Spring Wheat Productivity in dryland and irrigated environments

Jessica A. Torrion
Assistant Professor- Crop Physiology
Northwestern Ag Research Center, Kalispell, MT
Goal
Optimal productivity with the rainfall received and applied irrigation “more crop per drop” (Water for Food Inst)

Specific objectives
Characterize spring wheat variety response to water regimes – in yield and quality
Creston, Montana AgriMet Weather Station (CRSM)

Latitude: 48.1875 N
Longitude: 114.12777 W
Investor: 2000
Installation Date: 4/1/1998

http://www.usbr.gov/pn/agrimet/agrimetmap/crsmda.html
Daily Crop Water Use (Crop ET)

ETc = ETo x Kc

For example:

Creston Weather Station

ETo: 0.4
Current Kc: 0.8

ETc = 0.4 x 0.8 = 0.32 inch

http://www.usbr.gov/pn/agrimet/cropcurves/crop_curves.html
Permanent Wilting Point: Hygroscopic water. Remaining water adheres to soil particles and is unavailable to plants.

Field Capacity: Capillary water. Water held in micropores. Available water - plant roots can absorb this.

Saturated Water Content: Gravitational water. Drains out of the root zone.

Available water for plant growth
Water Holding Capacity of a **Fine Sandy Loam** Soil

1.5 or 2 ft Soil Depth to Consider: early vegetative

\[
\text{PAW}_{\text{today}} = \text{PAW}_{\text{yesterday}} - \text{CropET} - \text{Other Losses} + \text{Rainfall} + \text{Irrigation}
\]

3 ft Soil Depth to Consider: ~Boot
Field Research Set-Up

Water Treatment: 1) Soft dough (100ET), 2) early milk, 3) medium milk, 4) dough and, 5) Rainfed check

Varieties: Brennan, Buck Pronto, Cabernet, Expresso, McNeal, Solano Volt and WB Rockland
<table>
<thead>
<tr>
<th>Year</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>April-Aug</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean Temperature, F</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>44.5</td>
<td>53.3</td>
<td>56.9</td>
<td>67.5</td>
<td>64.9</td>
<td>57.4</td>
</tr>
<tr>
<td>2015</td>
<td>44.8</td>
<td>54.7</td>
<td>65.1</td>
<td>66.3</td>
<td>65.2</td>
<td>59.2</td>
</tr>
<tr>
<td>1989-2015</td>
<td>43.9</td>
<td>52.4</td>
<td>58.4</td>
<td>66.0</td>
<td>64.4</td>
<td>57.0</td>
</tr>
<tr>
<td><strong>Precipitation, in</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>0.84</td>
<td>1.6</td>
<td>6.05</td>
<td>0.46</td>
<td>1.88</td>
<td>10.8</td>
</tr>
<tr>
<td>2015</td>
<td>0.6</td>
<td>0.62</td>
<td>0.97</td>
<td>0.35</td>
<td>0.16</td>
<td>2.7</td>
</tr>
<tr>
<td>1989-2015</td>
<td>1.48</td>
<td>2.04</td>
<td>3.19</td>
<td>1.15</td>
<td>0.95</td>
<td>8.8</td>
</tr>
<tr>
<td><strong>Total Irrigation Applied</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Soft Dough</td>
<td>Medium milk</td>
<td>Early milk</td>
<td>Flower half complete</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>5.8</td>
<td>4.6</td>
<td>3.3</td>
<td>2.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>10.0</td>
<td>8.8</td>
<td>7.5</td>
<td>5.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Water Regimes: 2014

- Crop ET
- Soft Dough (100ET)
- Medium milk
- Early milk
- Flower half complete
- Effective Rain

Days after emergence

Water, inches
Water Productivity and UnProductivity

Yield, Bu/A

PAW (50% Spring+Rain+Irrigation), in

Yield = 6.1x + 5.1
R²=0.99
Plateau=11.0 inches
Slope (WUE)=6.1 Bu/in
What does this yield plateau mean?

In terms of water, time, and energy cost?

In terms of more crop per drop?

WP = Produce/total water

1 acre-inch = 27,154 gallons; 140 acres: 3.8 million gal
~average pumping cost for 1 acre-inch: $5/acre; $700 (140 Acres); x2 $1,400
2014 Yields

Nonsignificant yield response with water regimes
2015 Yields

Yield (bu/A)

- Soft dough (100ET)
- Medium milk
- Early milk
- Flower half complete
- Dryland

Species: Brennan, BuckPronto, Cabernet, Expresso, McNeal, Solano, Volt, WBRockland
Protein Response: Year x Irrigation x Variety

2014

2015

Yield, Bu/A

Maximum water response

PAW (50% Spring + Rain + Irrigation), in

Protein, %
Protein, 2014

Nonsignificant protein response with water regimes
I (*), V (*), I x V (ns)
Protein, 2015

Nonsignificant protein response with water regimes

I (ns), V (*), I x V (*)
Falling Number

WUE STUDY: Fine Sandy Loam

Plant Available Water (50% Spring + Rain + Irrigation)
Falling Number, 2014

Nonsignificant FN response with water regimes
I (*), V (*), I x V (*)

Graph showing the falling number of different wheat varieties under various water regimes.
In Summary:

Water-critical stage in spring wheat:
From seedling establishment to early milk.
• Consider the water holding capacity of soil, ‘bucket’ size, and make room for storing rain.

Non-Water Critical stage in spring wheat:
Late milk to dough
• **Schedule Final Irrigation** of the season starting early to medium-milk stages
Yield:
- Yield increased with irrigation (6 Bu per inch water).
- Plateau indicates the limits of water productivity (insensitivity of spring wheat to water at seed-fill).
- Temperature stress limited yield potential of irrigated wheat in 2015.

Protein:
Protein improvement at early milk irrigation is possible in case of 2014 weather- at least 80% of the yield potential was already achieved prior to this irrigation event.

Falling Number:
Brennan is the most susceptible to the decrease in falling number with irrigation.
Thank you
Test Weight, 2014

Nonsignificant TWT response with water regimes
Test Weight, 2015

Nonsignificant TWT response with water regimes