Promises and Pitfalls of Adapting New Technology…

Studies on Subsurface Drip Irrigation (SDI) in Alfalfa - What we’ve learned to date.

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Drip irrigated alfalfa field, California
What does the future hold?
Change in Groundwater Storage in the Central Valley, 1920 - 2010

-150 km³
(-130 MAF)
January 1 Milk Cows Numbers in California, 1996-2016

Source: USDA/NASS  *Estimate for 2016

University of Arizona-August 12, 2016
Future trends for Alfalfa?

- Dethroned as #1 acreage crop (~2012)
- ‘Tug of war’ between
  - Restrictions on acreage/production due to competition from other crops, water limitations
  - Strong demand from Western Dairies, Exports, horses, other livestock
- Need for:
  - Higher yields on limited land availability (this is a GLOBAL issue)
  - Lower water use
  - Water transfers
  - ‘Sustainable intensification’
- Alfalfa will remain a major crop for many years to come
California Alfalfa

- ~84% Surface irrigation
- ~14% sprinklers (pivots/ wheel lines)
- ~2-3% SDI
Why an interest in SDI in Alfalfa?

- Possibility of Higher Yields
- Experience with other crops
- Higher Hay price
- The Water Squeeze
UC SDI Studies:

- "Case Studies" of grower’s experiences across a range of environments (18-20)
  - Documenting successes/ failures
  - Costs/ benefits

- Controlled Studies on UC Facilities:
  - SDI compared with Flood
  - Variety interactions (with AZ, NMSU)
  - Deficit Irrigation with drip
  - Spacing Studies, understanding optimum irrigation management
  - Gopher Management

University of Arizona-August 12, 2016
To consider SDI in alfalfa:

- Must improve yields over surface irrigation to justify cost
- Must understand source of water, water quality, delivery
- Must be prepared for higher level of management
## Sample Costs for SDI
*(compared with surface irrigation)*

<table>
<thead>
<tr>
<th>Item</th>
<th>Partial Budget ($/a)</th>
<th>Annualized Costs ($/a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drip Tape (40”) – 6 yr.</td>
<td>$450 (400-500)</td>
<td>75</td>
</tr>
<tr>
<td>Drip Tape Installation– 6 yr.</td>
<td>$200 (100-300)</td>
<td>33.33</td>
</tr>
<tr>
<td>Irrig. Infrastructure (valves/pipes, pump) -15 yr.</td>
<td>$1400 (800-1800)</td>
<td>93.33</td>
</tr>
<tr>
<td>Water Cost (-8% SDI)</td>
<td>-$42 (+10% to -20%)</td>
<td>-$42</td>
</tr>
<tr>
<td>Energy Cost (vs. surface)</td>
<td>$118</td>
<td>$118</td>
</tr>
<tr>
<td>Labor Irrig. Management</td>
<td>-$66</td>
<td>-$66</td>
</tr>
<tr>
<td>Labor for Rodent mgt. &amp; repair</td>
<td>$75</td>
<td>$75</td>
</tr>
<tr>
<td>Remove Driplines—6 yr.</td>
<td>100 (80-120)</td>
<td>16.67</td>
</tr>
<tr>
<td><strong>Total Sample costs</strong></td>
<td>$2,050 initial + $185/yr</td>
<td>302.50/year</td>
</tr>
</tbody>
</table>

*Note: Actual costs may be higher or lower than these amounts*
What is needed to Justify SDI?

(Fixed costs)

- Assumptions: 15 yrs. infrastructure (pumps, filters, etc.)
- 6 years drip lines
- Does not consider support by NRCS or state agencies or rotation value
Are these yield improvements possible?

- Yield Increases appear real
- Confirmed by controlled studies (Lamm et al. 2012, UC studies)
- Growers report approximately 3.1 t/a improvement over flood.
- 20-35% range
- Why is that?
Why would we expect improved yields in SDI vs. surface?

- Superior Distribution Uniformity (in Space)
  - Less difference between top and bottom of field
  - Well known problems with surface systems

Key Recommendations
Innate Problems with Flood Irrigation

(Distribution uniformity can be poor due to soil infiltration rate, flow, and set duration)

In a 12 hour irrigation set:

- **Too Much**
- **Just Right**
- **Too Little**
- **Flooding**

- **Deep Percolation**
- **Dry Soil**

12 Hours 8 Hours 6 Hours Accumulation

(1320 feet)
Standing Water
(the enemy of alfalfa)
Tail - End Damage

Weeds intrude in damaged areas
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, depending upon flow available.
Innate Problems with Flood Irrigation

Check number:

Day 1

Water

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Innate Problems with Flood Irrigation

Check number:

Day 2

(3300 feet)

(1320 feet)
In a 28 day growth cycle, some parts of the field get water 7-8 days later.

Since 7 days before, and 7 days after harvest have to be dry, there is only a 14 day window for irrigation – so with flood irrigation, mostly can irrigate either 1x or 2x. Different parts of the field are irrigated differently.

(*Same issue with wheel lines!*)
Key Recommendations

Why Increased Yields with SDI?

3. Ability to Maintain Turgor

- Avoid temporary droughts
  - The moment turgor is lost, growth ceases
  - Avoid wetting-drying patterns (flood/drying)
Why Increased Yields?

