Subsurface versus Furrow Irrigation of Alfalfa – *comments & reflections*

(1990’s USDA-ARS study in Imperial Valley, CA)

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- Bob Swain (Brawley, CA)
- Dick Kershaw (Brawley, CA grower and President, IVCRCC)
- Imperial Irrigation District
- Dean Currie
  Imperial Valley Research Center
  Imperial Valley Conservation Research Center Committee
Subsurface versus Furrow Irrigation of Alfalfa – comments & reflections
(1990’s USDA-ARS study in Imperial Valley, CA)

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Alfalfa SDI versus furrow irrigation comparison – Imperial Valley

Project Initiated in 1991
- Located at USDA-ARS Irrigated Desert Research Station near Brawley, CA (joint with USSL, IVCRCC staff)
- Alfalfa plantings were established using about 230 mm (1\textsuperscript{st} planting) and 135 mm (2\textsuperscript{nd} planting) with sprinkler irrigation before switching irrig systems.
- Initial soil test K and P adequate, but applied 90 kg P205, 450 kg K2O/acre pre-plant

Bed Plantings:
- Decision made for all plots to be bed-planted so SDI plots would match furrow
- Important for bed planting of surface irrigated due to scalding problems occurring with low intake rate soil with anoxia problems
- One characteristic of the study (based on location) is the use of Colorado River water as the irrigation water source.
- Key irrigation water quality characteristics are shown below:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical conductivity (average)</td>
<td>1.15 to 1.3 dS/m</td>
</tr>
<tr>
<td>pH</td>
<td>7.4 to 7.9</td>
</tr>
<tr>
<td>Bicarbonate</td>
<td>2.2 to 2.7 mmol L⁻¹</td>
</tr>
<tr>
<td>Ca</td>
<td>80-125 mg/L</td>
</tr>
<tr>
<td>Mg</td>
<td>30-37 mg/L</td>
</tr>
<tr>
<td>Cl</td>
<td>2.5-3.6 meq/L</td>
</tr>
<tr>
<td>Boron</td>
<td>0.13 to 0.31 mg/L</td>
</tr>
<tr>
<td>SAR range</td>
<td>about 5.5 to 7</td>
</tr>
</tbody>
</table>
### Treatment descriptions in Alfalfa SDI versus furrow irrigation studies (1991-1997) – Imperial Valley (Hutmacher et al., USDA-ARS)

<table>
<thead>
<tr>
<th>Irrigation treatments</th>
<th>Drip Lateral Spacing (in.)</th>
<th>Number of beds per plot</th>
<th>Bed Width (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDI-Ram</td>
<td>40</td>
<td>8</td>
<td>40</td>
</tr>
<tr>
<td>SDI-Ram</td>
<td>80</td>
<td>4</td>
<td>80</td>
</tr>
<tr>
<td>SDI-Rootguard</td>
<td>40</td>
<td>8</td>
<td>40</td>
</tr>
<tr>
<td>SDI-Rootguard</td>
<td>80</td>
<td>4</td>
<td>80</td>
</tr>
<tr>
<td>Field Lysimeter (SDI Rootguard)</td>
<td>40</td>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>Furrow – 40” beds</td>
<td>-</td>
<td>16</td>
<td>40</td>
</tr>
</tbody>
</table>

- Difference between 1991-1992 versus 1993-1997 setup was in drip lateral depth of placement (0.4 m vs. 0.63 to 0.7 m)
- Soil type was heavy clay, with surface infiltration and aeration issues
SDI – Imperial: Management of Irrigation Systems

Drip System Mgmt
- Filtration = intake screen from reservoir & 200 mesh screen
- Dual sand media filter at field (daily flushing)
- Laterals flushed weekly
- Phosphoric acid injected to achieve 15 mg P/L
- Chlorine and N-phuric weekly to achieve pH<5.5 during Chl injection, about 14-18 mg/L free chlorine for 2 hours/week

Furrow Irrigation Mgmt
- Typically irrigated twice within each harvest cycle period (25-30+ days); 2.5 to over 4” per application
- Metered applications, gated pipe system
- Ran long sets & adjusted flow rates to avoid flooding bed tops for any significant durations – operated without tailwater
- After early irrigations of the season, ran shank 2-3” deep to improve intake
- Worked with consultant (Mr. Dean Currie) to compare our mgmt with grower practices
Phase I of trial (0.4 m drip line depth) – 1991 to 1992

- Original intent was to let lysimeter control the **amount** and **frequency** of SDI irrigation (avoid stress even during regrowth period).

