Irrigation Systems and Salinity Management in Alfalfa

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Irrigation Methods in California:

1- Surface irrigation (flood):
   - Border strip (flat) irrigation (slope 0.1-0.2%)
   - Furrow irrigation (slope)
   - Basin irrigation (zero slope)

2- Sprinkler Irrigation (various types, mostly hand move systems, little use of center pivots and linear move systems)

3- Drip Irrigation (various types)
   - Surface drip
   - Subsurface drip
Surface irrigation:

- Water application methods where water is applied over the soil surface by gravity (no energy is needed).
- Most common irrigation system throughout the world
- Has been used for thousands of years
- Land leveling practices over the past century made it more efficient
- High efficiency possible on medium and heavy soils

2013 Fraction of irrigated land totally or partially irrigated with gravity methods in western states.
Source: USDA Farm and Ranch Irrigation Survey -FRIS, 2013
Alfalfa Surface Irrigation vs SDI (subsurface drip)

Applied water = Root zone storage + runoff + deep percolation

Surface runoff (B)
Root zone storage (A)
Deep percolation (C)
Also for leaching
Irrigation management – applying the right amount of water
Irrigation system and salinity
~1,400 miles of irrigation canals
~1400 miles of open drainage channels
~ 4 million tons of salts/year
On-Farm Water Conservation = Higher Application Efficiency (AE)

IRRIGATION = Evapotranspiration (ET) + DEEP PERCOLATION + Runoff

\[ A + B + C \]

Application Efficiency (AE) = \[ \frac{A}{A+B+C} \]

To achieve higher efficiency, reduce B and/or C

BUT

Need to have a balance,
Deep Percolation sometimes is needed for salinity control
(650 ppm ~ 0.9 tons of salt/ac-ft)
Runoff is needed for Uniformity (100% AE means under irrigation)
ETo and Water Use
Field crops 3-7 ac-ft/ac
Tree and Vegetable Crops 2-4 ac-ft/ac
Salt accumulation: concentration and volume of applied water
Flood and Sprinkler: Clear understanding of leaching
Surface and subsurface: leaching, how often, how much water to apply??

ETo (in/mo)

<table>
<thead>
<tr>
<th>Month</th>
<th>ETo (in/mo)</th>
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<tbody>
<tr>
<td>J</td>
<td>3</td>
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<tr>
<td>F</td>
<td>3</td>
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<td>M</td>
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Salinity of Irrigation and Drainage Waters

Salinity units (electrical conductivity):

1 dS/m = 1 mmho/cm
1 dS/m is about 640 mg/l (ppm) for EC values less than 5 dS/m
1 dS/m is about 800 mg/l for EC values above 8 dS/m

1 ac-ft of water at EC of 1.2 dS/m contains about 1 ton of salts
Crop Salt Tolerance

Crop salt tolerance
- Ability of crop to maintain yield and quality with increases salinity

- Sensitive crops: strawberry
- Moderately sensitive: alfalfa?
- Moderately tolerant: wheat
- Tolerant: Bermudagrass

Alfalfa (literature)
- ECe of 2 dS/m or less: no yield loss
- For every unit increase in salinity above 2 dS/m, 10% reduction in yield
  If ECe is 3 dS/m, then yield loss would be 10%
  If ECe is 6 dS/m, then yield loss would be 40%
Fig. 1. Soil solution osmotic potential as a function of soil saturation extract salinity. Adapted from, USDA 1954. “Diagnosis and Improvement of Saline and Alkaline Soils. Agricultural Handbook 60.

Impacts on yield and forage tonnage decreased when the soil water potential (matric or capillary potential) dropped to -1 bar, -100 centibars, or just about the time a tensiometer breaks suction. Figure 1 shows that for every 1 dS/m (or mmho/cm) unit increase in the soil ECe as measured in the lab you add an extra -0.4 bars of osmotic water stress to potential root uptake. As a rule of thumb, for every 2 point increase in soil EC above 2 dS/m you can expect about a 10% decrease in normal ET and tonnage.

So the first best step in managing salinity in alfalfa is to review forage ET in the SJV to understand the “normal year”, unstressed water requirements to be supplied by irrigation.

