Salinity Management in Alfalfa Fields

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KAC Alfalfa and Forage Field Day
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Presentation outline

- Background – salts, soils, and plant responses
- Management approaches
- Research results
- Summary
Background

- Saline soil
- Saline-sodic soil
- Sodic soil
- Electrical conductivity (EC)
- Exchangeable sodium percentage (ESP)
- Sodium adsorption ratio (SAR)
Background

**EC**: the ability of a solution to conduct an electric current.

- Soil saturated paste (ECe), water (ECw), units dS/m

**ESP**: the degree to which the soil exchange complex is saturated with sodium.

**SAR**: the comparative concentration of Na\(^+\), Calcium (Ca\(^{2+}\)), and Magnesium (Mg\(^{2+}\)) on the soil exchange complex.

*Both ESP and SAR characterize the sodium status of an alkaline soil, but SAR is becoming more widely used.*
Background

**Saline soil:** has sufficient soluble salts to impair productivity.
- E\text{Ce} > 4 \text{dS/m}, \text{SAR} < 13, \text{pH} < 8.5

**Saline-sodic soil:** has sufficient soluble salts and exchangeable Na\textsuperscript{+} to impair productivity
- E\text{Ce} > 4 \text{dS/m}, \text{SAR} > 13, \text{pH} < 8.5

**Sodic soil:** has sufficient Na\textsuperscript{+} to impair productivity
- E\text{Ce} < 4 \text{dS/m}, \text{SAR} > 13, \text{pH} > 8.5
Background

Visual indicators of salt problems:

• White crusts on soil surface (*saline*)
• Black crusts on soil surface (*sodic*)
• Slick spots (*sodic*)
• Marginal leaf burn
• Presence of salt-tolerant weeds
Background

Effects on plants:
• Osmotic stress
• Physical changes to the soil
• Toxicities
Why is salinity an important consideration in alfalfa?

- Limited water supplies exacerbate salinity.
- Deficit irrigation may be employed, especially during droughts.
- More precise methods of irrigation (e.g. drip) may increase salinity if there isn’t sufficient water applied to meet crop evapotranspiration (ET) and leaching.
- Alfalfa is being grown on lower quality soils with lower quality water (e.g. recycled or degraded).
- Alfalfa is higher value than many other salt-tolerant plants

How can we manage salinity?

(Text modified from D. Putnam.)
Site selection

When sites have adequate rooting depth, nutrition, aeration, and water, and no salinity or alkalinity problems, and when good management practices are employed, average annual yields can meet or exceed 8-10 tons/acre.
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Ideal</th>
<th>Marginal</th>
<th>Undesirable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil texture</td>
<td>Sandy loam, silt loam, clay loam</td>
<td>Loamy sand, silty clay</td>
<td>Sand, clay</td>
</tr>
<tr>
<td>Soil depth (feet)</td>
<td>&gt;6</td>
<td>3-6</td>
<td>&lt;3</td>
</tr>
<tr>
<td>pH</td>
<td>6.3-7.5</td>
<td>5.8-6.3 and 7.5-8.2</td>
<td>&lt;5.8 or &gt;8.2</td>
</tr>
<tr>
<td>ECe (dS/m)</td>
<td>0-2</td>
<td>2-5</td>
<td>&gt;5</td>
</tr>
<tr>
<td>ESP</td>
<td>&lt;7</td>
<td>7-15</td>
<td>&gt;15</td>
</tr>
<tr>
<td>Boron (mg/L)</td>
<td>0.5-2.0</td>
<td>2-6</td>
<td>&gt;6</td>
</tr>
<tr>
<td>Water logging or high water table</td>
<td>Never</td>
<td>Only during dormant period</td>
<td>Sometimes during periods of active growth</td>
</tr>
<tr>
<td>Slope</td>
<td>Nearly level</td>
<td>Slightly sloping to 12% slope</td>
<td>&gt;12% slope</td>
</tr>
<tr>
<td>pH of water</td>
<td>6.5-7.5</td>
<td>7.5-8.2</td>
<td>&gt;8.2</td>
</tr>
<tr>
<td>ECw (dS/m)</td>
<td>&lt;1.3</td>
<td>1.3-3.0</td>
<td>&gt;3.0</td>
</tr>
<tr>
<td>SAR</td>
<td>&lt;6.0</td>
<td>6.0-9.0</td>
<td>&gt;9.0</td>
</tr>
</tbody>
</table>

