IDENTIFYING SALINE AND SODIC SOILS

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ABSTRACT

Soil salinity can become a sever limitation to crop yields and soil quality. Routine evaluation of salinity often involves a 1:1 extract of water to soil. However, salinity tolerance has been defined from saturated paste extracts, not 1:1. Saturated extracts take more time to determine in the lab but is the best method to ascertain crop susceptibility to yield loss. Mathematical conversions from 1:1 to saturated paste are possible to do but may not translate across regions. In a similar way, determine soil SAR / ESP is most often accomplished using ammonium acetate extractions of Ca, Mg, and Na. However, the standard method for determining SAR is through the saturated paste extract. Soil tests from New Mexico locations were performed to determine both the 1:1 and saturated paste EC as well as SAR by saturated paste and Ammonium Acetate extraction of cations. Results demonstrate that mathematical adjustments can be made for salinity measures but is not accurate 100% of the time. SAR, on the other hand, does not lend itself to mathematical conversion between 1:1 and saturated paste. Determining SAR by ammonium acetate methods most significantly leads to the underestimating the amount of amendments such as sulfur or gypsum that would be recommended for reclamation of sodic soils.

OBJECTIVES

The primary objective of this presentation is to demonstrate the differences that exist between two well-known methods of determining soil salinity and sodicity. Furthermore, the recommendations for irrigation water management as well as rates for reclaiming sodic soils are compared to demonstrate potential errors in reclamation activity.

METHODS

The standard practice for determining soil salinity or “saltiness” is to saturate the soil with distilled pure water (i.e., fill all of the pores in between soil particles with water), and then extract the water from the saturated soil paste after 24 hours. The EC determined from this procedure is abbreviated ECe. Some labs will mix one part water with one part soil by volume or weight to test for soil salts. This method takes less time than the saturated paste method. However, the saturated paste method is best for evaluating crop response to soil salinity since most reference tables are based on this procedure. Other methods, or different ratios of soil to water, are suitable for relative comparisons. The main reason why the saturated paste method works so well has to do with the solubility of salts in soil. Too much water could dilute the effects of salt on plant/water relationships seen in the saturated soil environment. The saturated paste is a compromise between having enough liquid to extract for analysis while still reflecting the soil conditions that a plant would experience after being watered.

Randomly selected soil samples were subjected to both the 1:1 and saturated paste extract methods for determining salinity. Soil SAR was also determined from the same samples utilizing the ammonium acetate extraction as well as the saturated paste method. Gypsum application rates were determined using results from both SAR methods. Regression equations were determined to estimate relationships between 1:1 and saturated paste extracts for determining saline soils.

RESULTS AND DISCUSSION

Plants are most sensitive to soil salinity when the seed is germinating. A soil sample should reflect the conditions around the seed, so sampling no deeper than 2 inches is suggested if you are concerned about germination and plant establishment. However, for purposes of cost and assessing the potential root zone for nutrients, sampling from the surface to 8 or 12 inches is acceptable. The soil should be sampled at least 6 to 8 weeks prior to planting.

Electrical conductivity values do not mean anything until they are interpreted or correlated to plant responses such as growth or yield. However, the higher the EC, the fewer the types of plants that will grow well. Most ornamental and crop plants do not thrive in saline soils with high EC. In general, a soil is saline if the conductivity of the saturated paste extract is greater than 4 mmhos/cm or dS/m. Saline soils do not mean that an excess of sodium is present. Saline soils have an exchangeable sodium percentage (ESP) less than 15%. However, sodium reclamation procedures should begin when ESP values are greater than 6%. Excess sodium causes its own set of problems and warrants special attention. The pH of a saline soil is also usually less than 8.2

