OPTIMIZING ECONOMIC VALUE OF WATER FROM OGALLALA AQUIFER USED FOR IRRIGATION

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OKLAHOMA STATE UNIVERSITY EXTENSION

Oklahoma Water Resources Center

Statement of Problem

- 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

	Acres irrigated
Corn	106236 (46%)
Wheat	67713(29%)
Sorghum	19457(8%)
forage	24005(10%)

- An increasing number of producers are experiencing declines in irrigation capacity

Fundamental Questions

- 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 capacities decline?
- How can economic value of water remaining be optimized

Project History

- 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

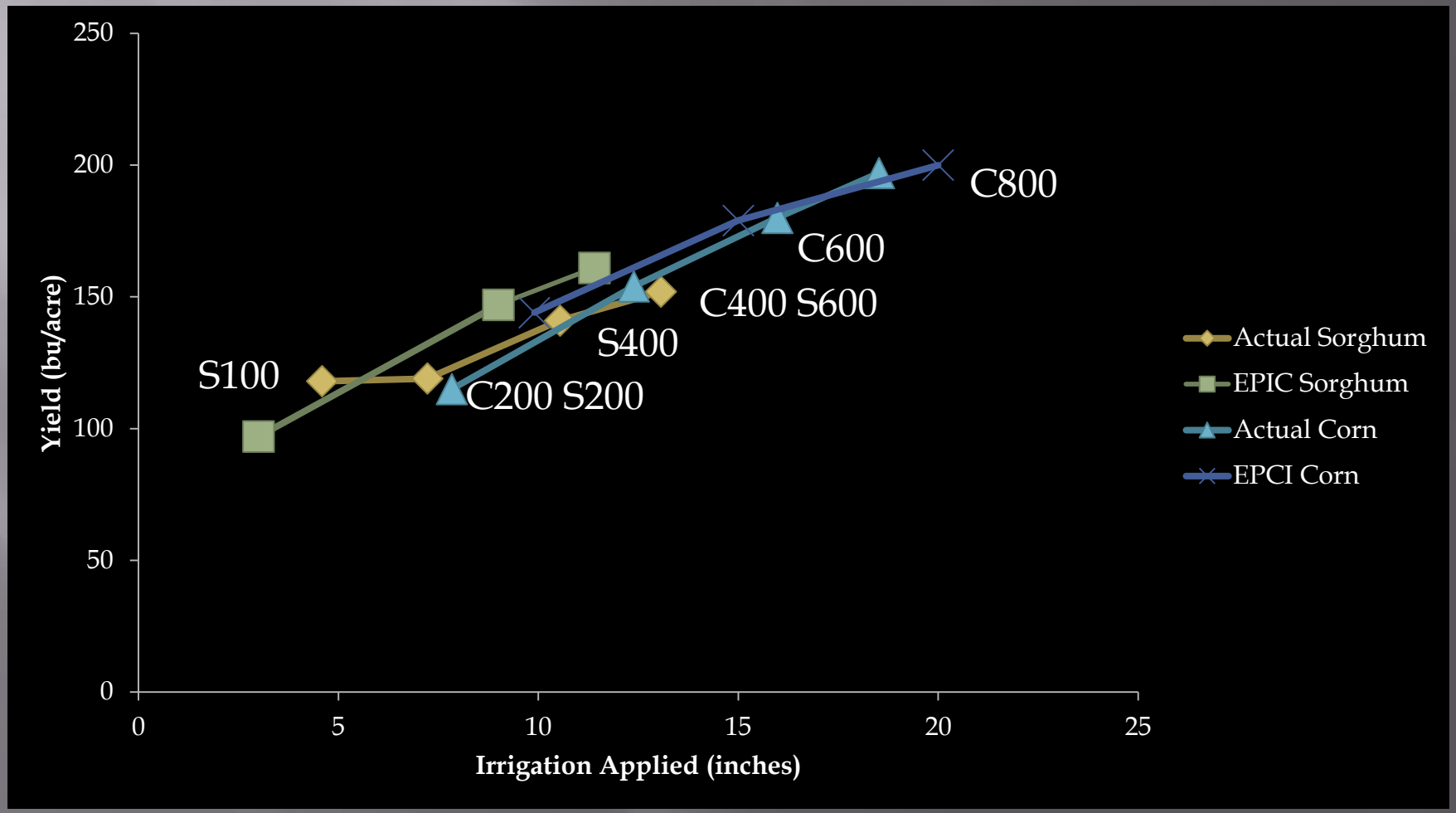
Short-term Impact

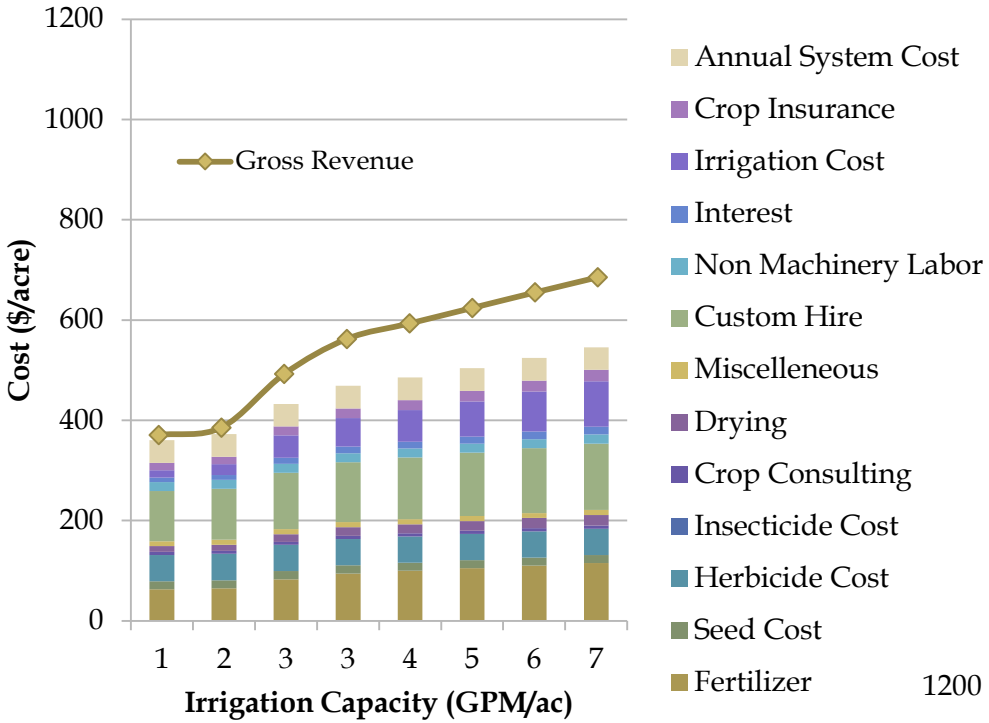
- Oklahoma State University is now regional recognized as a valuable partner in irrigation research and extension
- Producers throughout the State are engages in discussions to work towards improved efficiencies

