Salt-Affected Soils

by G.E. Cardon and J.J. Mortvedt¹

Quick Facts...

- Three types of salt-affected soils are saline, sodic and saline-sodic soils.
- Salt-affected soils may inhibit seed germination, retard plant growth and/or cause irrigation difficulties.
- Saline soils often can be reclaimed by leaching salts from the plant root zone.
- Sodic soils often can be reclaimed by replacing soil sodium with calcium by adding a calcium-based soil amendment.
- Sodic soils respond to continued use of good irrigation water, good irrigation methods and good cropping practices.

Soils high in salt and/or sodium may limit crop yields. Salt-affected soils may contain an excess of water-soluble salts (saline soils), exchangeable sodium (sodic soils) or both an excess of salts and exchangeable sodium (saline-sodic soils). Periodic soil testing and treatment, combined with proper management procedures, can improve the conditions in salt-affected soils that contribute to poor plant growth.

Types of Soils

Saline soils contain large amounts of water-soluble salts that inhibit seed germination and plant growth. The salts are white, chemically neutral and include the chlorides, sulfates and sometimes nitrates of calcium, magnesium, sodium, and potassium.

Sodic soils are high in exchangeable sodium. The clay particles in the soils attract and hold cations (positively charged atoms). Desirable cations in the soil include calcium, magnesium, potassium and ammonium. These cations readily interchange with one another. However, sodium also can occur in soils and replace desirable cations.

Sodic soils are hard and cloddy when dry and tend to crust. Water intake usually is poor, especially in soils high in silt and clay. The pH (acidity-alkalinity value) of the soil usually is high, often above nine, and plant nutritional imbalances may occur.

Saline-sodic soils contain large amounts of salts as well as high exchangeable sodium. If excessive salts are present as well as excessive sodium, the physical condition of the soil and water intake may be satisfactory, but plant growth may be restricted.

Salinity and Sodium Determination

Salinity is measured by conducting an electrical current through a soil solution made from

a soil sample. The ability of the solution to carry a current is called electrical conductivity and is measured in decisiemens per meter (dS/m) (equivalent to old measure of millimhos per centimeter). The lower the salt content of the soil, the lower the dS/m rating and the less effect on plant growth.

Crop yields are not significantly affected where the salt level is 0 to 2 dS/m. A level of 2 to 4 dS/m restricts some Crops. Levels of 4 to 5 dS/m restrict many Crops and above 8 dS/m restricts all but very tolerant Crops.

Exchangeable sodium in a soil is reported as the Sodium Adsorption Ration (SAR). This is a unitless ratio of the amount of cationic (positive) charge contributed to a soil by sodium to that contributed by calcium plus magnesium. An SAR value below 13 is desirable. Above 13, exchangeable sodium can cause soil structure deterioration and water infiltration problems.

Treatment

Saline soils cannot be reclaimed by any chemical amendment, conditioner or fertilizer. Only leaching can remove salts from the plant root zone. The amount of water necessary is related to the initial salt level in the soil, the final salt level desired and the quality of the irrigation water.

Six acre-inches per acre of good quality leaching water passing through a foot of soil will reduce the salinity by about 50 percent. One acre-foot per acre will reduce the salinity by about 80 percent, and 2 acre-feet per acre passing through 1 foot of soil will reduce the salinity by about 90 percent.

For example, if the soil has an average salt level of 18 dS/m in the top foot and the salt level is to be reduced to 2 dS/m, the amount of leaching water needed is calculated in the following way:

Amount to be reduced, 18 - 2 = 16Reduction desired, 16 / 18 = 89 percent Leaching water needed, 2 acre-feet/acre

Good land management methods prevent salt buildup. Leveling the land and using heavy irrigation prevents salt accumulation in high spots. Adequate drainage prevents salts leached from the surface by irrigation from returning to the plant root zone by upward capillary action. Regular irrigation and drainage provide successful reclamation of this type of soil.

Sodic soils are treated by replacing adsorbed sodium with a soluble source of calcium. Native gypsum, calcium in irrigation water or commercial amendments can supply the calcium. Adequate drainage also must be present.

In many cases, the common practice is to apply sufficient amendment to remove most of

the adsorbed sodium from the top 6 to 12 inches of soil. This improves the physical condition of the surface soil in a short time and permits the growing of Crops. By continued use of good quality irrigation water, good irrigation methods and cropping practices, further removal of adsorbed sodium, especially in the subsoil, usually takes place. In some cases, it may be necessary to reclaim to greater depths to obtain adequate drainage and root penetration.

Types of Amendments

The purpose of an amendment is to provide soluble calcium to replace exchangeable sodium adsorbed on clay surfaces. There are two main types of amendments: those that add calcium directly to the soil and those that dissolve calcium from calcium carbonate (CaCO₃) already present in the soil.

Calcium amendments include gypsum (hydrated calcium sulfate) and calcium chloride. Gypsum is moderately soluble in water. It requires about 1 acre-foot of water per acre to dissolve 1 ton gypsum per acre. Calcium chloride is highly water soluble and fast-acting, but it generally is too expensive to use.

Acid-forming or acidic amendments include sulfuric acid, elemental sulfur and calcium carbonate-sulfur. Sulfuric acid reacts immediately with the soil calcium carbonate to release soluble calcium for exchange with sodium. Elemental sulfur must be oxidized by soil bacteria and react with water to form sulfuric acid. The formation of appreciable amounts of sulfuric acid from elemental sulfur may take several months to several years.

Calcium carbonate-sulfur must go through essentially the same process as elemental sulfur and also is considered a slow-acting amendment. Calcium carbonate must be present in the soil when acid or acid-forming amendments are added.

Choose the amendment mainly on the basis of the cost of the soluble calcium furnished directly or indirectly by the amendment and the speed of the reaction. Also consider ease of application.

Table 1: Amounts of amendments required to supply one pound of soluble calcium.		
Amendment	Purity* %	Pounds
Gypsum	100%	4.3
Calcium chloride	100%	3.7
Sulfur	100%	0.8
Sulfuric acid	95%	2.6
Lime-sulfur	24% sulfur	3.3

*If the amendment has a purity different from that indicated on the table, determine the amount needed to supply one pound of soluble calcium by dividing the percent purity in the table by the percent purity of the material to be applied and multiply this by the number of pounds shown in the table.

Soil Tests

Since the application of amendments to replace sodium usually involves considerable expense, it is sound practice to determine the amount of amendment needed by means of a chemical soil test. It is worthwhile to have a soil test every year or two to determine whether adsorbed sodium is decreasing or increasing.

Water Analysis

In many cases, salt-affected soils are the result of applications of salt in irrigation water. All waters carry dissolved salts and some leaching is required to maintain desirable soil conditions. The Soil, Water and Plant Analysis Laboratory at Colorado State University provides water analysis service to evaluate the quality and usefulness of water for irrigation. This laboratory is located in Room A319, Natural and Environmental Sciences Building, Colorado State University, Fort Collins, CO 80523; (970) 491-5061.

Table 2: Summary of salt-affected soil problems.		
Problem	Treatments	
Saline (salty) soils	Improve the drainage. Leach with water to flush salts from root zone.	
Sodic soils and saline-sodic soils	 Improve the drainage. Supply soluble calcium. a. If soils contain gypsum within the root zone, additional gypsum may not be needed. Native soil gypsum may supply all or part of required soluble calcium. b. Irrigation water containing soluble calcium may furnish part of calcium requirement. c. Soil amendment may be needed. Leach with water to bring about reaction of amendment and to flush out the sodium replaced by calcium. 	

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