How Much Water Does Alfalfa Really Need?

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Water and Alfalfa in California

- Over 1 million acres in production
- Long growing season
- Seasonal water applications range from 4 million to 5.5 million acre-feet (one acre-foot = 326,000 gallons)
- Questions concerning alfalfa water use
  - What is the seasonal crop water use of alfalfa?
  - Is mid-season deficit irrigation of alfalfa feasible for water transfers to water short areas?
Evapotranspiration (ET)

- Evapotranspiration - crop water use (evaporation from plant leaves or transpiration; evaporation from soil surface)
  - Yield is directly related to evapotranspiration - higher ET = higher yield
  - Maximum ET is controlled by the climatic conditions
  - Insufficient soil moisture is usually the main reason for less-than-maximum ET

- Reference crop ET = ET of grass
  - CIMIS (California Irrigation Management Information System)
  - ET = crop coefficient x reference crop ET

- Depth of water - inches or feet of water
  - Depth = volume ÷ area
  - Standardizes water use (independent of field size)
  - One inch of water = one acre-inch (27,160 gallons) ÷ one acre
Historical seasonal evapotranspiration of alfalfa

- Intermountain area: 33 inches
- Sacramento Valley: 48 inches
- San Joaquin Valley: 49 inches
- Imperial Valley: 76 inches

Note: Source of Sacramento Valley ET is research conducted at UC Davis in the 1960’s. Source of the other crop water use values is unknown.
Mid-summer deficit irrigation of alfalfa

- **Irrigation strategy**
  - Full irrigation during early cuttings
  - No irrigation during mid-summer (July, August, September?)
  - Full irrigation in fall

- **Advantage**
  - Maintain high yields of early cuttings (higher yields and quality)
  - Deficit irrigate during period of lower yields and poorer quality
Why mid-summer deficit irrigation of alfalfa?

- Normally not recommended during periods of adequate water supplies
- Water transfers from agriculture during the mid-summer from water-rich areas (northern California) to water-poor areas (southern California)
  - Amount of water available for transfer: ET difference between fully-irrigated and deficit-irrigated alfalfa (DWR)
- Drought conditions - stretch limited water supplies
Questions

- What is the ET of fully irrigated alfalfa at various locations in California?
- What is the ET of the mid-summer deficit-irrigated alfalfa?
- How much water could be transferred due to mid-summer deficit irrigation?
- How much yield would be lost by mid-summer deficit irrigation?
- Does the mid-summer deficit-irrigation effect on yield carry over to the next year?
Procedure

- **Irrigation treatments in commercial fields**
  - Full irrigation
  - Deficit irrigation - no irrigations during mid-summer (July, August, September)

- **Measurements**
  - ET
  - Yield
  - Soil moisture tension
• **2007 sites**
  
  - **Imperial Valley (Holtville)** - flood irrigation; silt clay; elevation = -7 feet; \( T_{\text{max}} = 104 \text{ to } 113^\circ\text{F} \); 7 to 8 harvests
  
  - **Southern San Joaquin Valley (Buttonwillow, Kern County)** - flood irrigation; clay; elevation = 180 feet; \( T_{\text{max}} = 86 \text{ to } 104^\circ\text{F} \); 6 to 7 harvests
  
  - **Sacramento Valley (Davis)** - flood irrigation; silt clay to clay; elevation = 50 feet; \( T_{\text{max}} = 86 \text{ to } 35^\circ\text{C} \); 6 to 7 harvests
  
  - **Scott Valley (Yreka)** - sprinkle irrigation; loam; elevation = 2,700 feet; \( T_{\text{max}} = 20 \text{ to } 35^\circ\text{C} \); 3 harvests
  
  - **Tulelake (Klamath Basin)** - sprinkle irrigation; mucky silt clay loam; elevation = 4,000 feet; \( T_{\text{max}} = 25 \text{ to } 35^\circ\text{C} \); 3 to 4 harvests
● Meteorological methods for measuring ET
  ● Fully irrigated ET - eddy covariance, surface renewal
  ● Deficit-irrigated ET - Surface renewal
  ● Eddy covariance data were used to calibrate the surface renewal method

Eddy covariance energy balance  Surface renewal energy balance
Sacramento Valley 2007 - smoothed data

Evapotranspiration (inches per day)

Mar 1  May 1  Jul 1  Sep 1  Nov 1

Day of year
Imperial Valley 2007

Day of year

Daily evapotranspiration (inches per day)

Reference ET
Fully irrigated ET

May 1 Jul 1 Sep 1 Mar 1 Nov 1
Imperial Valley - August 12, 2008 - Heat stressed alfalfa
## Seasonal ET

