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Salinity Management in Alfalfa Fields

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Salt problems occur on approximately one-third of all irrigated land in the world. In the United States, salt problems occur near the coasts and in soils of the arid west. Some soils are salty because parent materials weather to positively-charged cations (Ca^{2+}, Mg^{2+}, K^+, and Na^+) that join with negatively-charged anions to form soluble salts (NaCl, $CaCl_2$, $MgCl_2$, and KCl). On croplands, salts may be carried in irrigation water to create or exacerbate salty conditions.

Soils affected by salt may be characterized in one of three ways. Saline soils are defined as those having sufficient soluble salts to impair productivity. These soils have an electrical conductivity (ECe) greater than 4 dS/m, a sodium adsorption ratio (SAR) less than 13, and a pH less than 8.5. Saline-sodic soils have sufficient soluble salts and exchangeable sodium (Na^+) to impair productivity, and have an ECe greater than 4 dS/m, SAR greater than 13, and pH less than 8.5. A sodic soil has sufficient Na^+ to impair productivity, with an ECe less than 4 dS/m, SAR greater than 13, and pH greater than 8.5.

The electrical conductivity and sodium adsorption ratio, named above, along with the exchangeable sodium percentage (ESP) are three properties measured to understand the degree to which soils are affected by salt. Electrical conductivity is a measure of a solution's ability to conduct an electric current. When the solution comes from a soil saturated paste, the abbreviation used is ECe, and when the solution is water, the abbreviation is ECw. Electrical conductivity is generally expressed in units of decisiemens per meter (dS/m). The SAR describes the concentration of Na^+ compared to the concentrations of calcium (Ca^{2+}) and magnesium (Mg^{2+}) on the soil exchange complex. The equation for SAR is $[Na+]/\sqrt{½([Ca^{2+}] + [Mg^{2+}])}$. The ESP is the degree to which the soil exchange complex is saturated with sodium, the equation being exchangeable Na^+/Cation Exchange Capacity x 100. Both SAR and ESP characterize the sodium status of an alkaline soil, but SAR is becoming more widely used. Note that commercial laboratory results may provide Total Dissolved Solids (TDS) instead of EC. This may be expressed as parts per million (ppm) or milligrams per liter (mg/L), which are equivalent. To convert ppm (or mg/L) to dS/m, divide by 640. To convert dS/m to ppm (or mg/L), multiply by 640.

Salt impairment may be visually identifiable by white or black crusts on the soil surface, wet spots on the soil surface, marginal leaf burn, or the presence of salt-tolerant weeds. Salt impairs plant growth by exerting osmotic stress that results in decreased turgor pressure in plant cells, degrading soil physical conditions that impair water penetration and the plant's ability to access water, and specific ion toxicities that vary by plant species. Limited water supplies due to drought and precision irrigation methods can exacerbate soil salinity, thus exacerbating these stresses on plants.

Management practices that could help to alleviate salinity effects on alfalfa include site selection, monitoring soil and water salinity, variety selection, and soil salinity management through irrigation. The following table provides ideal, marginal, and undesirable site characteristics for alfalfa production.

Characteristic	Ideal	Marginal	Undesirable
Soil texture	Sandy, silt, or clay loam	Loamy sand, silty clay	Sand, clay
Soil depth (feet)	>6	3-6	<3
pH	6.3-7.5	5.8-6.3 and 7.5-8.2	<5.8 or >8.2
ECe (dS/m)	0-2	2-5	>5
ESP	<7	7-15	>15
Boron (mg/L)	0.5-2.0	2-6	>6
Water logging or high water table	Never	Only during dormant period	Sometimes during periods of active growth
Slope	Nearly level	Slightly sloping to 12% slope	>12% slope
pH of water	6.5-7.5	7.5-8.2	>8.2
ECw (dS/m)	<1.3	1.3-3.0	>3.0
SAR	<6.0	6.0-9.0	>9.0

(From Irrigated Alfalfa Management, UC ANR 3512)

Seedling alfalfa is weak, and it is important to try to meet ideal soil conditions. If a grower has access to more than one source of irrigation water, use the best quality water available on seedling alfalfa. As the root system and crown develop, alfalfa can often tolerate more marginal conditions.

A smart phone application called Soil Web can assist in identifying alfalfa sites because it provides soil series information for one's current location. Search "soil web" in your application store, or visit http://casoilresource.lawr.ucdavis.edu/drupal/node/902 for more information on smart phone and computer interfaces that provide soil information. These interfaces were developed for accessing the USDA-NRCS soil surveys by members of the California Resource Soil Lab at UC Davis.

Periodically monitoring soil and irrigation water salinity is an important management approach, especially since agricultural practices can change soil characteristics from those named in the soil series.

Current research by Dan Putnam (forage specialist, UC Davis) and others is illustrating that certain alfalfa varieties may have a higher tolerance to salinity than others, which correlates with the varieties' affinity for accumulating K^+ in the shoots rather than Na^+. Current research by Michelle Leinfelder-Miles (farm advisor, UC Cooperative Extension) in the Delta shows that even relatively good quality water can result in increased soil salinity if leaching is impaired by soil conditions or a shallow groundwater table. Understanding soil properties and the current salinity profile can help in identifying irrigation practices that could help improve leaching. Such irrigation practices include leveraging winter rainfall with irrigation to lower baseline soil salinity in the spring and/or increasing irrigation opportunity time if the lower end of border checks needs more leaching. Understanding one's soil will help in determining whether longer opportunity times are possible without resulting in standing water. Standing water on alfalfa presents its own set of complications, including the susceptibility of alfalfa to Phytophthora root and crown rot.

Other salinity references include Water Quality for Agriculture, also called FAO 29, which provides salinity crop tolerance numbers, and equations for calculating the leaching requirement for crops. The document is available at http://www.fao.org/docrep/003/T0234E/T0234E00.HTM#TOC. Additionally, Blake Sanden (farm advisor, UC Cooperative Extension) presented on salinity at the 2008 Alfalfa Symposium. His proceedings paper describes alfalfa evapotranspiration and how this influences required leaching. It also provides an example of salinity reclamation using biosolids compost. The paper is available at http://alfalfa.ucdavis.edu/+symposium/proceedings/2008/08-103.pdf.

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