OPTIMIZING ECONOMIC VALUE OF WATER FROM OGALLALA AQUIFER USED FOR IRRIGATION

Jason Warren, Art Stoecker, Karthik Ramaswamy, Rodney Jones, Jody Campiche, Andre Paul, Brooke Lane, Jordan Gatlin, Dalton Sims, and Cameron Murley
Irrigation utilizes 86% of withdrawal from the Ogallala Aquifer in Oklahoma (OWRB, 2012)
- Estimated irrigation water demand = 337,000 AF/y
- Applied to 230,000 acres
  - 106,000 acres of corn
  - 19,500 acres of sorghum

An increasing number of producers are experiencing declines in irrigation capacity.
Can alternative low water use crops such as grain sorghum be economically viable alternatives to corn?

If so, why do producers not adopt them as well as capacities decline?

How can economic value of water remaining be optimized?
Originally funded to develop yield response as a function of irrigation capacity (FY2013)
Incorporated modeling effort to simulate corn and Grain Sorghum yields and provide robust evaluation of economic viability of crops under pivot and SDI (FY2014)
Evaluate yield response of wheat and continue economic analysis to assess risk of loss and value of crop insurance for corn and sorghum (FY2015)
Notable Short-term Outcomes

- 3 Undergraduate Students
- 4 graduate students
- 2 Presentations as international scientific meetings
- 6 Extension presentations
- 3 additional Grants funded to support irrigation research and extension
Synergistic Grants

- Sustaining Agriculture through Adaptive Management Resilient to a Declining Ogallala Aquifer and Changing Climate.
  - AFRI Coordinated Agricultural Project Program for $9,900,000.
- Promoting Sensor-based Technology to Improve Land and Water Resources Conservation.
  - NRCS-CIG for $772,029.
- On-farm sub-surface drip irrigation: How does soil type impact efficiency and management
  - Thomas E. Berry Faculty Fellow $20,000
Oklahoma State University is now regional recognized as a valuable partner in irrigation research and extension

Producers throughout the State are engages in discussions to work towards improved efficiencies
2015 Efforts

- Sorghum-Corn-wheat rotation evaluated at well capacities of 800-100 gal/min
  - Included wheat as a off season rotational crop
- Crop insurance issues was evaluated
- Discussions with producers indicated that lack of valuable coverage for sorghum prevented planting
3-Year Average Yield and Irrigation vs Simulated Results
Grain Prices used:
Corn= $4.48
Sorghum= $4.16
Sorghum Provides greater revenue per inch of water
Suggests that Net Present Value will be maximized but production of sorghum
Crop Insurance cost and coverage is based on County average yields or proven farm yields. Therefore, Long-term production of high yielding crops at the county or farm level will provide better economic risk management.
More corn policies are paid compared to sorghum.

### Beaver County

<table>
<thead>
<tr>
<th>Insurance Type</th>
<th>Mean</th>
<th>95% CL</th>
<th>Mean</th>
<th>Std Dev</th>
<th>95% CL</th>
<th>Std Dev</th>
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<tbody>
<tr>
<td>Yield Protection</td>
<td>0.0875</td>
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<td>0.182</td>
<td>0.1607</td>
<td>0.1197</td>
<td>0.2445</td>
<td>2.55</td>
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### Cimarron County

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<tbody>
<tr>
<td>Yield Protection</td>
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<td>0.0661</td>
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<td>-0.0011</td>
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<td>0.109</td>
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</tr>
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<td>-0.0976</td>
<td>0.0176</td>
<td>0.1298</td>
<td>0.0999</td>
<td>0.1855</td>
<td>-1.45</td>
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### Texas County

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<th>Mean</th>
<th>Std Dev</th>
<th>95% CL</th>
<th>Std Dev</th>
<th>t Value</th>
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<tbody>
<tr>
<td>Yield Protection</td>
<td>0.292</td>
<td>0.1887</td>
<td>0.3953</td>
<td>0.0832</td>
<td>0.0498</td>
<td>0.239</td>
<td>7.85</td>
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<td>Crop Revenue Coverage</td>
<td>0.19</td>
<td>0.1181</td>
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<td>0.1245</td>
<td>0.0902</td>
<td>0.2005</td>
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<tr>
<td>Actual Production History</td>
<td>0.2067</td>
<td>0.1736</td>
<td>0.2398</td>
<td>0.0727</td>
<td>0.0556</td>
<td>0.105</td>
<td>13.03</td>
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## Price of Crop Insurance

