Climbing the Learning Curve: What works and what doesn’t for Subsurface Drip in Alfalfa?

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Why an interest in SDI in Alfalfa?

SDI Fields in California
Currently <2% of Alfalfa Acreage
## What does the Future Hold?

<table>
<thead>
<tr>
<th>Area</th>
<th>Population</th>
<th>Irrigated Cropland</th>
<th>Water Supply</th>
<th>Water Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1985</td>
<td>2025</td>
<td>x1,000 ha</td>
<td>1985</td>
</tr>
<tr>
<td>Africa</td>
<td>543</td>
<td>1440</td>
<td>118</td>
<td>4520</td>
</tr>
<tr>
<td>Asia</td>
<td>2930</td>
<td>4800</td>
<td>1690</td>
<td>13700</td>
</tr>
<tr>
<td>Australiana</td>
<td>22</td>
<td>33</td>
<td>26</td>
<td>714</td>
</tr>
<tr>
<td>Europe</td>
<td>667</td>
<td>682</td>
<td>273</td>
<td>2770</td>
</tr>
<tr>
<td>N. America</td>
<td>395</td>
<td>601</td>
<td>317</td>
<td>5890</td>
</tr>
<tr>
<td>S. America</td>
<td>267</td>
<td>454</td>
<td>95</td>
<td>11700</td>
</tr>
<tr>
<td>Globe</td>
<td>4830</td>
<td>8010</td>
<td>2520</td>
<td>39300</td>
</tr>
</tbody>
</table>

*Vorosmarty et al., Science, 2008*
Water Use by California Crops (4-Year Ave. 2006-2009)

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>Annual Applied Water (Acre Feet x 1,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>6,000</td>
</tr>
<tr>
<td>Almonds &amp; Pistachios</td>
<td>5,500</td>
</tr>
<tr>
<td>Pasture</td>
<td>4,500</td>
</tr>
<tr>
<td>Other deciduous</td>
<td>4,000</td>
</tr>
<tr>
<td>Vineyard</td>
<td>3,500</td>
</tr>
<tr>
<td>Rice</td>
<td>3,000</td>
</tr>
<tr>
<td>Corn</td>
<td>2,500</td>
</tr>
<tr>
<td>Other Field</td>
<td>2,000</td>
</tr>
<tr>
<td>Citrus &amp; Subtropical</td>
<td>1,500</td>
</tr>
<tr>
<td>Truck Crops</td>
<td>1,000</td>
</tr>
<tr>
<td>Grain</td>
<td>500</td>
</tr>
<tr>
<td>Cotton</td>
<td>500</td>
</tr>
<tr>
<td>Tomato Processing</td>
<td>500</td>
</tr>
<tr>
<td>Onion &amp; Garlic</td>
<td>50</td>
</tr>
<tr>
<td>Cucurbits</td>
<td>50</td>
</tr>
<tr>
<td>Dry Beans</td>
<td>50</td>
</tr>
<tr>
<td>Sugarbeet</td>
<td>50</td>
</tr>
<tr>
<td>Tomato Fresh</td>
<td>50</td>
</tr>
<tr>
<td>Safflower</td>
<td>50</td>
</tr>
<tr>
<td>Potatoes</td>
<td>50</td>
</tr>
</tbody>
</table>

Notes:
- Alfalfa is the highest use with 16% of the total water use.
- Other deciduous crops follow, accounting for 22% of the total.
The Demand Side:

- Dairy, Horse, Exports

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GROWTH IN DAIRY AND ALFALFA - California

\[ y = 0.0018x^2 - 7.0953x + 6968.4 \]
\[ R^2 = 0.98976 \]

PERCENT OF 1970 Production

- Dairy
- Alfalfa

Metric Tons (Mt x 1,000)

- 1.2%
- 1.0%
- 1.6%
- 1.6%
- 1.8%
- 2.7%
- 3.0%
- 4.2%

1999 2001 2003 2005 2007 2009 2011 2013
California Alfalfa Hay Price Trends (10 Years)

Note: To convert from price per short ton to price per tonne (Mg), multiply by 1.102