2015 Efforts

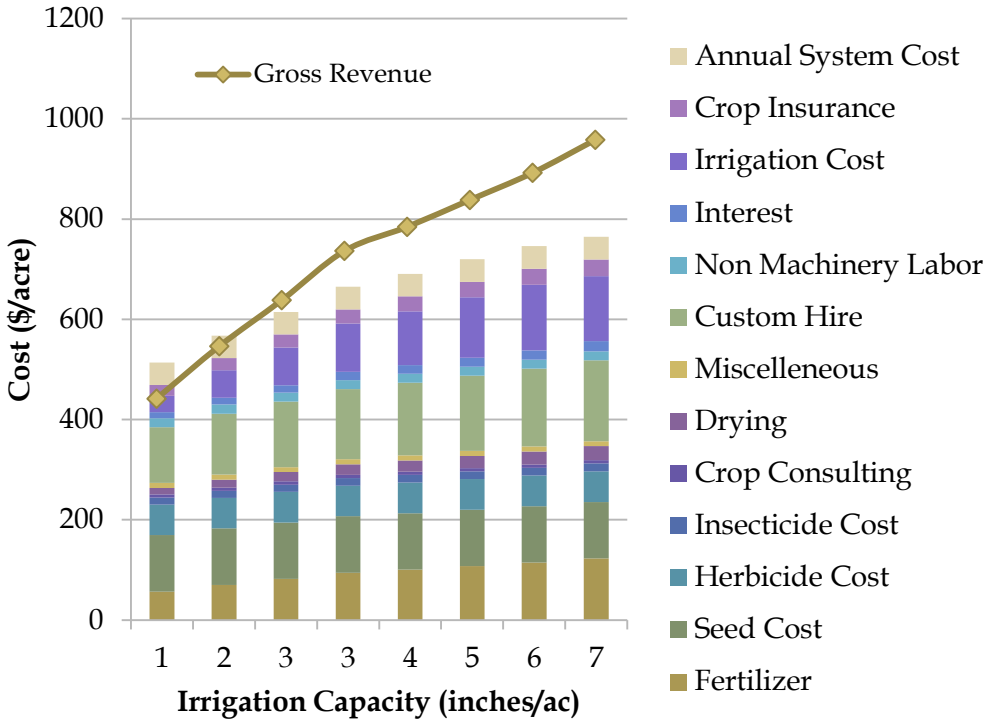
- Sorghum-Corn-wheat rotation evaluated at well capacities of 800-100 gal/min
  - Included wheat as a off season rotational crop
- Crop insurance issues was evaluated
- Discussions with producers indicated that lack of valuable coverage for sorghum prevented planting