*(From Irrigated Alfalfa Management, UC ANR 3512)*
Site selection

*There’s an app for that!*

Search Soil Web in your app store, or visit [http://casoilresource.lawr.ucdavis.edu/drupal/node/902](http://casoilresource.lawr.ucdavis.edu/drupal/node/902) for more information on smart phone and Google technologies. Brought to you by the California Resource Soil Lab at UC Davis.
Monitor soil and water

• Sample soil down several feet, keeping depths separate.
• Sample in several places in the field.
• Laboratory analysis includes grinding the soil, making a saturated paste, and measuring the $\text{EC}_e$. 
Variety evaluation

- Relative yield (RY, %)* – cumulative over 7 cuttings
- Ranking based on RY at 10 dS/m
- T (Tolerant) = > 75% RY
- MT (Mod. Tolerant) = 65 - 74% RY
- MS (Mod. Sensitive) = 55 - 64% RY
- S (Sensitive) = < 50% RY

* Relative to non-saline 0.5 dS/m treatment

<table>
<thead>
<tr>
<th>Tolerance**</th>
<th>Var. #</th>
<th>Variety name</th>
<th>ECw (dS/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>T</td>
<td>18</td>
<td>AZGERM SALT II</td>
<td>98.0</td>
</tr>
<tr>
<td>&quot;</td>
<td>17</td>
<td>AZ90NDCST</td>
<td>98.0</td>
</tr>
<tr>
<td>&quot;</td>
<td>7</td>
<td>HYBRIFORCE800</td>
<td>95.5</td>
</tr>
<tr>
<td>&quot;</td>
<td>9</td>
<td>FG96T707</td>
<td>97.9</td>
</tr>
<tr>
<td>&quot;</td>
<td>8</td>
<td>DS067092</td>
<td>95.6</td>
</tr>
<tr>
<td>MT</td>
<td>2</td>
<td>SW8421S</td>
<td>97.6</td>
</tr>
<tr>
<td>&quot;</td>
<td>13</td>
<td>CW8028</td>
<td>95.8</td>
</tr>
<tr>
<td>&quot;</td>
<td>5</td>
<td>WL656HQ</td>
<td>97.5</td>
</tr>
<tr>
<td>&quot;</td>
<td>3</td>
<td>6906N</td>
<td>97.2</td>
</tr>
<tr>
<td>&quot;</td>
<td>12</td>
<td>CW58S</td>
<td>96.2</td>
</tr>
<tr>
<td>&quot;</td>
<td>15</td>
<td>SW9215</td>
<td>96.9</td>
</tr>
<tr>
<td>MS</td>
<td>11</td>
<td>CW48S</td>
<td>96.2</td>
</tr>
<tr>
<td>&quot;</td>
<td>14</td>
<td>DS077661</td>
<td>97.2</td>
</tr>
<tr>
<td>&quot;</td>
<td>1</td>
<td>SW9720</td>
<td>96.2</td>
</tr>
<tr>
<td>&quot;</td>
<td>6</td>
<td>AMERISTAND901SQ</td>
<td>97.0</td>
</tr>
<tr>
<td>&quot;</td>
<td>20</td>
<td>CUF101(a)</td>
<td>94.7</td>
</tr>
<tr>
<td>&quot;</td>
<td>4</td>
<td>CUF101(b)</td>
<td>94.6</td>
</tr>
<tr>
<td>S</td>
<td>10</td>
<td>CW9S</td>
<td>97.0</td>
</tr>
<tr>
<td>&quot;</td>
<td>16</td>
<td>AZ88NDC</td>
<td>96.1</td>
</tr>
<tr>
<td>&quot;</td>
<td>19</td>
<td>MESA SIRSA</td>
<td>98.3</td>
</tr>
</tbody>
</table>