Soil salinity disrupts the water balance in plants. Plants generally respond to soil salinity with reduced growth and transpiration rates. However, not all plants respond the same to soil salinity because of myriad adaptations and biological processes that can improve plant tolerance to soil salinity. Plants are evaluated for their tolerance by growing them in controlled experiments where the soil salinity is varied in different containers or plots while other growing conditions are the same. The plants are all watered, fertilized, and grown the same way for a pre-determined amount of time. Plants are then harvested for dry matter or yield and plotted against the soil salinity as measured by EC (Figure 1). The salinity level at which plants are first affected by salinity is referred to as the "threshold." The threshold varies with crop tolerance and external environmental factors that affect the plant's need for water. The rate at which the yield decreases as salinity increases is the "slope." The threshold and slope reflect how sensitive the plant is to salinity. Armed with the threshold and slope of a given plant, as well as the soil salinity from a soil test, we can predict how well a plant will grow in that soil. Rhoades et al. (1992) present the following equation to estimate relative yield (A relative yield of 100% implies no salinity effect on plant yield or expected performance. A relative yield of 90% implies a 10% reduction in plant performance due to salinity or 90% of expected plant productivity without salinity.):

$$100 - ((\text{soil test EC} - \text{threshold}) \times \text{slope}) = \text{relative yield} \qquad \text{(Equation 1)}$$

The difference in salinity determined by 1:1 and saturated paste extracts for New Mexico soils is shown in Figure 2.

Sodic Soils

Sodic soils are identified when tested for exchangeable calcium, magnesium, and sodium. A high amount of exchangeable sodium relative to calcium and magnesium coupled with high pH causes soil crumbs to disperse or break apart. Soil particles that are dispersed are much smaller than well-aggregated or clumped soil and cause the destruction of soil structure. The soil surface usually forms a crust, and pore spaces become clogged with tiny, dispersed soil particles that prevent water movement into and through the soil. Such soils are called "sodic" and are high in exchangeable sodium as compared to calcium and magnesium. The sodium adsorption ratio (SAR) is above 13 and the exchangeable sodium percentage (ESP) is above 15%. The EC is less than 4 mmhos/cm and often less than 2 mmhos/cm, so while the total amount of salts may not be that high, the proportion of sodium to other salts is what makes a soil sodic or not. The soil pH is often greater than 8.5. The physical condition of the soil may exhibit crusting and dispersion at the surface, but this can be affected by soil texture, organic matter, and the EC of the irrigation water. Sodic soils often have a black color due to dispersion of dark organic matter and a greasy or oily looking surface with little or no vegetative growth. These soils have been called "black alkali" or "slick spots."

Soils that have high salinity and high exchangeable sodium are referred to as "saline-sodic." The soil pH can be above or below 8.5, salinity is greater than 4 mmhos/cm, and the SAR is greater than 13. These soils may have good water infiltration, but must be managed carefully. Figure 3 illustrates that soils can be non-saline/non-sodic, saline/non-sodic, non-saline/sodic, or saline-sodic.

REFERENCES

Rhoades, J.D., A. Kandiah, and A.M. Mashali. 1992. *The use of saline waters for crop production* [FAO Irrigation and Drainage Paper 48]. Rome: Food and Agriculture Organization of the United Nations.

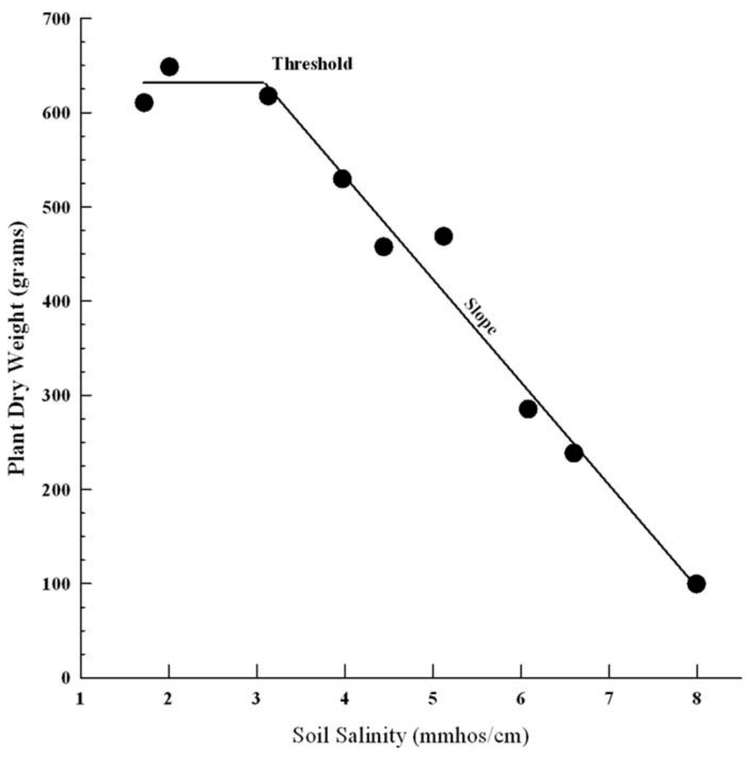

Figure 1. *Capsicum* sp response to soil salinity as determined by saturated paste.