3-Year Average Yield and Irrigation vs Simulated Results

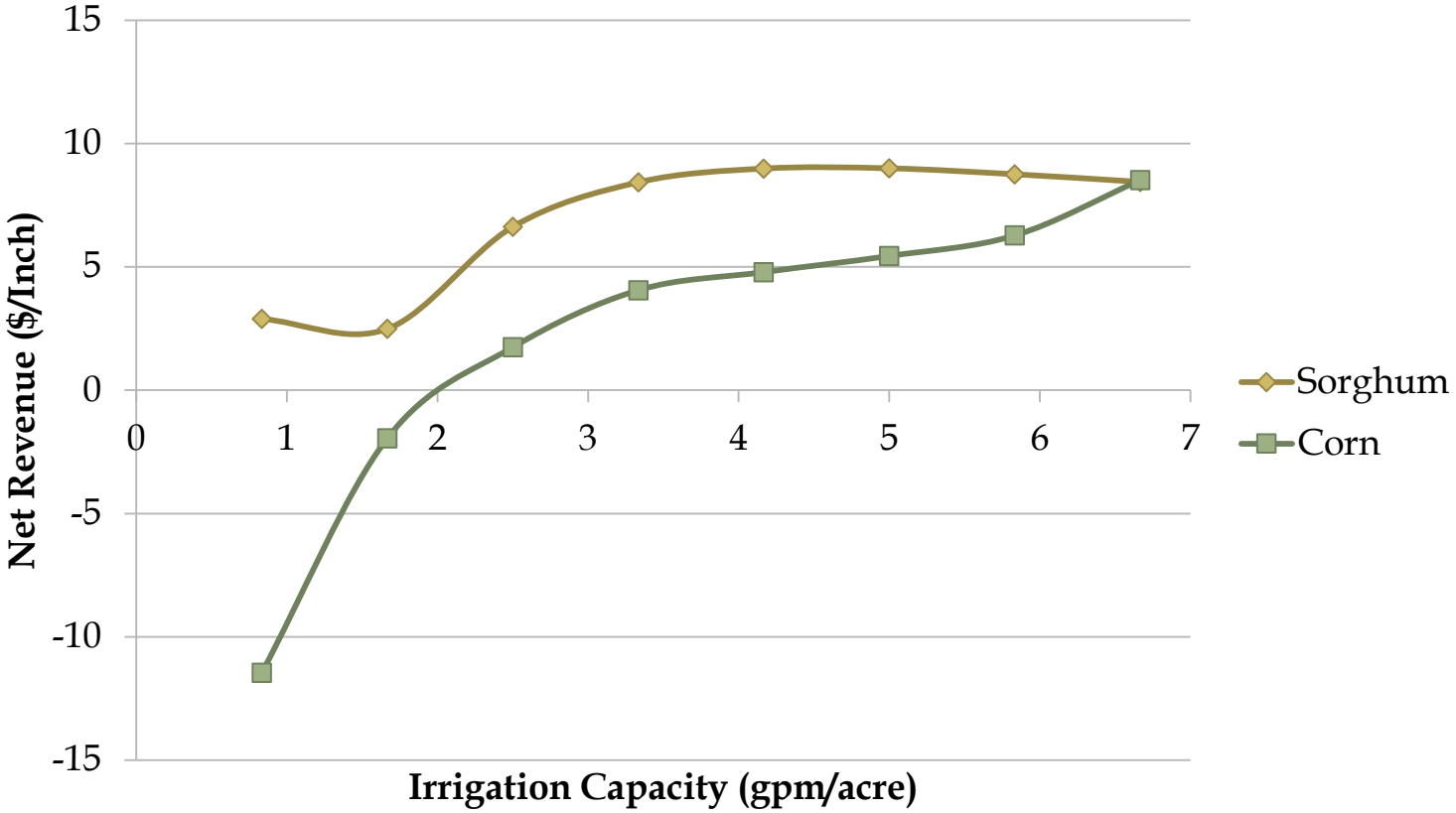




Grain Prices used:
Corn= $4.48
Sorghum= $4:16



Net Revenue per Inch of Irrigation

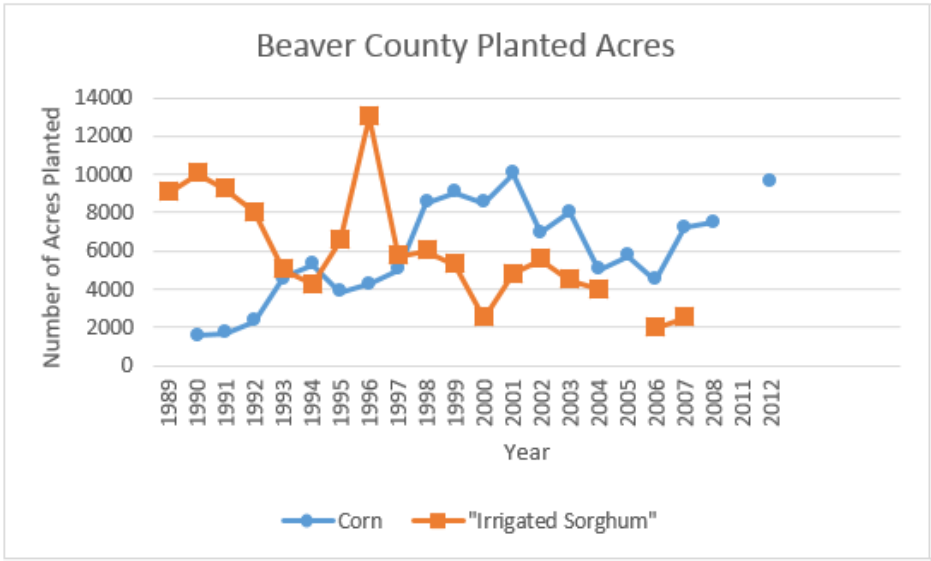


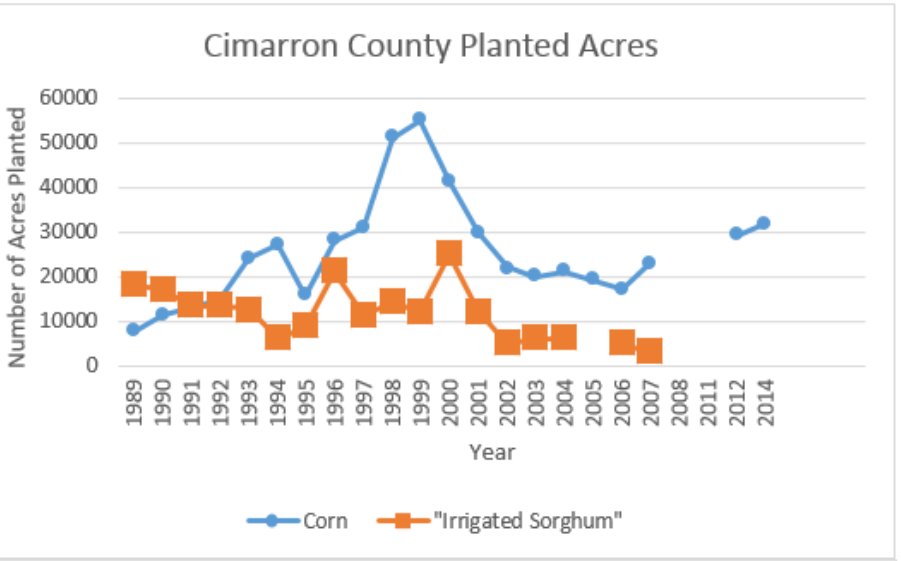
Sorghum Provides greater revenue per inch of water
Suggests that Net Present Value will be maximized but production of sorghum

