Deficit Irrigation of Alfalfa as a Irrigation Water Management Strategy

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Definitions

- Evapotranspiration (ET) – crop water use (transpiration & evaporation)
- Types of ET
  - Crop ET
  - Reference crop ET (ET of grass) – used by the CIMIS network to estimate the potential crop ET
    - \( \text{ET}_{\text{crop}} = \text{Crop coefficient} \times \text{Reference crop ET} \)
Main cause of ET less than maximum ET is insufficient soil moisture
Irrigation water management of alfalfa

- First spring irrigation – irrigate when the soil moisture tension approaches a recommended value
- Subsequent irrigations – controlled by cutting schedules
  - First irrigation between cuttings – after bales are removed
  - Last irrigation between cuttings – sufficient drying time before next cutting
- Options – 1, 2, or 3 irrigations between harvests
- Monitor soil moisture tension to determine if number of irrigations is adequate
Why deficit irrigation?

- Transfers from agriculture by DWR and other water agencies to provide water for urban and environmental uses in drought years
- DWR program - fallowing of agricultural land
  - No yield
  - $ET$ of fallow field $= 0$
  - Amount transferred $= ET$ of crop not planted
- Deficit irrigation of alfalfa (over 1 million acres; long crop season; about 5.3 million acre feet of water)
  - Reduced yield
  - $ET > 0$
  - DWR approach - $ET$ difference between fully irrigated and deficit irrigation alfalfa
Why (continued)?

- **Limited water supplies**
  - **Options**
    - Fully irrigate a reduced acreage. Acreage reduction depends on amount of available irrigation water
    - Apply smaller amounts of water per irrigation throughout the crop season
    - Mid-summer deficit irrigation
  - **Mid-summer deficit irrigation**
    - No irrigation during July, August, and September (?)
    - Maintains high yields of early harvests
    - Deficit irrigation during period of lower yields
Mid-summer deficit irrigation project - objectives

- Determine the ET of fully-irrigated and mid-summer deficit-irrigated (no irrigation) of alfalfa
- Determine the effect of mid-summer deficit irrigation alfalfa yield
- Determine any carry-over yield effects into the following year
Method

- **Sites (commercial fields except Tulelake)**
  - Imperial Valley
  - Kern County (near Buttonwillow)
  - Yolo County (near Davis)
  - Tulelake (near Klamath Falls, OR)
  - Scott Valley (near Yreka)
- **Experimental approach**
  - Most of the field was fully irrigated; mid-summer termination of irrigation on part of the field
- **ET measurements – meteorological methods** (eddy covariance and surface renewal)
Eddy covariance

Surface renewal
Deficit irrigation started at the end of June.
Kern County 2006

Daily evapotranspiration (inches per day)

- Full ET
- Deficit ET
- Reference ET

Day of year

1 May 1 Jun 1 Jul 1 Aug 1 Sep 1 Oct
### Seasonal ET

<table>
<thead>
<tr>
<th>Site</th>
<th>Measured Seasonal ET (inches)</th>
<th>Historical Seasonal ET (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imperial Valley</td>
<td>58.2</td>
<td>76</td>
</tr>
<tr>
<td>Kern County</td>
<td>53.0 (12 Oct)</td>
<td>49</td>
</tr>
<tr>
<td>Davis</td>
<td>59.8</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>49.5– 2005</td>
<td></td>
</tr>
<tr>
<td></td>
<td>54.2 – 2006</td>
<td></td>
</tr>
<tr>
<td>Scott Valley</td>
<td>39.0</td>
<td>33</td>
</tr>
<tr>
<td>Tulelake</td>
<td>41.1</td>
<td>33</td>
</tr>
</tbody>
</table>
### ET differences

<table>
<thead>
<tr>
<th>Site</th>
<th>ET difference (inches)</th>
<th>Fully –irrigated ET during deficit irrigation period (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imperial Valley</td>
<td>2.4</td>
<td>18.6</td>
</tr>
<tr>
<td>Kern County</td>
<td>1.4</td>
<td>8.5 - 2006</td>
</tr>
<tr>
<td></td>
<td>2.9 – 2006</td>
<td></td>
</tr>
<tr>
<td>Davis</td>
<td>7.8</td>
<td>21.5</td>
</tr>
<tr>
<td></td>
<td>9.4 – 2005</td>
<td>15.9 – 2005</td>
</tr>
<tr>
<td></td>
<td>8.8 – 2006</td>
<td>16.8 – 2006</td>
</tr>
<tr>
<td>Scott Valley</td>
<td>2.2</td>
<td>11.4</td>
</tr>
<tr>
<td>Tulelake</td>
<td>0.2</td>
<td>28.3</td>
</tr>
</tbody>
</table>
Conclusions

- Mid-summer deficit irrigation reduced both yield and evapotranspiration
- Yield and evapotranspiration reductions were site specific
- Yields of the deficit-irrigated alfalfa recovered the following year except for the Imperial Valley site
- Water transfer amounts based on ET differences is not practical because of the small amounts and the variability between sites
- Water transfer amounts should be based on the ET of full irrigation during the period of deficit irrigation
Irrigating with a limited water supply

- Fully irrigate a reduced acreage
- Distribute limited water supply throughout the irrigation season
- Mid-summer deficit irrigation
Example

- Normally irrigate 100 acres
- ET of maximum yield = 50 inches
- Drought condition – 50% of normal allocation (25 inches)
- Crop price = $110/ton
- Strategies
  - Irrigate 50 acres for maximum yield (50 inches)
  - Irrigate 100 acres by applying water throughout the season for seasonal application of 25 inches
  - Mid-summer deficit (no) irrigation
Seasonal evapotranspiration (inches)

Yield (tons/acre)

100% - 8.1 tons/acre

50% - 4.2 tons/acre
Economic Analysis

- Irrigate 50 acres with 50 inches of water (assume no yield from the remaining 50 acres)
  
  Yield = 8.1 tons/acre
  Total yield = 8.1 tons/acre x 50 acres = 405 tons
  Revenue = $110/ton x 405 tons = $44,550

- Irrigate 100 acres with 25 inches of water
  
  Yield = 4.2 tons/acre
  Total yield = 4.2 tons/acre x 100 acres = 420 tons
  Revenue = $110/ton x 420 tons = $46,200

Note: analysis does not consider other costs such as harvest, spraying, etc.
Mid-summer deficit irrigation

♦ 100 acres (full seasonal irrigation yield – 8.53 tons/ acres)
♦ Full irrigation for the first three harvests
♦ No irrigation for the last three harvests

Yield by harvest

<table>
<thead>
<tr>
<th>Harvest</th>
<th>Yield (tons/acre)</th>
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<tbody>
<tr>
<td>1</td>
<td>1.66</td>
</tr>
<tr>
<td>2</td>
<td>1.56</td>
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<tr>
<td>3</td>
<td>1.58</td>
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<tr>
<td>4</td>
<td>0.66</td>
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<tr>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>5.46</td>
</tr>
</tbody>
</table>

♦ Total yield = 100 acres x 5.46 tons/ac = 546 tons
♦ Total revenue = $110/ton x 546 tons = $60,060
Conclusions

- Mid-summer deficit (no) irrigation offers a potential for higher revenue
- Potential may vary due to site specific conditions
That’s All, Folks