drought tips

Number 92-33

Reclaiming Sodic and Saline/Sodic Soils

Excessive exchangeable sodium in the soil can severely degrade the soil structure, which severely reduces the soil infiltration rate. This reduction is caused by surface crusting and the swelling and dispersion of clays. The reduction in infiltration rate, in turn, may limit the amount of water available for plant growth and may prevent adequate salt leaching.

Sodic soils often occur when the sodium concentration of the irrigation water is large relative to calcium and magnesium and where bicarbonate concentrations are high. As the plants extract the water from the soil, the salts remain and become concentrated. This concentration causes the calcium to precipitate as calcium carbonate, while much of the sodium remains in the soil water. The exchangeable sodium therefore increases, which is reflected by an increase in the SAR. The large amount of exchangeable sodium causes the soil aggregates to break down and causes swelling and dispersion of clays in the soil. Crop use of shallow ground water can have a similar effect.

Table 1 shows the chemical characteristics of a sodic soil and a saline/sodic soil. Concentrations of calcium and magnesium are extremely small. Sodium is by far the dominant cation, and SAR's are very high. The pH is greater than 9 for both soils. Sodic and saline/sodic soils, therefore, usually have pH values greater than 8.5 to 9, very low concentrations of calcium and magnesium, high concentrations of sodium, and moderate concentrations of carbonate.

Table 1. Chemical characteristics of a sodic and saline/sodic soil. Concentrations are in milliequivalents per liter.

	Sodic	Saline/sodic
EC (dS/m)	1.9	8.1
pH	9.1	9.3
SAR	42	164
Sodium	18.6	97
Calcium	0.1	0.3
Magnesium	0.3	0.4
Bicarbonate/carbonate	9.2	12.8
Chloride	2.3	27.4
Sulfate	7.5	66

Table 2 shows the chemical characteristics of another sodic soil, which differs considerably from that in table 1. In this soil, the pH is 7.6, which reflects the presence of a relatively large concentration of a neutral salt (sodium sulfate). Both calcium and magnesium concentrations are higher than those in table 1, while the bicarbonate concentration is less.

Reclaiming Sodic Soils

Sodic soils can be reclaimed and the infiltration rate can be restored if the exchangeable sodium is replaced with calcium. Both these objectives can be achieved by providing a source of calcium to replace the sodium, either by adding a source such as gypsum, or by adding an amendment such as sulfur or sulfuric acid, which will dissolve lime if it is already present in the soil. These materials can be mixed in to the surface layer of the soil or dissolved in the irrigation water.

Gypsum

Studies have shown that gypsum mixed in to the soil can improve soil properties. Reclamation will occur first over the depth interval containing the gypsum and will occur at lower depths only after reclamation has occurred in the mixed depth interval. Therefore, if deeper reclamation is desirable, sufficient

Author: Blaine Hanson, Irrigation and Drainage Specialist

Table 2. Chemical characteristics of a sodic soil. Concentrations are in milliequivalent per liter.

EC (dS/m)	**4.2**
pH	**7.6**
SAR	**21**
Sodium	**50.6**
Calcium	**4.2**
Magnesium	**7.8**
Bicarbonate/carbonate	**4.2**
Chloride	**3.5**
Sulfate	**60.3**

gypsum should be added to the soil to ensure reclamation of the lower depths. Studies have also shown that while the shallower depths are being reclaimed, the salinity of the leaching water at lower depths increases, thus potentially enhancing the percolation rate at those depths. This, in turn, enhances the leaching of excess sodium below the root zone.

The amount of gypsum needed for reclamation depends on the initial and final amounts of exchangeable sodium, the ability of the soil to adsorb sodium and calcium, the bulk density of the soil, the depth interval to be reclaimed, and lime in the soil. The amount of gypsum needed - called the gypsum requirement - is determined by a laboratory analysis. Lacking such an analysis, recommended rates range from 3 to 5 tons per acre. As a rule of thumb for estimating the amount of water to apply: about 1 acre-foot of water dissolves 1 ton of gypsum.

Sulfurif Acid

Sulfuric acid, when mixed with the soil or added to the irrigation water dissolves lime already in the soil, thus releasing calcium that can exchange for sodium on the soil. The process is relatively rapid, but sulfuric acid is difficult and dangerous to handle.

Sulfur.

Sulfur is sometimes used to reclaim sodic soils containing lime. The process is time-consuming since the sulfur must first be oxidized by soil bacteria to form sulfuric acid. This, in turn, dissolves the lime.

However, the oxidation process requires a warm, well-aerated soil and is slow: sulfur applied in the fall may have little effect until the following summer.

Other amendments

Calcium chloride, calcium nitrate, lime sulfur, and ferric sulfate are other available amendments. Calcium chloride and calcium nitrate are highly soluble materials, but are expensive.

How Much Material to Apply

How much amendment should be applied? As explained above, the gypsum requirement should be determined from a laboratory analysis. Common values range from 3 to 5 tons per acre of pure gypsum. However, commercially available gypsum is not 100 percent pure and therefore requires a higher application rate. The application rate of other amendments can be estimated based on an amount equivalent to 1 ton of pure gypsum. To estimate the amount of impure gypsum or the amount of other amendments, use Table 3 and Equation 1, below.

$$\text{Applied amount} = \frac{100 \times}{\%\text{purity}} \;\text{tons equivalent}$$

Example 1. How much 60 percent-pure gypsum should be applied if the gypsum requirement is 3 tons per acre?

% purity = 60%
tons equivalent = 1.00
applied amount = 100/60 x 1 = 1.67

If the gypsum requirement is 3 tons per acre, then 3 x 1.67 = 5 tons per acre of 60 percent-pure gypsum should be applied.

Example 2. How much 80 percent-pure sulfuric acid should be applied if the gypsum requirement is 4 tons per acre?

% purity = 80%
tons equivalent = 0.61
amount applied = 100/80 x 0.61 = 0.76

For every ton of gypsum required, therefore, 0.76 tons of sulfuric acid should be applied. The total amount to be applied is 4 x 0.76 = 3 tons per acre of sulfuric acid.

Table 3. Tons equivalent to 1 ton of pure gypsum for various amendments

Amendment	Tons equivalent to 1 ton of pure gypsum
Gypsum	1
Sulphur	0.19
Sulfuric acid	0.61
Ferric sulfate	1.09
Calcium chloride	0.86
Calcium nitrate	1.06
Lime sulfur	0.78

References

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drought tips is a publication series developed as a cooperative effort by the following organizations:

California Department of Water Resources, Water Conservation Office
University of California (UC)
UC Department of Land, Air and Water Resources
USDA Drought Response Office
USDA Soil Conservation Service
USDI Bureau of Reclamation, Mid-Pacific Region

Published 1993