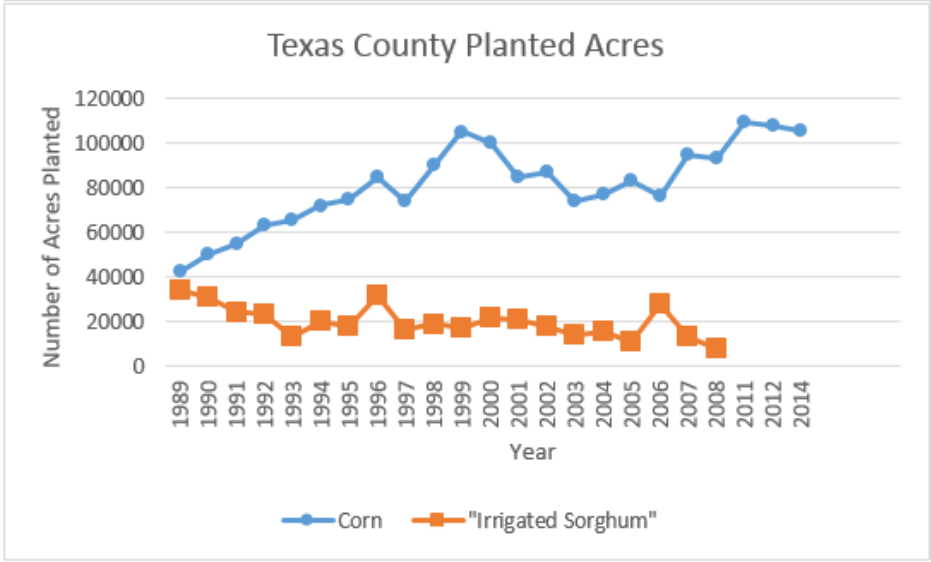
Crop Insurance and Yield History

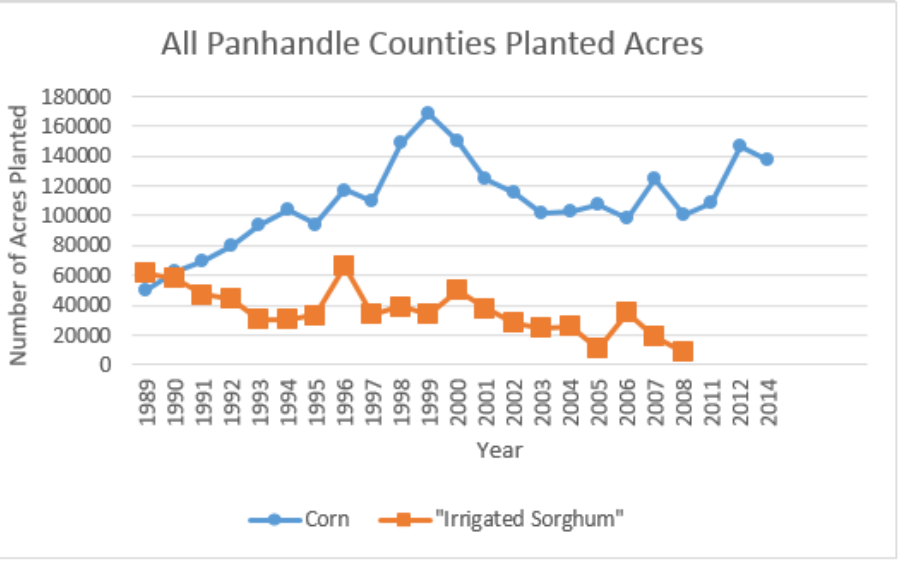
- Crop Insurance cost and coverage is based on County average yields or proven farm yields
- Therefore, Long-term production of high yielding crops at the county or farm level will provide better economic risk management