Source: Sanden and Sheesley, 2007. Salt Tolerance and Management for Alfalfa

University of California
Agriculture and Natural Resources Cooperative Extension
Crop Salt Tolerance

Crop salt tolerance
- Ability of crop to maintain yield and quality with increases salinity

Alfalfa (experience and recent work (Putnam et al.))
- No significant decline in yield for ECe at or below 6 dS/m for most varieties
**Salinity of Irrigation and Drainage Waters**

Leaching fraction (LF): depth of drainage water/depth of applied water

Example: irrigation water 6 ac-ft/ac and drainage water of 1 ac-ft/ac

LF = 1/6 or 17%

17% of applied water is used for leaching.

LF ~ salinity of drainage water/salinity of irrigation water (steady state- salts coming in with irrigation water are leaving the rootzone)
Salinity of Irrigation and Drainage Waters

Crop salt tolerance
- Most common: stunning of growth when EC at above threshold level (osmotic, total salt concentration is excessive)
- Specific ions (regardless of concentration, example; Na, Cl, B)

- Management strategies:
- Minimize water stress (combination of osmotic and water stress, SDI)
- Theoretical vs actual crop tolerance (alfalfa is a good example)
- Monitor soil salinity
- Leach soil if salinity is approaching threshold levels (crop salt tolerance)
- In general field crops are more tolerant to salinity than vegetable crops
Flood and Sprinkler Irrigation

-Leaching with every irrigation or at the end of season (vegetable and field crops)
Very little or no leaching with drip or SDI systems

Major issues with SDI: salt accumulation above drip tape (summer rain?)

Management practices:
- Another irrigation system for leaching (flood or sprinkler irrigation)
- Calculate LF and monitor salinity
- Monitor tile drain (volume and concentration)
- check soil salinity
Subsurface Drip Irrigation on Alfalfa

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<tr>
<th></th>
<th>DRIP</th>
<th>FLOOD</th>
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<tr>
<td></td>
<td>Total</td>
<td>Per Acre</td>
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<tr>
<td>Water Use Efficiency (Crop per Drop)</td>
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<tr>
<td>Acre Feet water used</td>
<td>2,464</td>
<td>6.50</td>
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<tr>
<td>Gallons water used</td>
<td>602,733,839</td>
<td>2,118,032</td>
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<tr>
<td>Tons hay per acre foot water</td>
<td>2.38</td>
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![Image of drip irrigation system and alfalfa field]
Crop Water use: Soil moisture

Saturation (S)
Field Capacity (FC)
Yield threshold (YT)
Permanent wilting point (PWP)
Oven dry

Total soil water
Plant Available water
Salinity Management- Alfalfa

Leaching: winter or spring time when ET is not high
System design (design for sprinkler demand or keep the flood system)
IID Salinity Assessment Vehicle
IID Salinity Assessment Vehicle

Electronic Components

- Global Positioning System (DGPS)
- Geonics EM-38-DD Salinity Sensor
- Laptop Computer
Salinity Assessment Vehicle
Salinity Assessment Vehicle

- Perform electronic field survey
- Develop sample plan based on statistical distribution of collected data
- Collect ‘ground truthing’ soil samples analyze for EC & SP
- Correlate electronic data with soil analysis
- Generate field maps
Salinity Assessment Vehicle
Selective leaching with flood irrigation is not practical. Sprinkler irrigation is much more effective.
Predicted sugarbeet yield loss = 22.5%  Actual yield loss = 18.5%

Image courtesy of
Stephen Kaffka
University of California – Davis
Extension Agronomist
UCDREC- Sunflower

Soil apparent electrical conductivity ($EC_a$) of 0-0.3m depth, 10m grid on true North
UCDREC Sunflower

Soil apparent electrical conductivity ($E_{Ca}$) of 0-1m depth, 10m grid on true North
Resources

UC ANR publications:

Drought Tip 8562   Crop Salt Tolerance
Drought Tip 8554   Use of Saline Water for Crop Production
Drought Tip 8550   Managing Salts by Leaching
Thank you
Actual Yield data

IID Salinity Assessment Vehicle Predicted Yield Loss Image Map

Image courtesy of Stephen Kaffka
University of California – Davis
Extension Agronomist