<table>
<thead>
<tr>
<th>Site</th>
<th>Seasonal ET (inches)</th>
<th>Historical ET (inches)</th>
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</thead>
<tbody>
<tr>
<td>Imperial Valley</td>
<td>58/63 (2007)</td>
<td>76</td>
</tr>
<tr>
<td>(Dec. 3, 2008)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kern County</td>
<td>56 (2007)</td>
<td>49</td>
</tr>
<tr>
<td>Tulelake</td>
<td>41/35 (2007, 2008)</td>
<td>33</td>
</tr>
</tbody>
</table>
Mid-summer Deficit Irrigation

UCD Alfalfa Workgroup
Scott Valley - October 2, 2008

Deficit irrigated

Fully irrigated
Imperial Valley - August 12, 2008

Deficit irrigated
Deficit-irrigated part of the field fully irrigated in October
Sacramento Valley 2007

Evapotranspiration (inches per day)

Day of year

Deficit ET
Full ET

May 1
Jul 1
Sep 1

Mar 1
Nov 1

UCD Alfalfa Workgroup
Scott Valley 2008

Daily evapotranspiration (inches per day)

- Fully irrigated ET
- Deficit irrigated ET

Day of year
Tulelake 2007

Evapotranspiration (inches per day)

- Full
- Deficit

Day of year

0 50 100 150 200 250 300 350 400

May 1 Jul 1 Sep 1 Mar 1 Nov 1
### Deficit Irrigation

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<tbody>
<tr>
<td><strong>ET differences</strong> (inches)</td>
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<tr>
<td>Imperial Valley</td>
<td>2.4</td>
<td>1.8</td>
<td>1.7</td>
<td>9.4</td>
<td>7.4</td>
<td>4.7</td>
<td>2.0</td>
<td>3.1</td>
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<tr>
<td>Kern County</td>
<td>22.5</td>
<td>8.9</td>
<td>14.0</td>
<td>23.4</td>
<td>21.2</td>
<td>18.7</td>
<td>10.6</td>
<td>12.6</td>
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<tr>
<td>Sacramento Valley</td>
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<tr>
<td>Scott Valley</td>
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<tr>
<td>Tulelake</td>
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</tbody>
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Yield

UCD Alfalfa Workgroup
*Yields smaller than 0.5 tons per acre are not economical to harvest.*
### Seasonal yield reductions

<table>
<thead>
<tr>
<th>Site</th>
<th>Actual yield difference (tons per acre)</th>
<th>Practical yield difference* (tons per acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imperial Valley</td>
<td>1.66</td>
<td>1.66</td>
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<tr>
<td>Kern County</td>
<td>0.66, 0.85</td>
<td>1.03, 1.16</td>
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<tr>
<td>Sacramento Valley</td>
<td>1.37, 2.78, 3.74</td>
<td>3.95, 4.59</td>
</tr>
<tr>
<td>Scott Valley</td>
<td>0.82</td>
<td>1.38</td>
</tr>
<tr>
<td>Tulelake</td>
<td>0.4</td>
<td>0.4</td>
</tr>
</tbody>
</table>

* adjusted for yields smaller than 0.5 tons per acre (not considered economical to harvest)
Conclusions

- Seasonal ET of alfalfa differed from historical ET
- Mid-summer deficit irrigation reduced ET and yield
  - Effect of mid-summer deficit irrigation was site specific
- Water transfer amounts should be based on ET of fully irrigated alfalfa during period of deficit irrigation
- Water transfer amounts based on ET differences is not practical because of the site specific responses
  - Penalizes growers because ET of deficit-irrigated field results from stored soil moisture from previous irrigations
  - Mid-summer yields were not economical to harvest
- Compensation for yield losses should be based on yield of fully irrigated alfalfa, not on yield differences
Irrigating alfalfa with limited water supplies

- **Options**
  - Reduce irrigated acres
    - Fully irrigate reduced acres
    - No irrigation on remaining acres
  - Reduce water applications between harvests - irrigate entire field
    - Distribute the limited water supply throughout the crop season
    - Reduce the number of irrigations between harvests - flood irrigation, sprinkle irrigation
    - Reduce the amount of applied water per irrigation - sprinkle irrigation
    - Combination of both
  - Mid-summer deficit irrigation
  - **Critical irrigation** - first irrigation just after harvest
Irrigation system considerations

- **Sprinkle irrigation**
  - Can apply small amounts of water to the entire field
  - Reduced irrigation set time - inconvenience factor

- **Flood irrigation**
  - Reduce the number of flood irrigations between harvests
  - Reduced set time - water may not reach the end of the field; inconvenience factor
  - Eliminate surface runoff - cut off irrigation water before water reaches the end of the field
  - Cracked soil - infiltration time of 2 to 3 hours
Effect of reducing the number of flood irrigations between harvests on the soil moisture tension

Note: the higher the soil moisture tension, the drier the soil
Which option is the best?

- **Best option** - provides the most revenue or maximizes profit
- **May be site specific**
- **Sacramento Valley**
  - 50% water supply
  - Mid-summer deficit irrigation resulted in the most revenue
    - Full irrigation for the first three harvests; no irrigation thereafter
- **Considerations**
  - Salinity - no leaching under limited water supplies
The End