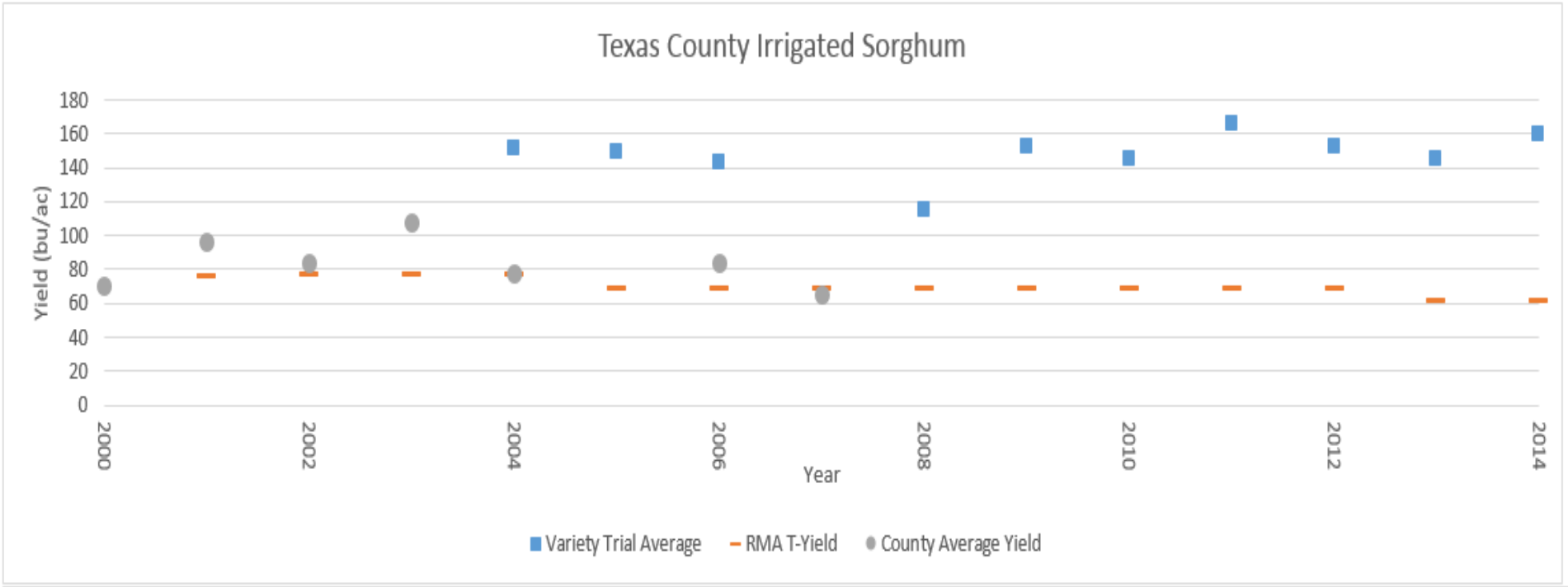
Planted Acres

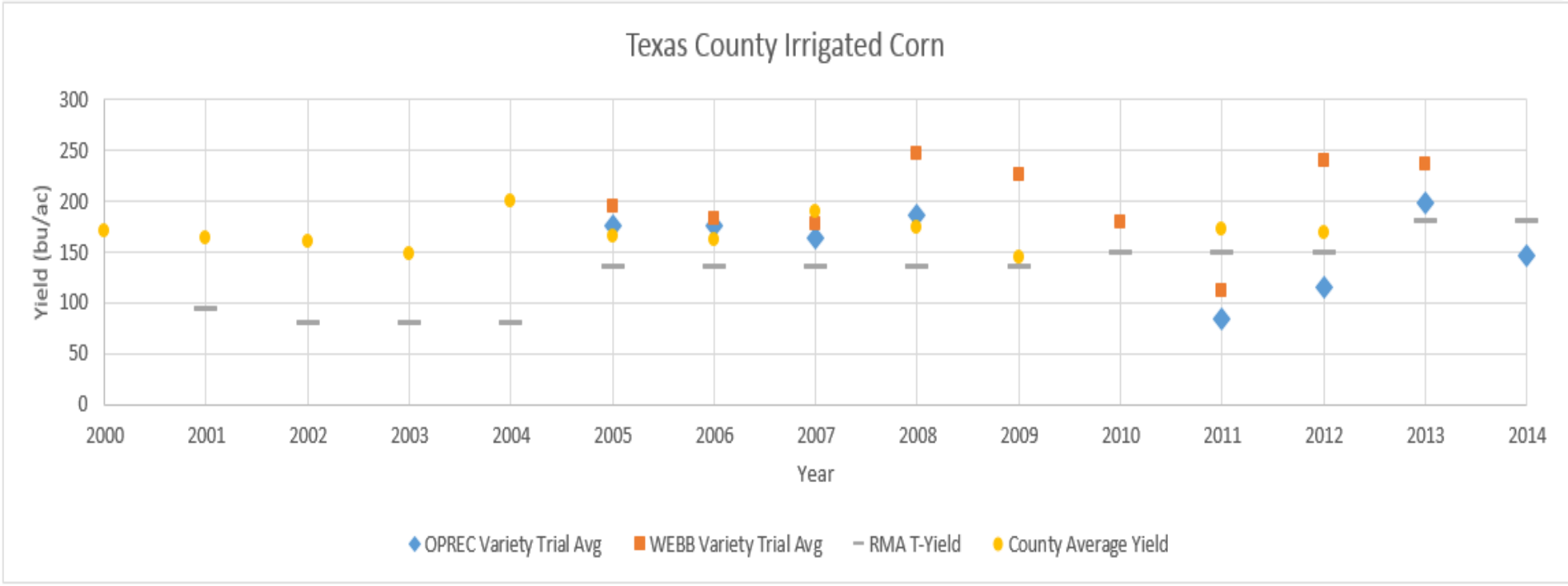









Texas County Irrigated Sorghum
Yield (bu/ac)
180
160
140
120
100
80
60
40
20
0
2000
2002
2004
2006
2008
2010
2012
2014
Year
Variety Trial Average
RMA T-Yield
County Average Yield


Texas County Irrigated Corn
Yield (bu/ac)
300
250
200
150
100
50
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Year
OPREC Variety Trial Avg
WEBB Variety Trial Avg
RMA T-Yield
County Average Yield

Historic Crop Insurance indemnity Payments

- More corn policies are paid compared to sorghum

	Beaver County						
	Mean	95% CL	Mean	Std Dev	95% CL	Std Dev	t Value
Yield Protection	0.0875	-0.2014	0.3764	0.1815	0.1028	0.6769	0.96
Revenue Protection	-0.085	-0.2023	0.0323	0.0737	0.0418	0.2748	-2.31
Crop Revenue Coverage	0.0543	-0.0526	0.1612	0.1851	0.1342	0.2982	1.1
Actual Production History	0.0994	0.0168	0.182	0.1607	0.1197	0.2445	2.55

	Cimarron County						
	Mean	95% CL	Mean	Std Dev	95% CL	Std Dev	t Value
Yield Protection	0.154	0.0309	0.2771	0.0991	0.0594	0.2849	3.47
Revenue Protection	0.092	-0.045	0.229	0.1103	0.0661	0.317	1.86
Crop Revenue Coverage	-0.0879	-0.1746	-0.0011	0.1503	0.109	0.2421	-2.19
Actual Production History	-0.04	-0.0976	0.0176	0.1298	0.0999	0.1855	-1.45

	Texas County						
	Mean	95% CL	Mean	Std Dev	95% CL	Std Dev	t Value
Yield Protection	0.292	0.1887	0.3953	0.0832	0.0498	0.239	7.85
Crop Revenue Coverage	0.19	0.1181	0.2619	0.1245	0.0902	0.2005	5.71
Actual Production History	0.2067	0.1736	0.2398	0.0727	0.0556	0.105	13.03

Price of Crop Insurance

	Base County Rate at 65% Coverage Level Cost Per Bushel Insured	
	Irrigated Corn	Irrigated Grain Sorghum
Beaver	$ 0.013	$ 0.071
Cimarron	$ 0.014	$ 0.080
Texas	$ 0.014	$ 0.065

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

well capacity	50% T-Yield coverage	80% T-yield Coverage	no crop insurance
GPM	----------Net Revenue----------		
600	$176	$176	$164
500	$162	$162	$192
400	$148	$123	$178

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

Why not Grain Sorghum

- 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

Why are we looking at Sorghum

- 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

	Yield (bu/ac)	Irrigation Inches	$/inch
Corn†	150 (6.83)	21	48.79
Grain sorghum†	186 (6.27)	10	110.63
Grain sorghum‡	155 (6.27)	10	97.19

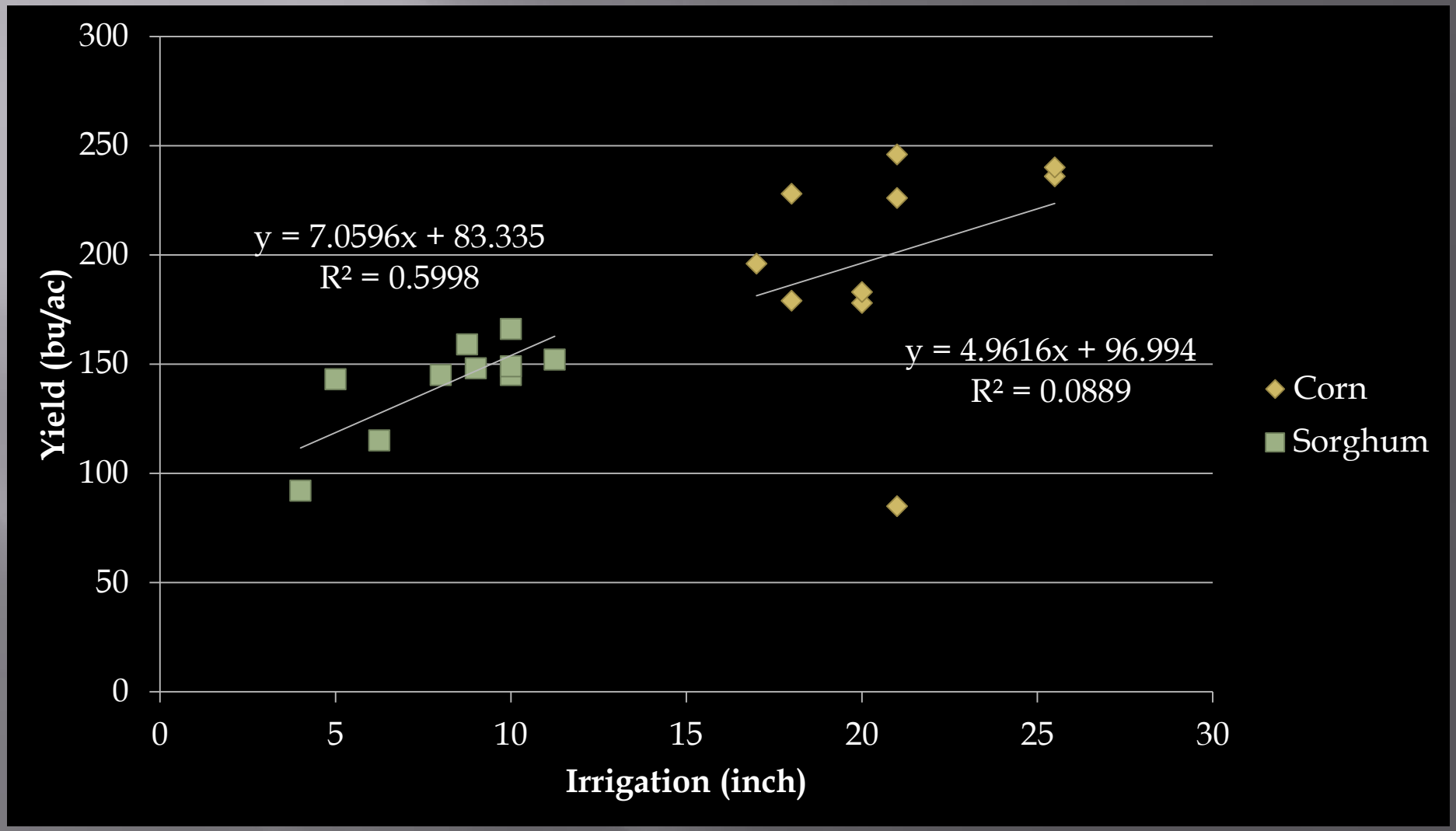
† Highest yielding hybrid
‡ Average of 32 hybrids

