Managing with Limited Well Capacity

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Management options with low-capacity irrigation wells:

- Increase irrigation application efficiency
- Employ use of reduced/no-till (more residue)
- Use selective timing of limited irrigation based on water-critical growth stages
- Substitute to crop with lower water need than current crop (wholly or in part)
- Make use of crops with differently-timed water need than current crop
- Reduce irrigated area
- Increase time span of well use through pre-season irrigation

Soil type and depth sets some constraints

Management Continuum

- Full Irrigation
- Limited Irrigation
- Dryland

What drives how we can respond to declining well capacity

- Soil Texture and Depth
  - Margin of error
  - Efficiency of preseason
- Flexibility in moving water
  - Multiple wells tied to multiple sprinklers vs. one well one sprinkler
Basics Still Matter

Irrigation Scheduling

Irrigation Scheduling Relevant at any Well Capacity

Lamm and Rogers, 2015 CPIA

<table>
<thead>
<tr>
<th>Year</th>
<th>Date of Anthesis</th>
<th>Date of Maturity</th>
<th>Irrigation Season Termination Date For 80% Max Yield</th>
<th>90% Max Yield</th>
<th>Max Yield</th>
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<tbody>
<tr>
<td>1993</td>
<td>20-Jul</td>
<td>30-Sep</td>
<td>5-Aug</td>
<td>5-Aug</td>
<td>15-Aug</td>
</tr>
<tr>
<td>1995</td>
<td>20-Jul</td>
<td>20-Sep</td>
<td>5-Aug</td>
<td>13-Aug</td>
<td>18-Aug</td>
</tr>
<tr>
<td>1999</td>
<td>23-Jul</td>
<td>6-Oct</td>
<td>24-Jul</td>
<td>13-Aug</td>
<td>20-Sep</td>
</tr>
<tr>
<td>2000</td>
<td>12-Jul</td>
<td>20-Sep</td>
<td>14-Sep</td>
<td>20-Sep</td>
<td>20-Sep</td>
</tr>
<tr>
<td>2001</td>
<td>16-Jul</td>
<td>29-Sep</td>
<td>30-Jul</td>
<td>22-Sep</td>
<td>22-Sep</td>
</tr>
<tr>
<td>2002</td>
<td>22-Jul</td>
<td>30-Sep</td>
<td>4-Aug</td>
<td>30-Aug</td>
<td>7-Sep</td>
</tr>
<tr>
<td>2003</td>
<td>22-Jul</td>
<td>23-Sep</td>
<td>3-Aug</td>
<td>3-Aug</td>
<td>18-Aug</td>
</tr>
<tr>
<td>2004</td>
<td>19-Jul</td>
<td>28-Sep</td>
<td>8-Aug</td>
<td>21-Aug</td>
<td>27-Aug</td>
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<tr>
<td>2008</td>
<td>24-Jul</td>
<td>10-Oct</td>
<td>31-Jul</td>
<td>6-Aug</td>
<td>27-Aug</td>
</tr>
</tbody>
</table>

Average: 19-Jul 27-Sep 2-Aug 13-Aug 28-Aug

Standard Dev.: 3 days 6 days 13 days 19 days 13 days

Earliest: 12-Jul 14-Sep 17-Jul 17-Jul 12-Aug

Latest: 24-Jul 10-Oct 14-Sep 21-Sep 21-Sep

* Estimated dates are based on the individual irrigation treatment dates from each of the different studies when the specified percentage of yield was exceeded.
**Timing of the final irrigation:**
- Determine crop growth stage and anticipated remaining water use
- Determine soil water status in the field by probe or calibrated soil sensor technology
- Determine irrigation strategy necessary to meet remaining crop water use while maintaining soil water content at or above 55% (limit depletion to 45%).
- Be ready to make adjustments based on changes in ET demand, precipitation, etc.

**Potential Water Loss**
In an 8’ profile, 60% available soil water would be approximately 9.6” in a Western Kansas silt-loam soil.
Storage efficiency of additional water approaches zero at 100% ASW, or 16” in this case.

**Water Loss to Drainage**
If the profile is at or above 60% full the storage efficiency of fall or spring precipitation or preseason irrigation diminishes rapidly.
Potential Water Loss

- Proper management of irrigation at the end of the season
- Calendar not a good method
- Don’t want to short the crop, but also don’t want to reduce our storage efficiency for winter precipitation and pre-season irrigation

Preseason Irrigation – When?

- Tradeoffs
  - Fall preseason is less efficient, especially if you don’t leave room for precipitation, let’s not forfeit the FREE water
  - Spring preseason has more losses to evaporation, especially in tilled systems, but allows you to capture winter precipitation without fear of losses
  - Ultimately a mixed approach is probably best
Managing irrigated corn with limited well capacity

Alan Schlegel, Professor and Agronomist-in-Charge
Southwest Research-Extension Center, Tribune, Kans.

Objectives

• Quantify yield benefit from preseason irrigation with diminished well capacities.