- Problem was that with this control set-up, there was (a) routine wetting of small but significant areas of the surface of planted beds; and (b) impacts of harvest equipment operations on soil / compaction and damage to alfalfa plants/crowns around the wet areas.

- The area routinely wetted was measured and was relatively small (about 2-3% of ground surface area). To deal with this, initially, water applications were scaled back to 25-50% crop Etc during few days pre-harvest through bale removal (*resulted in CWSI values of 0.1 to 0.2+ during dry-down pre-harvest*).

- Problem was that this practice reduced wetted areas, but research interests were in making sure SDI plants were not stressed during this regrowth period. This led to a decision to re-install the SDI system at a greater depth.
PHASE ONE (applied water and yields): April-December, 1991 and January-September, 1992

**Water (mm) applied or SWU**
- DRIP-40, DRIP-80, FURROW, LYSIM

<table>
<thead>
<tr>
<th>Year</th>
<th>DRIP-40</th>
<th>DRIP-80</th>
<th>FURROW</th>
<th>LYSIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>1400</td>
<td>1500</td>
<td>1300</td>
<td>1200</td>
</tr>
<tr>
<td>1992</td>
<td>1500</td>
<td>1600</td>
<td>1400</td>
<td>1300</td>
</tr>
</tbody>
</table>

**Yield (Tons/acre) corrected**
- DRIP-40, DRIP-80, FURROW, LYSIM

<table>
<thead>
<tr>
<th>Year</th>
<th>DRIP-40</th>
<th>DRIP-80</th>
<th>FURROW</th>
<th>LYSIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>10</td>
<td>9</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>1992</td>
<td>12</td>
<td>11</td>
<td>9</td>
<td>8</td>
</tr>
</tbody>
</table>
Phase II of trial (0.7 m drip line depth) – 1993 late to 1997

- Sudangrass grown in 1993 as transition crop between stages (after SDI system re-installed)
- Deeper installation depth was used to prevent applied water from coming to surface (*this deeper depth achieved this goal*)
- Fewer observed leaks, less rodent damage with deeper installation
- However .... The deeper installation changed soil salinity / salt accumulation patterns as well as surface soil drying & cracking
- With deeper installation of SDI, no need for phased-back irrigations prior to harvest through bale removal period (*could let lysimeter control irrigation again*)

Water (mm) applied or SWU

- Soil Water Use
- Applied

1994
1995
1996
1997
Alfalfa Forage Yields in alfalfa SDI versus furrow trial – Imperial Valley (USDA-ARS Fresno)

- Forage yields were corrected to uniform moisture content

FORAGE YIELDS (T/acre)

- 1991-part +25%
- 1992-part +23%
- 1994-part +18%
- 1995 +18%
- 1996 +18%
- 1997 +26%

- SDI-40
- SDI-80
- Furrow
Little ET difference between drip & furrow: why?
(1) Upper limit on furrow irrigation amount was restricted by intake rate and aeration; (2) In drip, lack of irrigation cutback resulted in higher transpiration, faster regrowth & > yields
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Salt Accumulation Issues

- Long term ... supposition that different mgmt approach required for drip versus furrow (furrow irrigation pushed salts to bed center, SDI patterns more complicated)
- Patterns develop within months in high ET locations
40 inch drip – soil Ece (dS/m) at horizontal distance from lateral

80 inch drip – soil Ece (dS/m) at horizontal distance from lateral
SDI Alfalfa – Imperial
Salt accumulation issues – 94 vs 95

40 inch drip – soil Ece (dS/m) at horizontal distance from lateral

Furrow plots – soil Ece (dS/m) at horizontal distance from lateral
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Salt Accumulation Issues

- Deal with accumulations or eventually problems develop

- An option we evaluated was to deal with salt accumulations by winter sprinkler applications in both furrow and SDI (worked well in evening out saline “hot spots” in upper root zone) – extra cost but if not done likelihood that would see yield declines over time
Another side issue: **Soil Nutrient Availability Issues over time?**

*Supplemental fertilization practices can become more important in some situations due to SDI operation impacts on root distribution*