SDI in Alfalfa Workshop
# A question of Value

## Table 2. Farm Gate Value of Top California Commodities (CDFA)

<table>
<thead>
<tr>
<th>Crop</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Gross Farm Receipts (x $billion)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk &amp; Cream</td>
<td>4.537</td>
<td>5.928</td>
<td>7.681</td>
</tr>
<tr>
<td>Almonds (shelled)</td>
<td>2.294</td>
<td>2.903</td>
<td>3.866</td>
</tr>
<tr>
<td>Grapes</td>
<td>3.260</td>
<td>3.209</td>
<td>3.860</td>
</tr>
<tr>
<td>Cattle &amp; Calves</td>
<td>1.676</td>
<td>2.068</td>
<td>2.825</td>
</tr>
<tr>
<td>Nursery</td>
<td>2.513</td>
<td>2.357</td>
<td>2.683</td>
</tr>
<tr>
<td>Berries, + Strawberries</td>
<td>1.725</td>
<td>1.814</td>
<td>1.948</td>
</tr>
<tr>
<td>Hay (all)</td>
<td>0.926</td>
<td>1.033</td>
<td>1.735</td>
</tr>
<tr>
<td>Lettuce</td>
<td>1.744</td>
<td>1.605</td>
<td>1.513</td>
</tr>
<tr>
<td>Walnuts</td>
<td>0.747</td>
<td>1.028</td>
<td>1.323</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>1.540</td>
<td>1.246</td>
<td>1.265</td>
</tr>
<tr>
<td>Flowers and Foliage</td>
<td>0.937</td>
<td>1.015</td>
<td>1.012</td>
</tr>
<tr>
<td>Cotton Lint, All</td>
<td>0.286</td>
<td>0.592</td>
<td>0.894</td>
</tr>
<tr>
<td>Pistachio</td>
<td>0.593</td>
<td>1.159</td>
<td>0.879</td>
</tr>
<tr>
<td>Rice</td>
<td>0.937</td>
<td>0.930</td>
<td>0.774</td>
</tr>
<tr>
<td><strong>Total California</strong></td>
<td><strong>$37,479</strong></td>
<td><strong>41,123</strong></td>
<td><strong>47,423</strong></td>
</tr>
</tbody>
</table>
Why an interest in SDI?

- **Price of Alfalfa Hay**
  - 1st time over $200/t in 2007
  - $200-$350/t past few years

- **The Water Squeeze**
  - Drought, possibility of water transfers

- **Possibility of yield increases**
  - Higher WUE, profitability

- **Well Known Limitations of Flood Irrigation**
UC Studies:

- “Case Studies” of grower’s experiences across a range of environments
  - Documenting successes/failures
  - Costs/benefits
- Controlled Studies on UC Facilities:
  - SDI compared with Flood
  - Variety interactions
  - Deficit Irrigation with drip
  - Spacing Studies, understanding optimum irrigation management
  - Gopher Management
To consider SDI in alfalfa:

- **Must** improve yields over surface irrigation to justify cost
- **Must understand** source of water, quality
- **Must be prepared** for higher level of management (particularly gophers)
What is needed to Justify SDI?
(Fixed costs)

- Assumptions: 15 yrs. infrastructure (pumps, filters, etc.)
- 6 years drip lines (Including interest)
- ONLY system costs, not differences in maintenance, water, energy, labor.

Hay Price ($/ton)

Yield Required (t/a)

Investment Cost ($/a)
What is needed to Justify SDI? (including several variable costs)

- Same assumptions as previous graph
- Includes several estimates for water, labor, energy, other differences (generally a trade-off)
- Will continue to examine trade-offs
Cost of Switching from Surface to SDI

- From 0.5 t/a to 2.5 t/a improved yields are needed, depending upon...
- Hay price
  - ($120-$320/t)
- Investment Costs:
  - ($1200 to $2800/a)
- Ability to maintain system over 6-15 years
- Controlling maintenance costs (gophers!)
Are these yields possible?