What happens with better conditions

	Yield (bu/ac)	Irrigation Inches	$/inch
Corn	200 (6.83)	21	65.05
Corn	225 (6.83)	21	73.18
Corn	250 (6.83)	21	81.31
Corn	275 (6.83)	21	89.44

Year	Corn			Sorghum		
	Max	Ave.	Irr.	Max	Ave.	Irr.
	---bu/ac---		inches	---bu/ac---		inches
2014	266	228	18	177	159	9
2013	278	236	26	164	145	10
2012	288	240	26	174	152	11
2011	**150**	**85**	**21**	**186**	**166**	**10**
2010	232	179	18	159	145	8
2009	255	226	21	169	148	9
2008	273	246	21	125	115	6
2007	214	178	20	102	92	4
2006	215	183	20	151	143	5
2005	220	196	17	158	149	10
Average=	239	200	21	157	141	8
bu/in=	**12 ($4.48)**	**10 ($4.48)**		**19 ($4.16)**	**17 ($4.16)**	
$/in	**$54**	**$45**		**$79**	**$71**	

Relationship between Yield and Irrigation



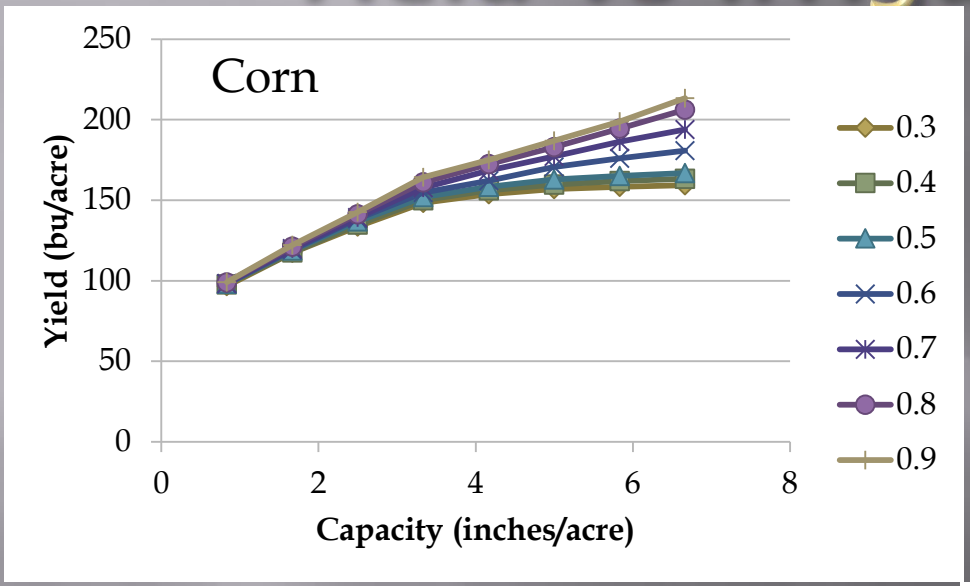
We have a dilemma

- 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

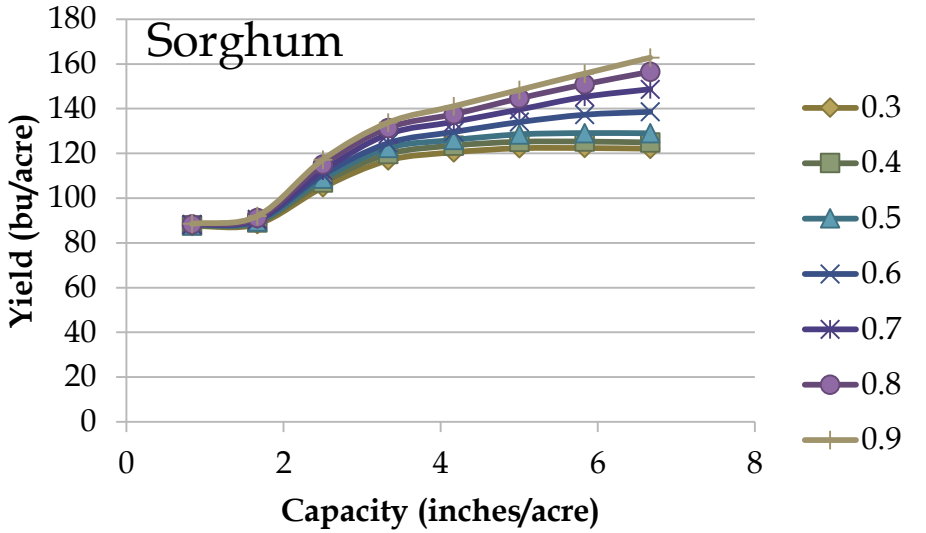
- Develop Production Functions providing a relationship between irrigation capacity and yield
  - Jordan Gatlin's Thesis and current field studies
- Determine comparative advantages of irrigated corn relative to sorghum
  - EPIC Crop Model Simulations
  - Maximization of short term profit as a function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

