

Agricultural Extension University of California

Central Coast Counties Grape Squeezes

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SALINITY ASPECTS OF THE SOIL ENVIRONMENT

What are saline soils?

Salts initially occur in the soil due to the weathering of rock, but salts are often transported by surface or ground waters. Salts accumulate, especially in arid or semi-arid regions, because rainfall is insufficient for adequate leaching of the soil, or because sub-surface drainage is inadequate to allow downward movement past the root zone.

Many soluble salts provide the mineral nutrients required for normal plant growth and fruit set--most chemical fertilizers supply essential nutrients in the form of soluble salts. Even so, an excess of soluble salts is harmful. When soluble salts are present in your soils in such an excess that they injure the vines, your soil is said to be saline.

How does salinity affect plant growth?

1. By decreasing the availability of water to plants.
2. By direct toxic effects.

The saltier the soil water, the harder it is for the vine roots to extract the water from the soils. Furthermore, certain salts such as boron, chloride, or sodium in the leaves causes them to burn progressively inward from the tip or edges and drop from the plant. Difficulties with water uptake and/or excessive foliar burn both can decrease your vine growth and yields.

What is exchangeable sodium?

Dissolved salts when in solution disassociate into charged particles called ions. The predominant ions in the soil moisture include the cations (such as calcium, magnesium, and sodium) which are positively charged and the anions (such as sulfate, nitrate, bicarbonate, chloride, etc.) which are negatively charged. As water containing dissolved salts passes through the soil, the positively charged cations are (1) attracted to, and held by, negative charges on the silt and clay particles and are (2) removed from the soil solution. However, cations held on the surface of the silt and clay particles in this manner may be replaced by, or exchanged with, other cations. For example, calcium applied as gypsum (calcium sulfate) can replace the sodium that is held by the silt and clay.

Exchangeable sodium, then, is that portion of the soil sodium that is absorbed by the soil and may be replaced by, or exchanged with, other cations such as

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calcium or magnesium. Sodium absorbed by the soil is no longer considered a part of the soil solution. However, other cations still in the solution may replace and exchange with the absorbed sodium.

What are sodic soils?

The ratio of the different cations, held in an exchangeable form, varies. This ratio ultimately will depend on the relative composition of the irrigation water. For example, the continual use of an irrigation water containing a high proportion of sodium as compared to calcium and magnesium will eventually result in a soil containing an excessively high proportion of exchangeable sodium. This is undesirable and leads to soil structure problems, toxicity, etc. Conversely, when the irrigation water contains a high proportion of calcium and magnesium as compared to sodium, the calcium and magnesium continue to predominate. This is desirable for good soil structure, aeration, etc. Soils containing excessive exchangeable sodium are termed sodic soils. These soils are often called sodium, alkali, or black alkali soils. Sodic surface soil conditions are not common in the Central Coast areas. However, sodic subsoil conditions are a hazard in some of our layered, non-uniform soils.

How does exchangeable sodium (sodic soil conditions) affect yields?

1. By causing soil particles to disperse and result in loss of favorable soil structure.
2. By upsetting the nutrient balance of the soil.
3. By toxic effects due to uptake of excessive sodium in the plant.

Soil particle dispersion can give you problems concerning aeration, water movement, and root growth. Because of the small pore space in a sodic soil, it sometimes becomes difficult to avoid complete displacement of the soil air when you irrigate. In this case roots are "drowned out."

The nutritional problems you encounter are usually related to the unbalanced accumulation of calcium and sodium in the plants. Plants grown on a sodic soil generally not only have a lower calcium but also have a higher sodium content than those grown on a non-sodic soil. Calcium deficiency coupled with sodium toxicity may result.

What other salts are also toxic to vines?

1. Boron
2. Chloride

Boron, chloride, and sodium excess, and sometimes potassium deficiency, cause leaves to burn progressively inward from the tip or edges. Excessively high levels of boron, chloride, and/or sodium may even cause defoliation and/or death when excessively high amounts are taken up by the vines.

Foliar intake, as well as root uptake of toxic ions, can occur when over-the-vine sprinklers are used. (We will further discuss foliar intake of toxic ions while discussing Water Quality.)

What do you need to know to appraise saline, sodic, or toxic ion soil hazards and conditions?

1. Have salt analysis performed on your (a) soil and (b) irrigation water.
2. Observe and determine the physical characteristics and limitations of your soil profiles.
3. Where possible, have comparative samples (of vine petioles or leaf blades) taken from problem and non-problem areas and have them analyzed.

