ET-based irrigation scheduling of lettuce, broccoli, (...and other cool season vegetables)

**Investigators:**
CSUMB/NASA
UC Coop. Extension
USDA-ARS

**Comm’l cooperators:**
Chiquita/Fresh Express
Tanimura & Antle
Sakata, Enza, Seminis

**Sponsor:**
Calif. Dept. Food Agric.
(Specialty Crop Block Grant Pgm)

**Presenter:** Lee Johnson, CSUMB/NASA; 650-604-3331
Improving irrigation efficiency

- **Agronomic** (conservation till, plant spacing...)
- **Engineering** (reduce applic. loss, improve DU...)
- **Institutional** (irrigation district improvements, water pricing, legal incentives...)
- **Managerial** (demand-based scheduling, RDI...)

Some definitions

- **Evapotranspiration [ET]**; water consumed (lost to atmosphere) by combined processes of soil Evaporation & plant Transpiration
- **Reference ET**; well-watered grass surface ET
- **Crop coefficient**; crop ET expressed as a proportion of reference ET
- **Fractional cover**; proportion of field covered by crop (vs. bare soil) as viewed from above
Project goals

• Replicated irrigation trials for head lettuce & broccoli during 2012, 2013
• Demo use of ET-based irrigation scheduling, using CIMIS Reference ET data
• Evaluate any tradeoffs of water reduction vs. yield/quality
CIMIS Reference ET

"Salinas-south" (#214)

"Spatial" CIMIS

Trial:
- lettuce
- broccoli

*Challenge: how to translate into “actionable” info?
Strategy

- Lettuce, broccoli
- Crop establishment by sprinkler
- Treatments applied by surface drip
- Equal inputs other than water (i.e., fertilizer, pest control, etc.)
Irrigation treatments

CropManage model (100% ET replacement)

SIMS model (100% ET replacement)

Standard practice (150% ET replacement)
CropManage model

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**CROPMANAGE**

Help and User Instructions for Irrigation and N management tool

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### Irrigation Summary

<table>
<thead>
<tr>
<th>Water Date</th>
<th>Irrigation Method</th>
<th>Recommended Irrigation Interval (days)</th>
<th>Recommended Irrigation Amount (inches)</th>
<th>Recommended Irrigation Time (hours)</th>
<th>Irrigation Water Applied (inches)</th>
<th>Kc</th>
<th>Canopy Cover (%)</th>
<th>Average Reference ET (inches/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/28/13</td>
<td>Drip</td>
<td>10.6</td>
<td>0.17 in</td>
<td>1.01 hrs</td>
<td>0.34 in</td>
<td>0.13</td>
<td>7</td>
<td>0.20</td>
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<tr>
<td>9/29/13</td>
<td>Drip</td>
<td>11.4</td>
<td>0.10 in</td>
<td>0.59 hrs</td>
<td>0.21 in</td>
<td>0.22</td>
<td>9</td>
<td>0.19</td>
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<tr>
<td>9/3/13</td>
<td>Drip</td>
<td>15.3</td>
<td>0.16 in</td>
<td>0.97 hrs</td>
<td>0.49 in</td>
<td>0.22</td>
<td>13</td>
<td>0.16</td>
</tr>
<tr>
<td>9/6/13</td>
<td>Drip</td>
<td>11.3</td>
<td>0.18 in</td>
<td>1.05 hrs</td>
<td>0.54 in</td>
<td>0.27</td>
<td>17</td>
<td>0.19</td>
</tr>
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<td>9/9/13</td>
<td>Drip</td>
<td>11.3</td>
<td>0.19 in</td>
<td>1.13 hrs</td>
<td>0.53 in</td>
<td>0.32</td>
<td>23</td>
<td>0.17</td>
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<tr>
<td>9/13/13</td>
<td>Drip</td>
<td>12.0</td>
<td>0.25 in</td>
<td>1.45 hrs</td>
<td>0.61 in</td>
<td>0.41</td>
<td>31</td>
<td>0.13</td>
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<td>9/16/13</td>
<td>Drip</td>
<td>10.2</td>
<td>0.24 in</td>
<td>1.43 hrs</td>
<td>0.48 in</td>
<td>0.52</td>
<td>38</td>
<td>0.13</td>
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<tr>
<td>9/19/13</td>
<td>Drip</td>
<td>9.1</td>
<td>0.29 in</td>
<td>1.69 hrs</td>
<td>0.55 in</td>
<td>0.61</td>
<td>46</td>
<td>0.13</td>
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<tr>
<td>9/22/13</td>
<td>Drip</td>
<td>8.5</td>
<td>0.36 in</td>
<td>2.24 hrs</td>
<td>0.65 in</td>
<td>0.72</td>
<td>57</td>
<td>0.13</td>
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</tbody>
</table>