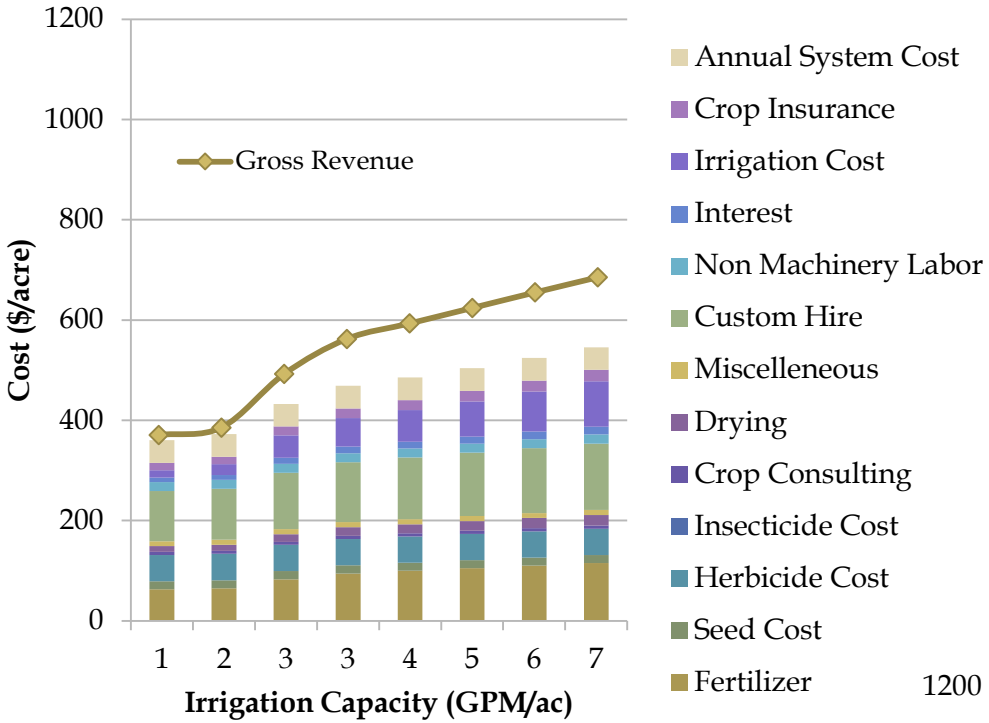
50 year simulations: Yield vs Irrigation Capacity



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

Triggering irrigation at lower water contents increases efficiency but decreased average yield





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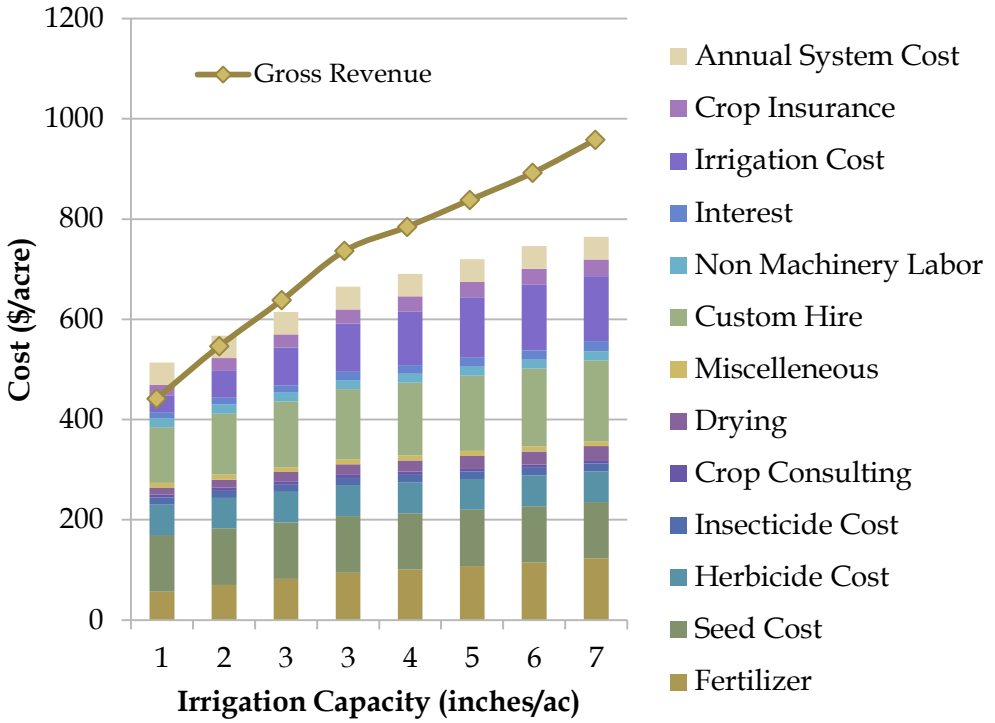
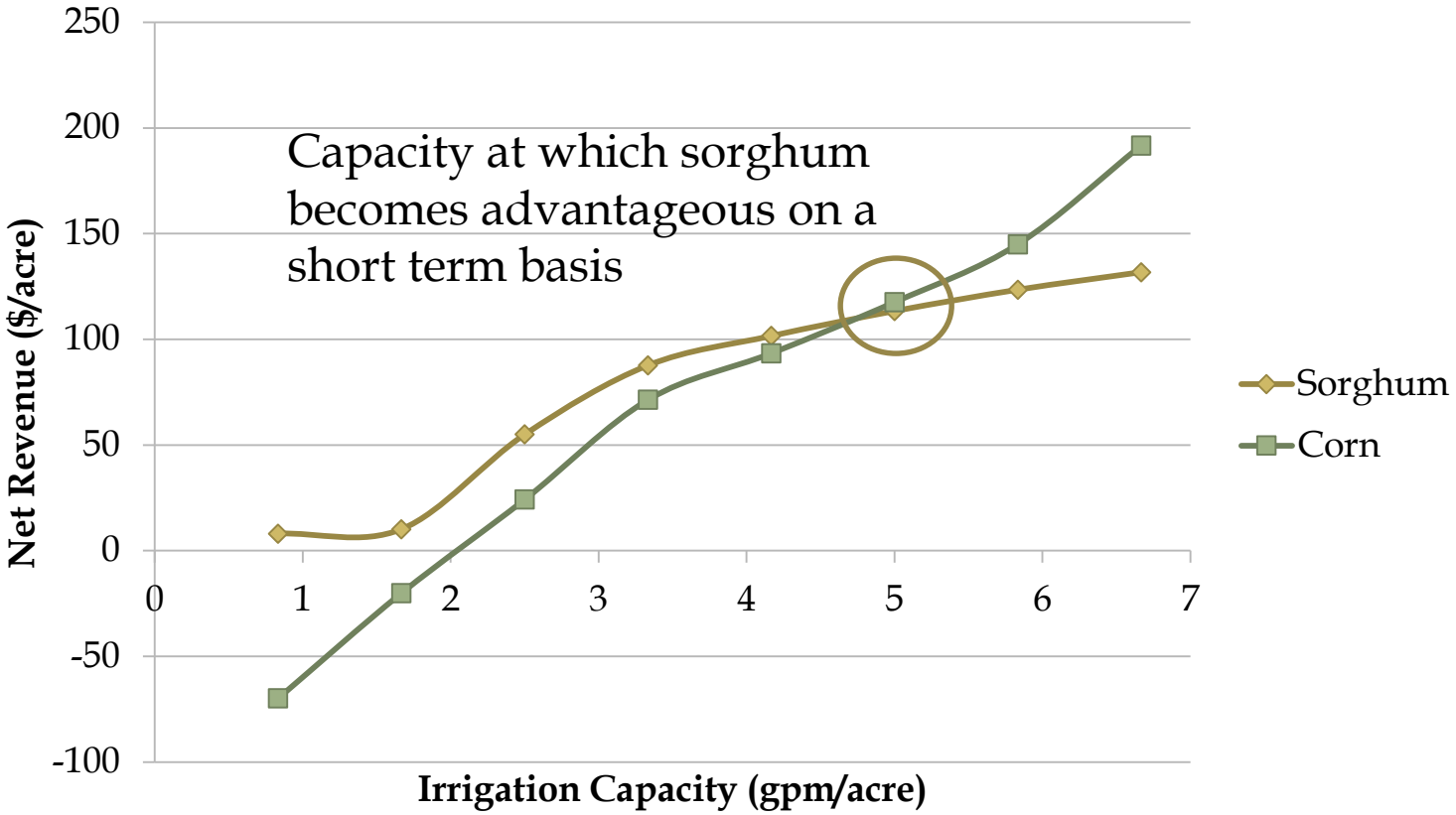