• Determine optimum seeding rate for corn at various irrigation levels.

• Determine profitability at various irrigation levels.

Treatments

• Preseason irrigation: With and without (~3 inch)

• Sprinkler irrigation capacities: 0.10, 0.15, and 0.20 inch/day

• Seeding rates: 22.5, 27.5, and 32.5 thousand/a
Site characteristics

• Ulysses silt loam soil (12% sand, 63% silt, 25% clay)
• Level (<1% slope)
• Annual precipitation – 17 in

Water Inputs

<table>
<thead>
<tr>
<th></th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Growing season</td>
<td>6.93</td>
<td>8.08</td>
<td>9.36</td>
<td>14.35</td>
</tr>
<tr>
<td>Preseason Irrigation</td>
<td>3.23</td>
<td>2.96</td>
<td>3.01</td>
<td>3.15</td>
</tr>
<tr>
<td>Irrigation Capacity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5 mm/day</td>
<td>9.55</td>
<td>7.21</td>
<td>8.22</td>
<td>8.84</td>
</tr>
<tr>
<td>3.8</td>
<td>12.61</td>
<td>10.10</td>
<td>10.96</td>
<td>11.77</td>
</tr>
<tr>
<td>5.0</td>
<td>19.01</td>
<td>15.62</td>
<td>14.77</td>
<td>17.85</td>
</tr>
</tbody>
</table>

Approx. 74% efficient on average

Profile Water at Planting

- No Preseason Irrigation: 9.2 inch
- Yes Preseason Irrigation: 11.5 inch

Summer Rainfall

- Precipitation, inch:
  - June: 0, 1, 2, 3, 4, 5, 6
  - July: 0, 1, 2, 3, 4, 5, 6
  - August: 0, 1, 2, 3, 4, 5, 6
- Normal: 0, 1, 2, 3, 4, 5, 6

No Yes
Avail. water, inch
2007-2009, Tribune, KS
**Corn Grain Yield**

- **irrigation capacity=0.10 inch/day**
  - Yield, bu/acre
    - 2006-2009, Tribune, KS
    - Preseason Irrigation
      - No: 153, 158, 155
      - Yes: 171, 179, 183

- **irrigation capacity=0.15 inch/day**
  - Seed Rate: 22.5, 27.5, 32.5
  - Yield, bu/acre
    - 2006-2009, Tribune, KS
    - Preseason Irrigation
      - No: 172, 173, 171
      - Yes: 185, 197, 201

- **irrigation capacity=0.20 inch/day**
  - Seed Rate: 22.5, 27.5, 32.5
  - Yield, bu/acre
    - 2006-2009, Tribune, KS
    - Preseason Irrigation
      - No: 200, 211, 223
      - Yes: 204, 218, 229
Yield Increase from Preseason Irrigation

<table>
<thead>
<tr>
<th>Seed Rate</th>
<th>22.5</th>
<th>27.5</th>
<th>32.5</th>
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</thead>
<tbody>
<tr>
<td>Irrigation Capacity, inch/day</td>
<td>0.1</td>
<td>0.15</td>
<td>0.2</td>
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<tr>
<td>Yield Increase, bu/a</td>
<td>2006-2009</td>
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Net Return without Preseason Irrigation

<table>
<thead>
<tr>
<th>Seed Rate</th>
<th>22.5</th>
<th>27.5</th>
<th>32.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation Capacity, inch/day</td>
<td>0.1</td>
<td>0.15</td>
<td>0.2</td>
</tr>
<tr>
<td>Net Return, $/a</td>
<td>2006-2009, Tribune, KS</td>
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</table>

Net Return with Preseason Irrigation

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<th>32.5</th>
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<tr>
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<td>2006-2009, Tribune, KS</td>
<td></td>
<td></td>
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</tbody>
</table>

A side track on hybrids....

- The previous work was done with one commercial hybrid
- We know hybrids response to water and seeding rate can vary widely
  - E.g. Full irrigation at Colby, I seeded 4 hybrids at rates from 13k to 50k. There were some hybrids making close to 200 bu on 13k dropped
- Knowing your hybrids is going to be key to maximizing any limited irrigation/limited capacity scenario
2016 Corn School - Oakely

\[ y = -8 \times 10^{-8} x^2 + 0.0058 x + 129.74 \]
\[ R^2 = 0.6116 \]

\[ y = -9 \times 10^{-8} x^2 + 0.0067 x + 97.146 \]
\[ R^2 = 0.4922 \]

\[ y = -4 \times 10^{-8} x^2 + 0.0033 x + 145.2 \]
\[ R^2 = 0.5035 \]

