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COLORADO STATE UNIVERSITY COOPERATIVE EXTENSION

Salt-affected soils

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Quick Facts

- Three types of salt-affected soils are saline, sodium and saline-sodium soils.
- Salt-affected soils inhibit seed germination, retard plant growth and cause irrigation difficulties.
- Saline soils can be reclaimed by leaching salts from the plant root zone.
- Sodium soils can be reclaimed by replacing soil sodium with calcium by adding a calcium type soil amendment.
- Sodium soils respond to continued use of good irrigation water, good irrigation methods and good cropping practices.
- Permanent salt removal depends on adequate drainage.

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

Types of Soils

Saline soils contain large amounts of water-soluble salts which 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.

Sodium 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 if more than 15 percent of the ions retained by the clay are sodium, the soil is considered to be a sodium or sodic soil.

Sodium soils are hard and cloddy when dry and tend to crust badly. Water intake is usually poor, especially in soils consisting mainly of silt and clay. The pH (acidity-alkalinity value) of the soil is usually high, often above nine, and plant nutritional imbalance often occurs.

Saline-sodium soils contain large amounts of salts as well as more than 15 percent 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 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 usually measured in millimhos per centimeter (mmhos/cm). The lower the salt content of the soil, the lower the mmhos/cm rating and the less effect on plant growth.

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

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 (1525 m^3 per hectare) of good quality leaching water passing through a foot (30.5 cm) of soil will reduce the salinity by about 50 percent. One acre-foot per acre (3050 m^3 per hectare) will reduce the salinity by about 80 percent, and two acre-feet per acre (6100 m^3 per hectare) passing through one foot (30.5 cm) of soil will reduce the salinity by about 90 percent.

For example, if the soil has an average salt level of 18 mmhos/cm in the top foot (30.5 cm) and

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the salt level is to be reduced to 2 mmhos/cm, the amount of leaching water needed is calculated in the following way:

Amount to be reduced, 18 - 2 = 16
Reduction desired, 16 ÷ 18 = 89%
Leaching water needed, two acre-feet/acre (6100 m^3 per hectare)

Table 1: Amounts of amendments required to supply one pound (.5 kilogram) of soluble calcium.

Amendment	Purity* %	Pounds (kg)
Gypsum	100%	4.3 (1.94 kg)
Calcium chloride	100%	3.7 (1.97 kg)
Sulfur	100%	0.8 (.36 kg)
Sulfuric acid	95%	2.6 (1.17 kg)
Lime-sulfur	24% sulfur	3.3 (1.49 kg)

**If the amendment has a purity different from that indicated on the table, determine the amount needed to supply one pound (.45 kg) 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 (kg) shown in the table.*

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.

Sodium 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 (15.2-30.5 cm) 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. Amendments can be considered as two main types: those which add calcium directly to the soil and those which dissolve insoluble calcium from lime already present in the soil.

Calcium furnishing amendments include gypsum (hydrated calcium sulfate) and calcium chloride. Gypsum is moderately soluble in water. It requires about one acre-foot of water per acre (3050 m^3 per hectare) to dissolve one ton per acre (1 metric ton per hectare) of applied mine-run gypsum.

Calcium chloride is highly water soluble and fast-acting, but it is generally too expensive to use.

Acid-forming or acid amendments include sulfuric acid, elemental sulfur and lime-sulfur. Sulfuric acid reacts immediately with the soil lime 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.

Lime-sulfur must go through essentially the same process as elemental sulfur and is also considered a slow-acting amendment.

Lime must be present in the soil when acid or acid-forming amendments are added.

The amendment should be chosen mainly on the basis of the cost of the soluble calcium furnished directly or indirectly by the amendment and the speed of the reaction. Ease of application also should be considered.

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 low quality irrigation water. The Soil Testing Laboratory at Colorado State University provides water analysis service to evaluate the quality and usefulness of water for irrigation.

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.
Sodium soils and Saline-sodium soils	Improve the drainage. Supply soluble calcium. a. If soils contain gypsum, 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.