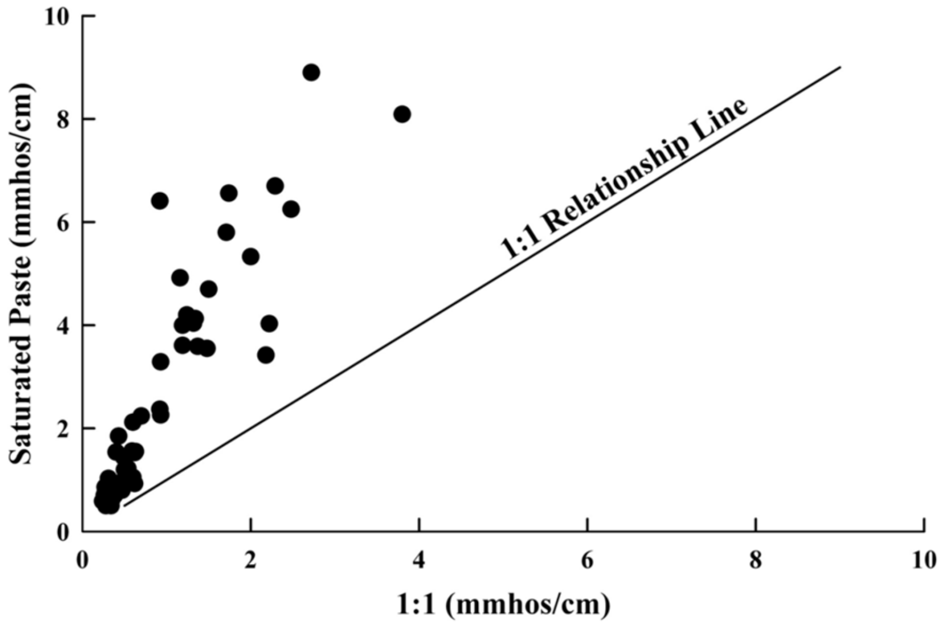

Figure 2. Relationship between 1:1 and (ECe) Saturated Paste Extractable Soil Salinity.

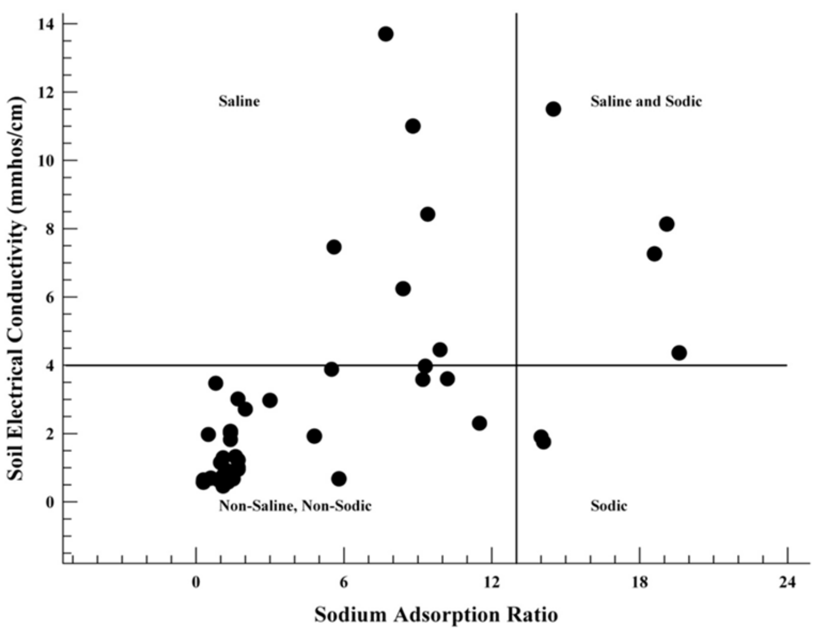

Figure 3. Example of soil test results interpreted as non-saline/non-sodic, saline/non-sodic, non-saline/sodic, or saline-sodic.

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