Remember depth, texture, permeability, and drainage characteristics of your soil can all be components of the "salt affected" soil situation.

Appraise saline, sodic, and toxic ion conditions by having laboratory analyses performed. Laboratory tests on soil saturation extracts are made by wetting soil samples with distilled water until the

soil is just saturated. By extracting the soil solution with suction or pressure, the laboratory obtains a solution of dissolved salts which are then analyzed.

Which laboratory test should you request?

For grapes, the laboratory tests listed below are used to appraise "salt affected" soil conditions. You should note that the following laboratory tests and interpretations for electrical conductivity, calcium plus magnesium, sodium, exchangeable sodium percentage, and boron have been based on saturation extract methods of analysis.

1) Saturation Percentage (SP)
2) Degree of acidity or alkalinity (pH)
3) Electrical Conductivity (EC_e)
4) Calcium plus Magnesium (Ca+Mg)
5) Sodium (Na)
6) Exchangeable Sodium Percentage [ESP(est.)]
7) Boron (B)
8) Gypsum Requirement (GR)

On pages 9 and 10, the above mentioned criteria are listed with ranges of values for comparing and interpreting laboratory test results of your soils.

Even though most varieties of grapes can not tolerate high levels of chlorides, separate soil tests for chlorides usually are not suggested. For grapes, critical chloride levels usually are considered to be included satisfactorily in the electrical conductivity appraisal. In other words, for grapes, electrical conductivity values above four millimhos per centimeter (2560 ppm) not only indicate problems associated with excessive amounts of salts, but also could indicate problems associated with toxic levels of chlorides. See page 9.

Many tree crop species on the other hand are more sensitive to chlorides than grapes -- and consequently tests for chloride levels in the soil are recommended for the more sensitive crop species.

Reclamation procedures for correcting "salt affected" soils problems associated with toxic levels of chlorides are the same as those employed for correcting salinity problems shown by excessively high electrical conductivity values.

How are analyses interpreted?

Results of soils analyses should be interpreted by an experienced agriculturist who must evaluate the laboratory data in relation to vine tolerance and other factors affecting production. These factors include: poor aeration, soil compaction, restricted root system, inadequate drainage, unfavorable climatic conditions, plant pests, plant nematodes, plant diseases, or insufficient soil moisture. Regardless of the chemical status of the soil, crop production may be limited by any one of these factors.

Quality of the irrigation water should also be taken into account when appraising soil analysis.

How are soil samples taken?

Soil samples, according to James Quick, Extension Technologist, must be taken in such a manner as to represent each specific situation or problem. Hurriedly obtained small "grab" samples are of little or no value. It is not possible here to describe sampling procedures for all situations. In general:

1. Select the sampling sites on the basis of the particular problem or soil variation.
2. For saline, sodic, or toxic ion conditions, take separate (not composite) samples. Take samples at locations representing a range of conditions from poor to good plant growth areas and/or from shallow to deep soil areas. Samples should be taken at 12 inch depth increments for soils of uniform texture and kept separate. For layered soils, try to confine a given sample within a textural layer rather than mix the layers of differing textures.
3. Sample size -- should be about one quart of soil per sample.
4. Use a waterproof container to hold the samples.
5. Be sure to label each sample according to location and depth.

Run that by again!!?

To visualize the amount of salt represented by an electrical conductivity of 1 millimho per centimeter of soil extract ($EC_e \times 10^3$ = 1 mmho./cm.) imagine that you have a 50 gallon barrel of pure water and that you dissolve in it four ounces of table salt.

The salt concentration of the solution would be approximately 640 parts per million.

If you used this water to saturate a sample of salt free soil, the solution extract would have a conductivity of about 1 millimho per centimeter at 25°C.

If you applied an acre foot of water containing 640 ppm dissolved salts on an acre, about 1740 lbs. or 0.87 tons of salt would be applied via the water.

"Backhoe analysis"?!

Many growers are evaluating land with a backhoe -- for soils diagnosis you have to get up awfully early in the morning to beat the backhoe!

Before planting or replanting a vineyard, a number of well placed backhoe slots will tell you a lot more in half a day than you could discover with a soil auger or shovel in weeks. Soil texture, consistency, uniformity ---- interface conditions, plowpans, claypans, hardpans --- drainage, perched water tables --- and other soil depth limitations can be looked at and evaluated. Judgements on whether to chisel, disk plow, deep rip or slip plow can be weighed.