- timing and type of fertilizer materials can be important
- placement of fertilizers / consider impacts of system placement relative to plant rows, application frequency on opportunity for root uptake
- with less mobile nutrients such as P or K, depth of drip line relative to root growth can impact availability at times
- Same can be true with perennial crops several years down the line example: in some alfalfa work, we had problems delivering K effectively to an established, drip irrigated crop with high yields & high K uptake – how get adequate nutrients to active part of plant root zone?
- follow-up plant (or soil) evaluations to: (1) assess adequacy at key periods, and; (2) avoid excess and waste
Comments – Grower site visits & issues seen

- In New Mexico, Colorado, Nevada sites visited, range of soil and water quality conditions seen in SDI alfalfa (water quality impacts on system operation, plugging issues, filtration & water trt must be dealt with to be successful)
- Soil type and hydraulic characteristics of course impact acceptable choices for lateral depth, lateral spacing, etc. not just in terms of surface wetting, but also root system development and long term plant survival if deficit irrigation practices used.
- Research trial used drip tubing ... thinner wall drip tape may have other impacts on long term survival of system, particularly with pests
- In semi-arid low growing season rainfall areas, lateral placement and how system is run (full ET replacement, partial irrigation, supplemental irrigation) will greatly affect root system development and root distribution over time (ie. some roots will not persist)
- Salt accumulations need to be dealt with, and a deeper placed SDI system alone probably will not do an adequate leaching job, especially in low rainfall areas
- Root intrusion not generally big issue as long as water quality and filtration issues addressed
Summary Comments from Brawley area long term study (1):

- WUE increases (yld/mm ET) of about 20% were seen with SDI compared with furrow (this soil, this site)
- WUE mostly due to yield increases, not reductions in applied water, or reductions in ET
- As system operated over multiple years, rooting became more limited
- due to water application patterns, soil characteristics resulted in some fertility issues, apparent K responses
Summary Comments (continued):

- In Phase II, deeper depth allowed continued water applic. during harvest and regrowth, faster regrowth rates

- Short furrow run lengths make furrow fairly efficient and uniform, but counterbalanced by lighter, more frequent irrigations needed in this soil to avoid “scalding” and aeration problems

- May be more opportunities for water savings in soils where intake uniformity with flood or furrow is more variable

- As usual, system and mgmt costs need to be balanced against water availability and costs
CONSIDERATIONS

“Should I consider switching to drip?”
- can apply to other systems too

• Does research or local evidence suggest a yield response likely with system or management change? If so, how much?
• If the answer “yes”, how much additional yield, what is it worth?
• How well the system will work depends in part on soil type, slope, groundwater depth, other factors – will it work with your field?
• How much savings in water or fertilizer or other inputs are expected and needed to justify costs?
• Installation, design, annual operating costs for system?
• Labor and expertise available to install, maintain, manage?
• Availability of effective control measures for pests (gophers, etc.)
• Longevity required to make system cost-effective, and how does that influence installation & maintenance costs?
• Compatibility of the system with crop rotation plans?
Actual Water Savings That Can Be Achieved?

- **Question to ask:**
  - Is ability to save significantly on applied water a vital part of the equation?
  - Do you need savings due to limits on water availability? Impacts on water cost?

- **Ability to deliver water savings depends on:**
  - soil factors as well as irrigation system choices
  - Experiences of many has shown a very large range in actual water savings (soil types, inefficiencies of prior systems, crop sensitivity to stress, ability to judge water needs to avoid deep percolation losses all can impact ACTUAL SAVINGS)
Drought or limited water supply – *Options*

*Change irrigation mgmt with existing system & understand how the crop will respond*

**Alfalfa example: (Blaine Hanson) - crop where ET tightly linked to yields – all options likely reduce yields**

1. Reduce acreage irrigated *(stand damage if no irrigation)*
2. Fully irrigate early on, none later *(full/deficit)* *(target early harvests with best ylds & quality, flood & sprinkler compatible)*
3. Distribute reduced applications over entire field, full season *(eliminate an irrig. between cuttings (ok with flood or spinkler); reduce irrigation amount per irrigation (more possible with drip or sprinklers)*)
4. Reduce applied water per irrigation *(reduce yields, hard to achieve with flood or furrow; ok with drip or sprinkler; too small amts may result in uneconomical yields in terms of covering harvest costs)*

*With alfalfa and even more with trees & vines, one of the major considerations may be the longer-term impacts of water mgmt practices on survivability and future productivity of the crop*