Grain Yield with Limited Irrigation
2008 and 2001-2008

<table>
<thead>
<tr>
<th>Irrigation amount</th>
<th>Corn</th>
<th>Sorghum</th>
<th>Soybean</th>
<th>Sunflower</th>
</tr>
</thead>
<tbody>
<tr>
<td>inches</td>
<td>-----</td>
<td>-------</td>
<td>-------</td>
<td>---------</td>
</tr>
<tr>
<td></td>
<td>bu/acre</td>
<td>lb/acre</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>101 (113)</td>
<td>88 ( 94)</td>
<td>38 ( 31)</td>
<td>1660 (1800)</td>
</tr>
<tr>
<td>10</td>
<td>168 (172)</td>
<td>127 (111)</td>
<td>48 ( 42)</td>
<td>1950 (2080)</td>
</tr>
<tr>
<td>15</td>
<td>200 (201)</td>
<td>143 (123)</td>
<td>51 ( 47)</td>
<td>2500 (2160)</td>
</tr>
</tbody>
</table>

Yields in parenthesis are 2001-2008 average yields

Crop Rotations with Limited Irrigation

• Corn-corn (10”)

• Corn – Wheat (15”-5”)

• Corn – Wheat – Grain sorghum (15”-5”-10”)
  • Corn – Wheat – Grain sorghum – Soybean (15”-5”-10”-10”)

Crop Rotations with Limited Irrigation

• Corn-corn (10”)

• Corn – Wheat (15”-5”)

• Corn – Wheat – Grain sorghum (15”-5”-10”)
  • Corn – Wheat – Grain sorghum – Soybean (15”-5”-10”-10”)

Tribune, KS
Playing the Timing Game

• Split the circle (or well) with multiple crops
  – corn/sorghum
  – corn/dry beans
  – wheat/dry beans
  – wheat/corn
  – dryland corn/irrigated corn?
• What about splitting the same crop in time?

Irrigation Timing and Grain Sorghum
Tribune, KS

<table>
<thead>
<tr>
<th>Time of Irrigation</th>
<th>Yield (bu/ac)</th>
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<tbody>
<tr>
<td>Preplant only</td>
<td>65</td>
</tr>
<tr>
<td>Pre+Boot Stage</td>
<td>125</td>
</tr>
<tr>
<td>Pre+Half-Bloom</td>
<td>115</td>
</tr>
<tr>
<td>Pre+Soft-Dough</td>
<td>114</td>
</tr>
<tr>
<td>Full Season Irrigation</td>
<td>126</td>
</tr>
</tbody>
</table>

Grain Sorghum Managed Deficit Irrigation Study

• Full Irrigation (FI)
• Non-Irrigated (NI)
• Deficit Irrigation (DI)
• Managed Deficit Irrigation (MDI)

J. Bell et al., Texas AgriLife
Full and Deficit Irrigation

- Full Irrigation (FI)
  - 100% crop water use or based on a managed allowable depletion using soil moisture sensors

- Deficit irrigation = 50% FI
  - similar depth as FI, but longer time period between applications
  - Critical to maintaining WUE of limited irrigation

Managed Deficit Irrigation

1. Eliminate 1-2 early season irrigation events compared with DI
2. Differentiation to half bloom, irrigation scheduled at 75% FI
3. Half bloom to maturity, irrigation scheduled at 50% FI
4. Must have the well capacity to apply greater depth during critical growth periods.

Crop water use and grain sorghum yield for an average year (2010) and an extreme year (2011) at Bushland, TX (Bell, 2014)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Irrigation</th>
<th>Rainfall</th>
<th>Soil water</th>
<th>Total Water</th>
<th>Yield</th>
<th>WUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full Irrigation</td>
<td>12.7</td>
<td>7.1</td>
<td>1.8</td>
<td>21.6</td>
<td>198</td>
<td>9.2</td>
</tr>
<tr>
<td>Managed Deficit (MDI)</td>
<td>6.5</td>
<td>7.1</td>
<td>3.6</td>
<td>17.2</td>
<td>142</td>
<td>8.3</td>
</tr>
<tr>
<td>Deficit (DI)</td>
<td>5.7</td>
<td>7.1</td>
<td>3.1</td>
<td>15.9</td>
<td>123</td>
<td>7.7</td>
</tr>
<tr>
<td>2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Full Irrigation</td>
<td>24.0</td>
<td>2.4</td>
<td>-1.1</td>
<td>25.3</td>
<td>190</td>
<td>7.5</td>
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<tr>
<td>Managed Deficit (MDI)</td>
<td>15.3</td>
<td>2.4</td>
<td>0.2</td>
<td>17.9</td>
<td>132</td>
<td>7.4</td>
</tr>
<tr>
<td>Deficit (DI)</td>
<td>13.1</td>
<td>2.4</td>
<td>0.9</td>
<td>16.4</td>
<td>106</td>
<td>6.5</td>
</tr>
</tbody>
</table>

Sorghum Grain Production

- Yield
- Seeds/Panicle
Where do I see opportunities:

- Edges of the season
  - Technology can help with this
- Use of key timings in responsive crops
  - Cotton (not for NECO), Sorghum, what else?
  - There has been very little research on limited irrigation of dry beans
- There is still a place for irrigation scheduling, even under limited well capacities
- Pre-season irrigation is a tool, **but** we must be smart with it

Questions?

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