<table>
<thead>
<tr>
<th></th>
<th>Irrigated Corn</th>
<th>Irrigated Grain Sorghum</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base County Rate at 65% Coverage Level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cost Per Bushel Insured</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beaver</td>
<td>$</td>
<td>0.013</td>
</tr>
<tr>
<td>Cimarron</td>
<td>$</td>
<td>0.014</td>
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<tr>
<td>Texas</td>
<td>$</td>
<td>0.014</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$</td>
</tr>
</tbody>
</table>
Net revenue with and without insurance

- Net revenue is lower when growing sorghum with insurance
- Increased costs and low likelihood of receiving indemnity payment because T-yields are low

<table>
<thead>
<tr>
<th>well capacity</th>
<th>50% T-Yield coverage</th>
<th>80% T-yield Coverage</th>
<th>no crop insurance</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPM</td>
<td>Net Revenue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>600</td>
<td>$176</td>
<td>$176</td>
<td>$164</td>
</tr>
<tr>
<td>500</td>
<td>$162</td>
<td>$162</td>
<td>$192</td>
</tr>
<tr>
<td>400</td>
<td>$148</td>
<td>$123</td>
<td>$178</td>
</tr>
</tbody>
</table>
Reasons for Low T-yields

- Sorghum as a double crop
- Limited experience with high yielding sorghum
- Sorghum is a low input crop!!!!
- It will yield something with little or no irrigation
- Poor quality land and/or low water systems used for sorghum
Questions

- Funded by:
  - USGS 104b grants
  - DASNR
Corn is King!!!!

Approximately 110,000 acres grown in Panhandle annually

Corn yields are generally double those of Grain Sorghum
- NASS, 10 year (08-98) average irrigated yield in Panhandle
  - Corn =174 bu/ac
  - Sorghum = 84 bu/ac

Corn provides higher price
- Todays cash price at Elkhart, KS
  - Corn = $3.54/bu
  - Sorghum = $2.89/bu
Sorghum has always been considered a low input, low cost alternative to Corn
- Less water, less fertilizer= “less grain”!!!

Historically, Sorghum has only been grown under very limited water situations

Research at the Oklahoma Panhandle Research and Extension Center (OPREC) has shown:
- Limited irrigation of sorghum can produce consistent yield in excess of 140 bu/acre.

Sorghum is cheaper to grow!!!
### 2011 corn and grain sorghum yields at OPREC

<table>
<thead>
<tr>
<th></th>
<th>Yield (bu/ac)</th>
<th>Irrigation Inches</th>
<th>$/inch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn†</td>
<td>150 (6.83)</td>
<td>21</td>
<td>48.79</td>
</tr>
<tr>
<td>Grain sorghum†</td>
<td>186 (6.27)</td>
<td>10</td>
<td>110.63</td>
</tr>
<tr>
<td>Grain sorghum‡</td>
<td>155 (6.27)</td>
<td>10</td>
<td>97.19</td>
</tr>
</tbody>
</table>

† Highest yielding hybrid
‡ Average of 32 hybrids
## What happens with better conditions

<table>
<thead>
<tr>
<th>Yield (bu/ac)</th>
<th>Irrigation Inches</th>
<th>$/inch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn 200 (6.83)</td>
<td>21</td>
<td>65.05</td>
</tr>
<tr>
<td>Corn 225 (6.83)</td>
<td>21</td>
<td>73.18</td>
</tr>
<tr>
<td>Corn 250 (6.83)</td>
<td>21</td>
<td>81.31</td>
</tr>
<tr>
<td>Corn 275 (6.83)</td>
<td>21</td>
<td>89.44</td>
</tr>
<tr>
<td>Year</td>
<td>Max Corn ---bu/ac---</td>
<td>Ave Corn inches</td>
</tr>
<tr>
<td>------</td>
<td>----------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>2014</td>
<td>266</td>
<td>18</td>
</tr>
<tr>
<td>2013</td>
<td>278</td>
<td>26</td>
</tr>
<tr>
<td>2012</td>
<td>288</td>
<td>26</td>
</tr>
<tr>
<td><strong>2011</strong></td>
<td><strong>150</strong></td>
<td><strong>21</strong></td>
</tr>
<tr>
<td>2010</td>
<td>232</td>
<td>18</td>
</tr>
<tr>
<td>2009</td>
<td>255</td>
<td>21</td>
</tr>
<tr>
<td>2008</td>
<td>273</td>
<td>21</td>
</tr>
<tr>
<td>2007</td>
<td>214</td>
<td>20</td>
</tr>
<tr>
<td>2006</td>
<td>215</td>
<td>20</td>
</tr>
<tr>
<td>2005</td>
<td>220</td>
<td>17</td>
</tr>
<tr>
<td><strong>Average</strong>=</td>
<td><strong>239</strong></td>
<td><strong>200</strong></td>
</tr>
<tr>
<td>bu/in=</td>
<td>12 ($4.48)</td>
<td>10 ($4.48)</td>
</tr>
<tr>
<td>$/in</td>
<td>$54</td>
<td>$45</td>
</tr>
</tbody>
</table>
Relationship between Yield and Irrigation