*UC Cooperative Extension*

*web-based tool for growers*

*combines weather, soil and plant-based info*
SIMS model

Landsat image of Salinas vicinity; ¼ acre resolution

Satellite
Landsat OLI/TM/ETM+
MODIS MOD09Q1
TOMS/TOVS ozone

SIMS
At sensor radiance
Surface reflectance
NDVI
Tiling / Masking
Gap-filling
Fractional cover
Crop coefficient ($K_{cb}$)
Basal crop ET ($ET_{cb}$)

((OPENDAP))

Web interface
Web services

User

NASA/CSUMB

NCEP/NCAR Reanalysis Data

CIMIS
Satellite
GOES cloud cover
Surface $T_{air}$, $RH$, Wind speed
Spatial CIMIS ET$_0$
In-situ or remote sensing meas. → Fractional cover

Rain, past irrig. → Fractional cover

SIMS → Crop coefficient → Crop ET → ET since last irrigation → Irrig. amt

CM → Crop coefficient → Crop ET → ET since last irrigation → Irrig. amt

Crop configuration, days since planting

Daily

CM

CIMIS ETo
Monitoring

Nutrient

Soil moisture

Fractional cover

Drainage sub-surface

Applied water
Lettuce trials
May 2 – July 11, 2012
April 30 – July 8, 2013

Treatments:
- Standard practice
- SIMS
- CropManage

*3 tmts, 5 reps, randomized block design
*total area: ~1.4 ac
*40” bed spacing, 2 seedlines/bed, thinned to 12” interval
*variety: Gabilan (2012), Telluride (2013)
Drip irrigation events

2012

2013

Irrig. (inches)

0 0.5 1 1.5 2 2.5


std. SIMS CM

std. SIMS CM
Cumulative drip

2012

2013

Cumul. irrig (in.)

std.

SIMS

CM


0 4 8 12

0 4 8 12
Irrigation & yield totals, Lettuce

2012

Irrigation (in.):

- Std: 15
- SIMS: 20
- CM: 15 (drip + spklr)

Yield (tons/ac):

- Std: a
- SIMS: a,b
- CM: b

2013

Irrigation (in.):

- Std: 0
- SIMS: 5
- CM: 10 (drip + spklr)

Yield (tons/ac):

- Std: a
- SIMS: a
- CM: a

Water savings: 29%

Water savings: 23%
Quality metrics

• Transport
• Refrigeration
• Packaging
• Storage
• Evaluation:
  – Flavor, physiological defects, decay, pinking, vascular discoloration, browning, tip burn, chunks
  – No significant difference between the standard & reduced water treatments

Courtesy Fresh Express
Broccoli trials
July 25-Oct 29, 2012
July 23 – Nov 4, 2013

Treatments:
- Standard practice
- SIMS
- CropManage

*3 tmts, 5 reps, randomized block design
*total area: ~1.4 ac
*40” bed spacing, 2 seedlines/bed, 5” interval
*variety: Patron
Drip irrigation events

2012

2013

Irrigation (in.)

std.
SIMS
CM
Cumulative drip

2012

2013

Cumul. irrig. (in.)


Cumul. irrig. (in.)


std. | Sims | CM

0 4 8 12 16 20
Irrigation & yield totals, Broccoli

**2012**

<table>
<thead>
<tr>
<th>Irrigation (in.)</th>
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<th>Sims</th>
<th>CM</th>
<th>(drip + spklr)</th>
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<th>Yield (tons/ac)</th>
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<tr>
<td>a</td>
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<td>a,b</td>
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<td>a,b</td>
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**2013**

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</tr>
</tbody>
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Water savings: 30%  
Water savings: 34%
Summary

• ET-based scheduling; replicated trial conducted over 2 years
• Industry-average marketable yields realized throughout
• ET-replacement approaches represented 23-34% reduction in applied water
closing note about fractional cover...

- Measured Fractional cover
  - SIMS
    - Crop coefficient
    - Crop ET
    - ET since last irrigation
    - Irrig. amt

- Modeled Fractional cover
  - Rain, past irrig.
    - CM
    - Crop coefficient
    - ETo
    - Crop ET
    - ET since last irrigation
    - Irrig. amt

Daily

CIMIS

Assumed DU
Satellite NDVI via SIMS
SIMS Fractional cover
Broccoli growth, ground vs. satellite 2013

Crop Development

Salinas

7/3-10/9
(satellite)

~6 mi

7/23-10/23
(ground)
Ongoing/future work

• CropManage: Cooperative Extension expanding to other cool-season veg’s
• SIMS: Finalization of Salinas Valley datasets, processing stream, data delivery
• Linking CropManage, SIMS
Investigators


Cooperative Extension: M. Cahn, B. Farrara, T. Lockhart, L. Murphy

USDA: F. Martin, S. Benzen, D. Lara, G. Ochoa, J. Schrandt, W. Orth

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