In existing vineyards, a backhoe slot will not only uncover soils and water penetration facts but also expose vine roots. Root distribution and depth can tell you a lot about how the vine feels about the existing situation.

Have the backhoe operator dig the slot with a gradual incline on one end so you can walk down into the slot. About 8 feet is usually deep enough. Use good judgement though -- some slots are not safe to walk down into.

Try to schedule "backhoe analysis" soon after the slots are dug and before the side walls dry out. Moist to wet soil conditions are much easier to evaluate and give better information than dry soil conditions.

Next Issue

Water quality analysis and appraisal
Foliar intake of toxic ions

Suggested reading

Physical Characteristics of Soil(AXT 152)
Salt Tolerance of Plants (USDA Bul 283)
Salt Tolerance of Fruit Crops(USDA Bul 292)

A limited number of these publications are available from our office. Please feel free to request them.

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CRITERIA FOR EVALUATING "SALT AFFECTED" SOILS FOR GRAPES 1/

SP

Saturation Percentage - Grams of water required to saturate 100 grams of soil. Related to soil texture and soil water holding capacity. Used to correlate exchangeable sodium percentage (ESP) effects with soil texture.

Below 20	Sand or loamy sand -	Deep soils may be satisfactory for grapes
20 - 35	Sandy loam ---------	Preferred for grapes
35 - 50	Loam or silt loam --	
50 - 65	Clay loam ----------	May be satisfactory for grapes
65 - 135	Clay ----------	Limiting; - difficult to manage

The water holding capacity of a field soil when irrigated and allowed to drain is approximately half the SP value. About half the water holding capacity is readily available for crop use.

pH

Degree of Acidity or Alkalinity

Below 4.2	Too acid for most crops to do well.
4.2 - 5.5	Adapted to a growth of acid tolerant crops
5.5 - 8.4	Adapted to growth of most crops including grapes.
Above 8.4	Indicates a probable sodium problem, however, sodium problems can occur at pH's lower than 8.4.

EC_e

Electrical Conductivity of the saturation extract expressed as millimhos per centimeter at 25°C. An index of the salt content. Electrical conductivity values allow appraisal of salinity as follows:

Below 2	No salinity problem for most crops.
2 - 3	Restricts growth of very sensitive crops but usually not grapes.
4	May slightly restrict growth of grapes. May reduce yields of grapes up to 10%.
10	Restricts growth of most crops. Severly restricts growth of grapes. May reduce yields of grapes up to about 50%.
10 - 16	Restricts growth of all but very salt tolerant crops.

Ca+Mg — Calcium plus Magnesium in the saturation extract expressed as milliequivalents per liter. Used in estimating the exchangeable sodium percentage of the soil [ESP(est)] .

Na — Sodium in the saturation extract expressed as milliequivalents per liter. Used in estimating the exchangeable sodium percentage [ESP(est)] .

ESP (est) — Exchangeable Sodium Percentage - A close approximation of the degree the soil exchange complex is saturated with sodium. High ESP has two effects: (1) toxicity to vines and (2) permeability problems for soils.

1) Toxicity hazard to vines.

Below 5%	Usually no toxicity problem for grapes.
5 - (?)%	Increasing toxicity problem for grapes.
10 - 20% *	Hazardous toxicity problem for grapes.

2) Permeability hazard for soils.

Below 10%	Generally no permeability problem.
10 - 15% *	Possible permeability problems with clay loams and clays (SP above 50).
Above 15 %	Permeability problems are likely on all mineral soils with possible exceptions of sands and loamy sands (SP below 20).

* where ESP levels are above 10, gypsum requirement (GR) is needed to confirm a permeability problem due to sodium.

B — Boron expressed as ppm in the saturation extract. Indicative of possible toxicity problems to grapes.

Below 1 ppm	Satisfactory for nearly all crops.
1 ppm	Leaf symptoms may be apparent for sensitive crops such as grapes.
1 to 5 ppm	Leaf symptoms and yield reduction become an increasing hazard for grapes.
5 ppm	Semi-tolerant crops such as barley, oats, corn, etc., may show visible injury. Hazardous for grapes unless reclamation of the soil is practical.

GR — Gypsum Requirement confirms there is a permeability problem due to sodium and donates whether or not soil ammendments should be considered.

1/ Adapted from data from the following authors:

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** NOTE: Laboratory tests and interpretations for EC_e, Ca+Mg, Na, [ESP(est)] , and B are based on saturation extract methods of analysis.