Soil Salinity Management

Introduction

Salinity is an accumulation of salts. In soil, salts can form when parent material (i.e. rock) gradually breaks down (i.e. weathers). Additionally, salts can be carried in irrigation water, added as fertilizers or other soil amendments, or be present due to shallow saline groundwater. Salt accumulation problems occur in many areas of California and other Mediterranean climates, where rainfall generally occurs in the winter months, and irrigation is essential for crop productivity during the summer months. This seasonal distribution of water resources can result in an increase in soil salinity over time if no corrective action is taken. The salt load of a soil is typically estimated by measuring electrical conductivity (EC). In addition to EC, a soil may be characterized by its sodium status, typically estimated using the sodium adsorption ratio (SAR).

Effects of Salinity on Plant Growth

Salt impairs plant growth and health in several ways. Osmotic stress is the most common effect, resulting in restricted water uptake and stunted growth. Ions, like sodium (Na^+), chloride (Cl^-), or boron (B) can accumulate in plant stems and leaves and cause tissue yellowing or necrosis. The presence of Na^+ may also cause nutrient deficiencies by limiting plant calcium, magnesium, or potassium uptake. Salinity can also degrade soil conditions and impair water infiltration and drainage (Fig. 1).

Figure 1. White crusting due to salt accumulation can reduce crop stand and result in weed infestation

Strategies for Salinity Management

Site Selection. Site selection is arguably the most important time to consider potential problems with salinity and management. Irrigation water should be tested, ideally over a span of time that would represent the irrigation season. Irrigation water carries salts, and when it is applied to fields, salts are added to the soil. Salts accumulate in the soil at higher concentrations than they existed in the irrigation water and may accumulate unevenly in the soil. In order to assess the extent and severity of soil salinity problems, soil sample as deeply as is physically and economically feasible. Over time, growers may not be aware of the soil salinity profile if soil has not been sampled and tested to sufficient depth (Fig. 2).

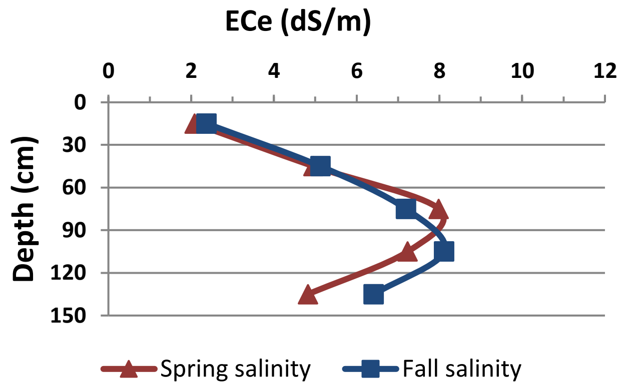

Figure 2. Soil salinity profile of a fine sandy loam in spring and fall of the same year. The border check flood irrigated alfalfa field was irrigated with surface water that had a seasonal irrigation water salinity (ECw) of 1.0 dS/m. Soil salinity, as measured by the saturated paste extract (ECe), is substantially higher below 30 cm (1 ft).

Management practices, like deep ripping before planting a permanent crop, or conditions of fluctuating shallow groundwater, may redistribute salts in the soil profile and impact a subsequent crop. Limited water supplies due to drought and precision irrigation methods can exacerbate soil salinity. Growers should consider whether there are seasonal patterns of salinity or patterns across the field. These may indicate a need for managed off-season leaching (see below) or modifications to irrigation. In gravity-fed systems, modifications to irrigation may include increasing the on-flow rate of irrigation water, narrowing border checks, or shortening row length. These modifications could increase the opportunity time for water to infiltrate (Fig. 3). Additionally, if more than one irrigation source is available, consider using the best source on seedling crops, which are generally more sensitive than mature plants. Mixing poorer quality water with better quality water may also be part of the solution with certain crops.

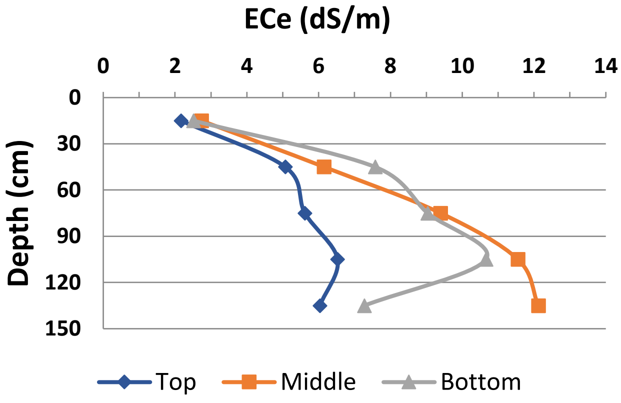

Figure 3. Soil salinity profile of a border check flood irrigated alfalfa field as a function of location along the water run in the field. More leaching occurred on the top end of the field where water was introduced. Irrigation modifications or field layout changes might improve infiltration and leaching at the lower end.

Crop and Variety Selection. Crops will vary in salinity tolerance. Barley, cotton, sugar beet, asparagus, and pistachio, for example, have relatively high tolerance. Almond, tomato, lettuce, and common beans have relatively low tolerance. See 'For more on this topic' for crop salinity tolerance references. In some crops, there may be differences in tolerance among varieties. Farmers, however, have many considerations when selecting crops and varieties, including market factors, yield potential, and pest resistance, so crop and variety selection should not be considered a substitute for soil salinity management.

Soil amendments. Soil amendments are most effective in reducing salt-induced problems when Na^+ is the dominant ion (i.e. sodic soils). Gypsum ($CaSO_4$) is the most common amendment. It may be used in acidic or alkaline soils, and it will not change the soil pH. Lime may also be added and would raise the pH of an acidic soil. "Free line" (i.e. calcium carbonate, $CaCO_3$) may be present in alkaline soils. When it is present in adequate quantity, adding an acid, like sulfuric acid (H_2SO_4), will liberate inherent soil calcium and help reduce the dominance of sodium ions. Soil amendments can be costly and slow to produce a result depending on how much correction is needed, and they do not eliminate the need for leaching.

Leaching. The primary management strategy for combating salinity is leaching. Leaching is the transport of soluble salts in soil water, and it occurs when water is applied in amounts that exceed soil moisture depletion due to evapotranspiration. Leaching may occur during the rainy season or whenever an irrigation event occurs. A grower's field-level knowledge of water infiltration rates, uniformity of infiltration, and groundwater depth will help in determining effective leaching practices or limitations to the ability to leach salts. Leaching during the season may not be advisable because nutrients (like nitrogen) may be lost from the system. Low winter rainfall may mean that leaching during the off-season is inadequate; however, growers may be able to enhance off-season leaching by leveraging rainfall with irrigation water, wetting the soil profile before a rain event.

Conclusion. Successful salinity management in semi-arid and arid zone agriculture requires a long-term approach, including sustained commitment to soil and water analyses and crop-specific practices to manage the accumulation and leaching of salts.

For more on this topic:

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- ✓ Ayers, R. S. and Westcot, D.W. 1985. Water Quality for Agriculture. FAO Irrigation and Drainage Paper 29 Rev. 1. FAO, United Nations, Rome. 174p. http://www.fao.org/docrep/003/T0234E/T0234E00.HTM
- ✓ Hanson, B., Grattan, S.R., Fulton, A. 2006. Agricultural Salinity and Drainage. Publication 3375. University of California Agriculture and Natural Resources. Oakland, CA.

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