(Courtesy D. Putnam)
Variety evaluation

Na (%) accumulated in alfalfa shoots

K (%) accumulated in alfalfa shoots

(Courtesy D. Putnam)
Soil salinity management

- Plant breeding is not a substitute for soil salinity management.
- Leaching occurs when water is applied in excess of what the crop needs to meet its ET requirement.
- Leaching fraction is the fraction of water that passes below the root zone divided by the total applied water.
## Delta research

<table>
<thead>
<tr>
<th>Site</th>
<th>Soil Series</th>
<th>Root Zone ECe (dS/m)</th>
<th>Irrigation Water ECw (dS/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Range</td>
<td>Average</td>
</tr>
<tr>
<td>1</td>
<td>Merritt silty clay loam</td>
<td>1.9-10.8</td>
<td>6.8</td>
</tr>
<tr>
<td>2</td>
<td>Merritt silty clay loam</td>
<td>1.5-14.1</td>
<td>8.9</td>
</tr>
<tr>
<td>3</td>
<td>Merritt silty clay loam</td>
<td>0.9-1.2</td>
<td>1.0</td>
</tr>
<tr>
<td>4</td>
<td>Merritt silty clay loam</td>
<td>1.3-9.5</td>
<td>5.1</td>
</tr>
<tr>
<td>5</td>
<td>Grangeville fine sandy loam</td>
<td>1.8-3.2</td>
<td>2.4</td>
</tr>
<tr>
<td>6</td>
<td>Grangeville fine sandy loam</td>
<td>2.4-8.1</td>
<td>5.7</td>
</tr>
<tr>
<td>7</td>
<td>Ryde clay loam</td>
<td>0.9-2.9</td>
<td>1.8</td>
</tr>
</tbody>
</table>
Delta research

**Site 5**
- ECe = 2.4 dS/m (root zone average)
- ECw = 1.8 dS/m (seasonal average)
- Fine sandy loam
- Ksat = 101 mm/hr to 152 cm depth

**Site 7**
- ECe = 1.8 dS/m (root zone average)
- ECw = 0.4 dS/m (seasonal average)
- Clay loam
- Ksat = 10 mm/hr to 70 cm depth
Delta research

Site 1

ECe = 6.8 dS/m (root zone average)
ECw = 0.6 dS/m (seasonal average)
Silty clay loam
Ksat = 10 mm/hr to 124 cm depth

Site 6

ECe = 5.7 dS/m (root zone average)
ECw = 0.9 dS/m (seasonal average)
Fine sandy loam
Ksat = 101 mm/hr to 152 cm depth
Delta research

Site 1

Site 6

ECo (dS/m)

Depth (cm)

Average - Spring
Average - Fall
Average Groundwater - Spring
Average Groundwater - Fall

ECo (dS/m)

Depth (cm)

Average - Spring
Average - Fall
Average Groundwater - Spring
Average Groundwater - Fall

Top - Spring
Middle - Spring
Bottom - Spring
Top - Fall
Middle - Fall
Bottom - Fall
Summary

• Site selection:
  – Know your soil series and its inherent characteristics (texture, Ksat, EC)
• Monitor soil and irrigation water salinity
• Variety selection
  – Research currently being conducted by Dan Putnam and others
  – Preliminary results show ECw tolerance up to 10 dS/m
  – Tolerant varieties accumulate K⁺ over Na⁺ in the shoots
Summary

• Soil salinity management
  – Leaching: applying water in excess of ET.
  – Establish stand with best quality water (if different sources are available).
  – Blend water when multiple sources are available.
  – Look for seasonal patterns and patterns across the field and down the border check. Consider ways to manage irrigation based on those patterns.
  – Leach during the off-season by leveraging rainfall with irrigation water to wet profile before a rain event.
Thank you!

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