Yield (bu/ac) vs. Irrigation (inch)

- Corn: $y = 7.0596x + 83.335$, $R^2 = 0.5998$
- Sorghum: $y = 4.9616x + 96.994$, $R^2 = 0.0889$
We have a dilemma

- Corn is more profitable per acre because with sufficient inputs yields are higher
- “UNLESS” water is limited?????
- At what point does Sorghum become advantageous?????
- What if Net Present Value of future production is consider instead of short term profit maximization
- Will value of water prevail??????
Project Goals

- Develop Production Functions providing a relationship between irrigation capacity and yield
  - Jordan Gatlin’s Thesis and current field studies
- Determine comparative advantages of irrigated corn relative to sorghum
  - EPIC Crop Model Simulations
  - Maximization of short term profit as a function of well capacity
  - How can producers gain the maximum value from the water remaining in Ogallala
50 year simulations: Yield vs Irrigation Capacity

Different lines represent irrigation being triggered at 90-30% soil water holding capacity.

Triggering irrigation at lower water contents increases efficiency but decreases average yield.
Grain Prices used:
Corn= $4.48
Sorghum= $4:16
Irrigation capacity per acre can be managed by diverting water and irrigating less of a pivot.

How do we maximize value of water???????
Sorghum Provides greater revenue per inch of water
Suggests that Net Present Value will be maximized but production of sorghum
Why is Sorghum Revenue higher per inch???

- Seed is cheaper
- Sorghum uses less irrigation water per bushel
  - Sorghum growing season coincides with rainy season!!!
Sorghum provides a shorter season that start during a wetter period
Peak ET is lower as well
Temps are declining during grain fill and senesce
Example for a Single Pivot

5 GPM/acre initial well capacity
Surrounding area Fully or 50 % Irrigated

Prices

<table>
<thead>
<tr>
<th></th>
<th>Corn</th>
<th>Sorghum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>$4.48/bu</td>
<td>$4.16/bu</td>
</tr>
</tbody>
</table>

Disc Rate 4%

Center Pivot 120 acres @ $60,100, 15 year life, 85%ef

Evaluate 2 Business strategies:

-BSYC: Select crop & irrigation that maximizes current return to acre

-MNPV: Select crop & irrigation to maximize discounted 15 year profits
BSYC: Select crop & irrigation that maximizes current return to acre

MNPV: Select crop & irrigation to maximize discounted 15 year profits
**BSYC:** Select crop & irrigation that maximizes current return to acre

**MNPV:** Select crop & irrigation to maximize discounted 15 year profits

Well Capacity drops to below 5 gpm/acre

Profits are maximized by GS production as a result of extending aquifer life and maintaining irrigated sorghum yields.
Simulations of 50 years of weather data combined with economic analysis suggests that at irrigation capacities below 5 gpm/acre sorghum favored.

Long-term Net Profit Maximization is favored by production of sorghum.

However, this will require collective action.
Current Policies require producers take a Short-term maximization approach

Use or Loose it!!!!!!!

Also, rental agreements, government programs and crop insurance are all on a per acre basis

Need to redevelop our thinking and policy to a per inch basis.
A collective decision by producers in the panhandle to conserve water through the production or grain sorghum will maximize net present value

- How does this influence land value???
- How should it influence rental rates?

Can cost share programs to increase system efficiency include requirements to grow more efficient crops?
Current Efforts

- Inclusion of wheat in the analysis.
- Evaluate the impact of declining irrigation capacity on yield stability and its potential impact of insurance premiums.
Questions

- Funded by:
  - USGS 104b grants
  - DASNR