- Yield Increases appear real, at least reported by growers
- Confirmed by controlled studies (Lamm et al. 2012, UC studies)
- Growers report approximately 2.5 t/a improvement over flood.

\[ Y_{SDI} = 1.063Y_{Flood} + 2.5 \]
\[ R^2 = 0.90 \]
Why would we expect improved yields in SDI vs. surface?

1. Superior Distribution Uniformity (in Space)
   - Less difference between top and bottom of field
   - Well known problems with surface systems
   - Tail end management
Irrigation distribution uniformity (DU) determined by soil infiltration rate, flow rate down the check and set duration.

\[ DU(\%) = 100 \times \frac{\text{“low quarter” infiltration}}{\text{Average field infiltration}} \]

Possible stress
N leaching, water logging

Stressed plant growth
Too little water

Head

Rootzone Depth (m)

Infiltration @ 6 hrs
Infiltration @ 12 hrs
Infiltration @ 18 hrs
Infiltration @ 24 hrs

Tail – no leaching

Deep percolation – lost water & N fertilizer

(slid: Blake Sanden)
Standing Water
Tail –End Damage
Why would we expect improved yields in SDI vs. surface?

2. Distribution Uniformity (in Time)

- Ability to ‘charge’ a field within hours, not days
- Most Flood-irrigated (and some sprinkle irrigated) fields require 4-12 days to irrigate.
- Problem for 30-day growth cycle
- Differences in yield between sections of field in surface systems
- Loss of Stand in flooded fields vs. drip (observed in second year at El Centro)
Why Increased Yields?

3. Ability to Maintain Turgor

- The moment turgor is lost, growth ceases
- Avoid wetting-drying patterns (flood/drying)
- Watering closer to harvest times
6- to 20-day period during which fields cannot be irrigated
In many fields, a ‘corrugation’ effect was seen, in spite of improved yields. Perhaps 10-20% yield hit? Likely a spacing issue-soil type dependent.
What we’ve learned:

- Growers were sometimes unable to fully charge fields with moisture at the beginning of the season with SDI
- Problems subbing between laterals
- 40” spacing (the most common) may not be ideal for many soil types
Different Rooting Patterns

Khaled Bali, photo
Over Irrigating to compensate for lack of lateral movement

Standing Water, Grassy Weed Intrusion
What we’ve learned:

- Growers should consider retaining ability to flood-irrigate fields in SDI fields.
- Fully re-charge fields periodically (particularly at beginning of season)
- Assist with gopher management
- Consider <40” spacing strategies (e.g. 30”) – (cost $100-$200/a?)
What we’ve learned:

- Sprinklers best for germination.
- Retaining possibility of flood or sprinkler irrigation for fully charging profile
What we’ve learned:

- Rodents are perhaps THE major challenge for SDI in alfalfa
Gopher Management

- No one solution
- An Integrated Approach to gopher management
  - Primarily increased awareness/scouting
  - Trapping
  - Baits
  - Exclosures (barriers)
  - Repellents (Pro-Tech T)
  - Occasional flood irrigations
  - Predators (owl boxes)
SDI Drip Irrigation

Advantages:
- Excellent DU (time/space)
- ‘Spoon feeding’ water
- Fertigation
- Irrigate close to harvest
- Labor Savings
- 0 runoff (water quality)
- Oxygen to root zone

Disadvantages:
- Cost
- Gopher damage
- Requires energy
- Maintenance
- Filtration
- Less wildlife habitat
Crop Rotation Considerations

- Rotation with tomato, row crops
- Assist in covering costs
- Explore spacing issues (60? 40? 30?)
- Different rooting patterns
Labor is perhaps one of the primary limitations of surface irrigation.
82% of growers (so far) are highly satisfied
18% are medium to less satisfied with SDI
Summary

- Most growers are largely positive about SDI results on their farms
- Improved yields (9-15 t/a range)
- Improved stand longevity? Labor?
- Economics work with improved yields
- Remaining questions about spacing
- Remaining questions about optimum irrigation scheduling
- Gopher management remains critical challenge
Many thanks!

Wagner farm, WA state, photo