4. Manipulating Irrigation Schedules to match ET

- Essentially any schedule desired
- Can irrigate every day
- Many hours, few hours
- Maintaining turgor
- Irrigating close to harvests (during??)
Alfalfa Cumulative ET (Lysimeter Trail - Davis 2015)

Over 7 cuts
\[ K_a = \frac{CET_c}{CET_o} = 0.85 \]
6- to 20-day period during which fields cannot be irrigated

Steve Orloff, photo
Can a system follow ET?

- Is it restricted in terms of applying small amounts?
- Can it recharge the profile?
Distribution Uniformity was not perfect in SDI fields:

- 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.
- More to learn on lateral spacing/flow rates.
‘Corrugation Effect’
what we’ve learned:

- Rodents are perhaps THE major challenge for SDI in alfalfa
Variety X Water Deficits under drip Irrigation
-El Centro & Davis
Water Use Efficiency (t ac⁻¹ in⁻¹)

I1: 0.25  I2: 0.33
I3: 0.31  I4: 0.43

Alfalfa dry matter (t ac⁻¹)

Irrigation treatment

I1  I2  I3  I4

100% of ET  75% of ET  75% of ET  50% of ET

Irrigated applied (inch)

0  10  20  30  40  50
<table>
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<tr>
<th>Consideration</th>
<th>SDI</th>
<th>Flood</th>
<th>Notes</th>
</tr>
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<tbody>
<tr>
<td>Water Use per Acre</td>
<td>(+)</td>
<td>(-)</td>
<td>Generally favors SDI, although will depend upon soil type and efficiency of flood system.</td>
</tr>
<tr>
<td>Water Use per unit prod. (ton)</td>
<td>(+)</td>
<td>(-)</td>
<td>Clearly favors SDI given innate advantages in water application.</td>
</tr>
<tr>
<td>Energy Use per acre</td>
<td>(-)</td>
<td>(+)</td>
<td>Gravity-fed systems are almost always superior in energy flux per unit area.</td>
</tr>
<tr>
<td>Energy Use per unit prod. (ton)</td>
<td>(+)</td>
<td>(-)</td>
<td>Improving yield is likely to lower energy use per unit production, depends upon extent</td>
</tr>
<tr>
<td>GHG per unit production</td>
<td>(+)</td>
<td>(-)</td>
<td>Not fully known but likely to be lower in SDI, due to higher yields and lower direct emissions</td>
</tr>
<tr>
<td>Irrigation Mgt.</td>
<td>(+)</td>
<td>(-)</td>
<td>Clear advantages to SDI, if managed correctly</td>
</tr>
<tr>
<td>Refill profile</td>
<td>(-)</td>
<td>(+)</td>
<td>Flood irrigation is likely superior</td>
</tr>
<tr>
<td>Germination</td>
<td>(-)</td>
<td>(+)</td>
<td>Sprinklers are preferred, flood works, SDI no</td>
</tr>
<tr>
<td>Salinity</td>
<td>(-)</td>
<td>(+)</td>
<td>Salinity may be an issue with SDI-mitigated</td>
</tr>
<tr>
<td>Wildlife</td>
<td>(-)</td>
<td>(+)</td>
<td>Favors flood but can be mitigated</td>
</tr>
</tbody>
</table>
## SDI - A Balance Sheet

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<th>Consideration</th>
<th>SDI</th>
<th>Flood</th>
<th>Notes</th>
</tr>
</thead>
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<tr>
<td>Yield</td>
<td>(+)</td>
<td>(-)</td>
<td>Mechanisms for yield increases appear genuine</td>
</tr>
<tr>
<td>Stand Longevity</td>
<td>(+)</td>
<td>(-)</td>
<td>Evidence for superior stand longevity</td>
</tr>
<tr>
<td>Controlling Fertilizers</td>
<td>(+)</td>
<td>(-)</td>
<td>Delivery directly to root system, prevention of losses (N, P).</td>
</tr>
<tr>
<td>Weed Intrusion</td>
<td>(+)</td>
<td>(-)</td>
<td>Evidence for less weed pressure due to dry surfaces and less stand decline</td>
</tr>
<tr>
<td>Surface runoff (pesticides etc.)</td>
<td>(+)</td>
<td>(-)</td>
<td>SDI eliminates surface runoff which protects surface water quality</td>
</tr>
<tr>
<td>Oxygen to Root system</td>
<td>(+)</td>
<td>(-)</td>
<td>On many heavy soils likely better O2 to roots</td>
</tr>
<tr>
<td>Labor</td>
<td>(+)</td>
<td>(-)</td>
<td>Labor savings in SDI irrigations, but greater management for repairs, gophers are needed</td>
</tr>
<tr>
<td>Rodent Management</td>
<td>(-)</td>
<td>(+)</td>
<td>Rodents are a problem in all systems, but flood irrigation keeps populations in check.</td>
</tr>
<tr>
<td>Flexibility with Deficit Irrigation</td>
<td>(+)</td>
<td>(+)</td>
<td>Both systems can be deficit irrigated. May improve yields under SDI, but higher costs.</td>
</tr>
</tbody>
</table>
Summary

- SDI Not appropriate for all farms—must have yield potential and higher level of management
- Variation in price is an economic limitation
- Improved yields (9-15 t/ a range) 2-3 tons/ a improvement in CV and desert regions
- Possibility of improved stand longevity, less weeds, Labor savings
- Water benefits, ability to do deficit irrigation
- Yield per unit water, energy, greenhouse gas
- Sustained effort required to solve problems:  
  - Rodent management  
  - Scheduling/ spacing  
  - Water quality
Questions?

Wagner farm, WA state, photo
Web Resources for SDI & Alfalfa

http://alfalfa.ucdavis.edu