ratio (SAR), Exchangeable Sodium Percentage (ESP), and pH. It is best to sample during a dry period of the growing season and should be taken at least one week after the last rain. Samples should only be taken from the top 1 to 3 inches of soil (seeding depth).

MANAGEMENT FOR SALINE AND ALKALI SOILS

Whenever the source of the salt or sodium is external, such brine from oil wells, eliminate the source as soon as possible.

Apply irrigation according to the NRCS National Engineering Handbook, Part 652, Irrigation Guide and the Oklahoma NRCS Irrigation Water Management (449) standard. On irrigated lands, determine leaching requirements from the NRCS National Engineering Handbook Part 623, Chapter 2.

Using effluent water for irrigating crops and grasses can increase salt concentrations in the soil creating a negative impact on plant growth. Oklahoma Technical Note Agronomy OK-17 contains guidance for irrigating with effluent water.

Improve Internal Soil Drainage

Salt concentrations in the soil profile must be reduced in the plant root zone. Internal drainage in the soil profile must be good enough so that water can easily pass through the soil to leach salts out of the root zone.

There are a number of ways internal drainage can be improved. Tile drains and open ditches are effective in lowering subsoil water that accumulates above compacted clay and bedrock zones. The water table should be lowered to a minimum of 6 ft. below the soil surface for clays and loams and 4 ft. for sandy loams or lighter textures.

Compacted soil layers near the soil surface can be broken up by using deep tillage implements. The soil has to be dry enough to have a shattering effect on the hardpan layer.

Incorporate Organic Material

Once internal drainage is assured, the water movement into the soil must be improved. Incorporating 15 to 20 tons/ac of organic material, such as hay mulch, into the top 4 to 6 inches create large pore space for water to enter the soil.

Apply Gypsum to Alkali Soils

Management for saline and alkali soils is the same to this point. Alkali soils will require additional treatment.

Sodium is attached to the soil particles very tightly and must be replaced before it can be leached through the soil. Gypsum is the most effective soil amendment for removing sodium from the soil. It is a slightly soluble salt of calcium and sulfate. Gypsum will react with the sodium in the soil very slowly but for a long period of time.

The amount of gypsum required varies depending on the percent of exchangeable sodium and soil texture.

Soil Texture	Exchangeable Sodium Percentage				
	15	20	30	40	50
	Tons per acre Gypsum				
Coarse	2	3	5	7	9
Medium	3	5	8	11	14
Fine	4	6	10	14	18

Incorporate the gypsum to a depth of only 1 or 2 inches in the soil. It should be mixed well enough with the soil to keep it from blowing away.

When the application of gypsum exceeds 5 tons/ac, the rate should be split into two or more applications of no more than 5 tons per application. Successive applications should not be made until some time has allowed for leaching to occur (1 year) and a second soil test verifies the need for the additional application of gypsum.

Tillage and Planting of Saline and Alkali Soils

Inversion type tillage, such as moldboard plowing, should be avoided for several years to promote uninterrupted leaching of the salts through the soil profile. Inversion tillage brings soil and salts from the depth of tillage up to the soil surface and starts the leaching process over again. Avoid tillage when the risk for compacting the soil is high on problem areas.

When the salt level in the soil will permit, a salt tolerant crop or forage should be established on the problem area. It is especially important to have a crop or cover on the soil surface during the summer when evaporation is high. The surface should be kept covered as much as possible to keep moisture from evaporating and groundwater from wicking to the surface bringing up salts.

Use soil testing to avoid applying excess fertilizer. Fertilizers contain salts and if applied in excess can add to the problem.

Management of the Saline Seep Recharge Area

Saline seeps are caused by water escaping the plant root zone in the recharge area and moving downslope until surfacing.

Plant and maintain adapted high water use vegetation in recharge areas to utilize soil water before it escapes the root zone. At least 80% of the recharge area should be planted to perennial vegetation. Apply fertilizer according to soil test recommendations for grass plantings.

Where practical, divert run-on water and/or install surface and/or subsurface drainage to minimize water infiltration and decrease soil water in recharge areas.

Management of Saline Seep Area

Plants that produce satisfactory yields under the existing salinity should be used in the seep area. Adapted vegetation may be established in saline seep areas at the same time as the recharge area, however, it is best to delay planting until water tables have been lowered sufficiently to prevent capillary movement of water and salts into the root zone and to the soil surface.

Apply fertilizer according to soil test recommendations for grass plantings.

TABLE 1 - General Crop Tolerances to Soil Salinity (EC is in mmho/cm)

Species	Maximum Soil EC Without Yield Loss [1/] [2/]	Percent of Normal Yield as EC Increases [1/] [2/]				
		EC 4	EC 8	EC 12	EC 16	EC 20
Field Crops						
Barley [3/]	8.0	100%	100%	80%	60%	40%
Cotton	7.7	100%	98%	78%	57%	36%
Sunflower	4.8	100%	84%	64%	44%	24%
Rye	11.4	100%	100%	93%	50%	7%
Canola	11.0 [5/]	100%	100%	87%	35%	-
Wheat [3/]	6.0	100%	86%	57%	29%	-
Grain Sorghum	4.0	100%	71%	42%	14%	-
Sudangrass	2.8	95%	78%	61%	43%	-
Cowpea	1.3	63%	8%	-	-	-
Corn	1.8	84%	54%	24%	-	-
Alfalfa	2.0	85%	56%	27%	-	-
Soybean	5.0	100%	40%	-	-	-
Peanut	3.2	77%	-	-	-	-
Grasses						
Alkali Sacaton	14 [4/]	100%	**	**	**	**
Tall Wheatgrass	7.5	100%	96%	79%	62%	46%
Bermudagrass	6.9	100%	93%	67%	42%	16%
Western Wheatgrass	6.0 [4/]	100%	**	**	**	**
Tall Fescue	3.9	99%	78%	57%	35%	14%
Perennial Ryegrass	5.6	100%	82%	52%	21%	-
Orchardgrass	1.5	98%	73%	48%	24%	-
Lovegrass	2.0	83%	50%	16%	-	-
Native grass	5.0**	**	**	**	**	**

**No data available or NRCS Estimation
[1/] NRCS National Irrigation Guide, Chapter 13, Table 13-3 (Salt Tolerance of Selected Crops)
[2/] Western Fertilizer Handbook 8th Edition, Table 2-6
[3/] Wheat and Barley are less salt tolerant at germination and seedling stage. EC values should not exceed 4 to 5 at this stage.
[4/] Montana Plant Materials Technical Note No. 26 – 1981 and revised 1996
[5/] Francois, 1994a

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