Cornell University
School of Integrative Plant Sciences

Add-on Test: Salinity

Soils become saline when the concentration of soluble salts (mostly made up of compounds of Mg^{+2}, Ca^{+2}, Na^{+}, K^{+}, Cl^{-}, SO_4^{-2}, HCO_3^{-} and CO_3^{-2}) in the soil profile becomes excessive. **Salinity** can be measured by electrical conductivity, and this is offered as the 'soluble salts add-on' with a Cornell Soil Health Assessment. **Sodic** soils are those with excessive sodium ion concentrations, relative to magnesium and calcium, measured by the sodium adsorption ratio. These conditions may occur together or separately.

The sodium adsorption ratio is not currently available from the CSHL. Although salinity and sodicity are often mistaken as the same thing, they are in fact quite different from each other. We include the comparison between salinity and sodicity here for clarification.

Salt affected corn. Photo credit: University of Delaware

Crusting in a saline-sodic urban soil.

FIGURE 1 A and B. Management challenges in saline and sodic soils.

How salinity and sodicity relate to soil function

Problems with salts (salinity) and sodium (sodicity) may occur naturally, but are especially prevalent under irrigated agriculture in semi-arid and arid areas, where water from rainfall would not otherwise be adequate for crop production. This situation is prevalent in western regions of the United States. It is also prevalent in high tunnels and greenhouses used for season extension in the Northeast – these are effectively irrigated deserts when they are covered year-round. Localized saline-sodic soils may also occur in coastal regions when soils are affected by sea water, or in urban areas in cold climates where salt de-icing materials are used. Salinity and Sodicity have severe impact on growing crops through very different mechanisms.

High salinity decreases the osmotic potential of the soil water relative to plant water. This means that the crops must exert more energy to get water from a saline soil, which holds the water more tightly. Therefore soils with high salinity could have sufficient water but growing crops will lack access to it and may wilt and die (Figure 1 A). In addition, high concentrations of some elements that make up the salts in the soil such as sodium and chloride can become toxic for some plants, affecting their metabolism and consequently reducing their growth.

High sodium concentrations break down soil structure, as sodium replaces calcium and magnesium on mineral surfaces. This prevents fine particles from sticking to each other, so that aggregates are dispersed into single grains. A sodium-affected soil becomes crusted and severely compacted, so that water cannot properly infiltrate or drain, and water storage is diminished as well (B). This has a major impact on soil physical functioning, so that crops will not be able to grow properly. Sodic soils also have high pH, negatively affecting the availability of certain nutrients like phosphorus.

Add-on Test: Salinity

Managing salinity and sodicity concerns

Salinity and sodicity problems have multiple causes and may be difficult to address. In general, salts can be leached out of the soil with the application of excess water through natural rainfall or irrigation. But this is often problematic in regions where shallow groundwater is a primary source of the salts, which in turn is often the results of excessive irrigation. Such areas may therefore require installation of subsurface drainage to remove the excess groundwater before salts can be leached.

Sodicity is often addressed through the application of gypsum, where calcium substitutes for the sodium on the soil exchange complex, thereby improving soil aggregation and reducing pH. It is then important to leach the sodium out of the surface soil to prevent the reoccurrence of sodicity.

Basic Protocol

Electrical Conductivity (EC) - to measure salinity

Soluble salts are extracted from the soil with water, in a 1:1 soil:water suspension by volume, and the electrical conductivity of the supernatant is determined as follows:

- 20ml of distilled deionized water are added to 20 ml of dried ground soil and stirred;
- Suspension is settled for one hour;
- Electrical conductivity of the supernatant is measured with a calibrated conductivity meter (Fig. 2).

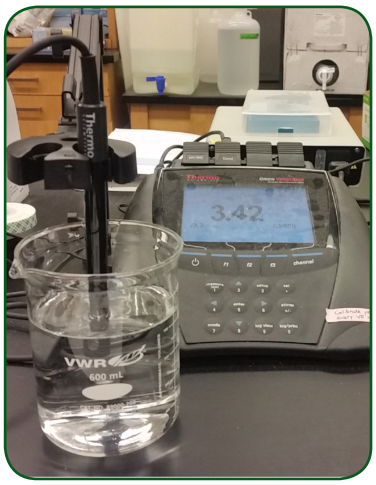

FIGURE 2. Electrical conductivity (EC) meter used to measure salinity.

Interpretation

Tables 1 A and B to the right show threshold criteria for interpreting salinity measured by the 1:1 volumetric extraction of soluble salts (A). These thresholds are general interpretations that are not crop specific (B). The effect of soil salinity is often judged by the extent to which crops respond to different levels of salinity.

Some crops are very sensitive while some others are more tolerant. Vegetables sensitive to salinity include radish, celery, and green beans, while those with high salt tolerance include kale, asparagus and spinach. Crop response is also influenced by texture.

TABLE 1 A. Interpretation of 1:1 soluble salts test (Dahnke and Whitney, 1988).

		EC (mmhos cm^{-1}) BY SOIL TEXTURE			
DEGREE OF SALINITY	CROP RESIDUE	COARSE SAND TO LOAMY SAND	LOAMY FINE SAND TO LOAM	SILT LOAM TO CLAY LOAM	SILTY CLAY LOAM TO CLAY
Non-saline	Almost negligible effects	0 – 1.1	0 – 1.2	0 – 1.3	0 – 1.4
Slightly-saline	Yield of the most sensitive crops reduced	1.2 – 2.4	1.3 – 2.4	1.4 – 2.5	1.5 – 2.8
Moderately saline	Yield of most crops reduced	2.5 – 4.4	2.5 – 4.7	2.6 – 5.0	2.9 – 5.7
Strongly saline	Only tolerant crops yield well	4.5 – 8.9	4.8 – 9.4	5.1 – 10.1	5.8 – 11.4
Very strongly saline	Only very tolerant crops yield well	> 9.0	> 9.5	> 10.1	> 11.5

TABLE 1 B. General threshold criteria defined to classify a soil as saline, sodic, or saline-sodic. It is important to note that the pH of the soil is also important in defining these conditions.

ECe = Electrical Conductivity of a saturated soil extract
pH = Acidity or alkalinity of the solution

	ECe	pH
SALINE	> 4 mmho cm^{-1}	< 8.5
SODIC	< 4 mmho cm^{-1}	> 8.5
SALINE - SODIC	> 4 mmho cm^{-1}	> 8.5

For a more comprehensive overview of soil health concepts including a guide on conducting in-field qualitative and quantitative soil health assessments, please download the Cornell Soil Health Manual at bit.ly/SoilHealthTrainingManual.

Acknowledgement

Thanks to the NE Sustainable Agriculture Research & Education Program, New York Farm Viability Institute, USDA-NRCS and Cornell Cooperative Extension for funding and support of the Cornell Soil Health program.

This fact sheet represents the best professional judgment of the authors and does not necessarily reflect the views of the funders or reviewers.

For more information contact:

Cornell University
Soil Health Laboratory
bit.ly/SoilHealthContacts

Harold van Es
Robert Schindelbeck
Aaron Ristow, Kirsten Kurtz and Lindsay Fennell

May 2017