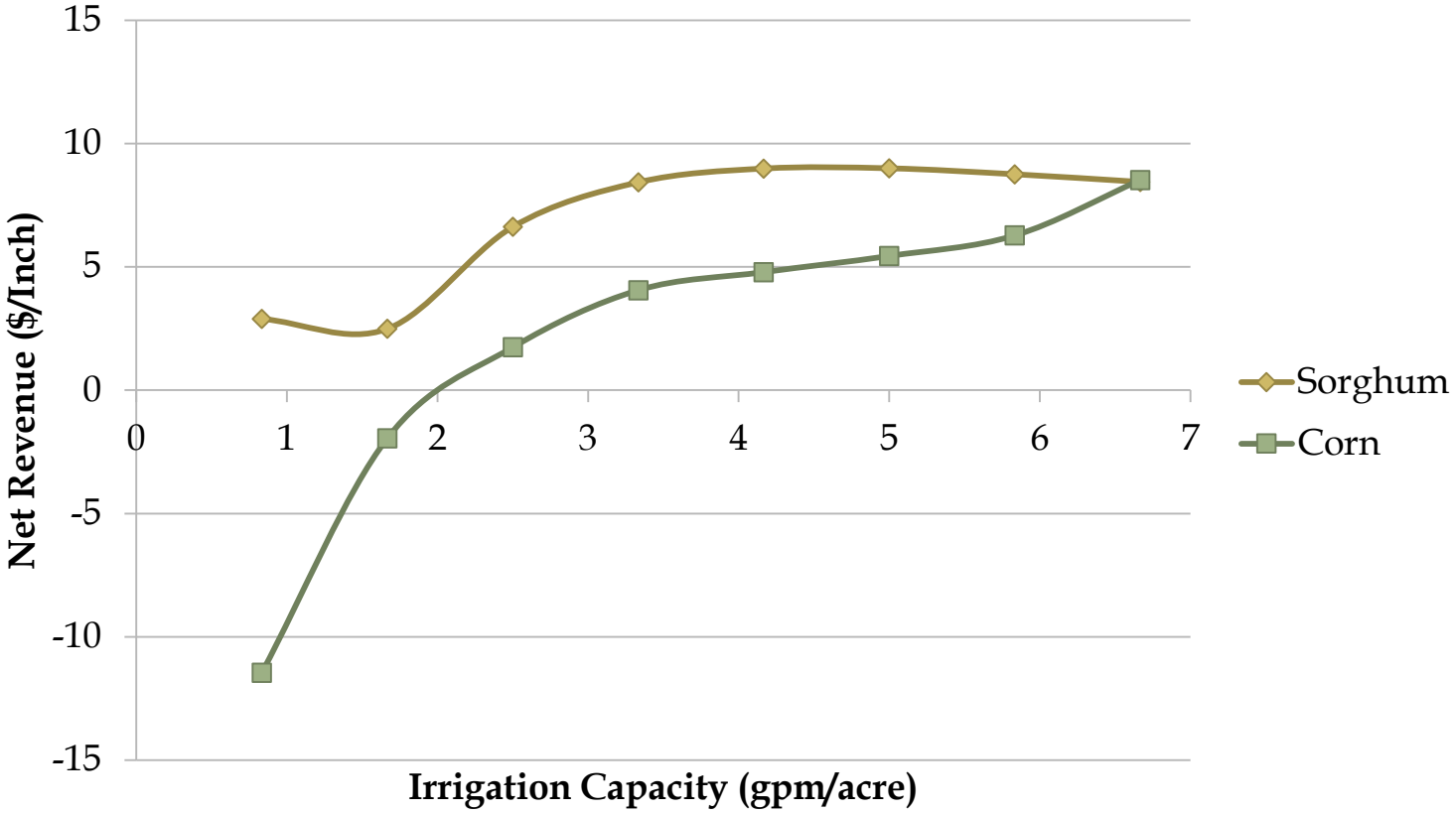
Net Revenue per Acre



Irrigation capacity per acre can be managed by diverting water and irrigating less of a pivot

How do we maximize value of water??????

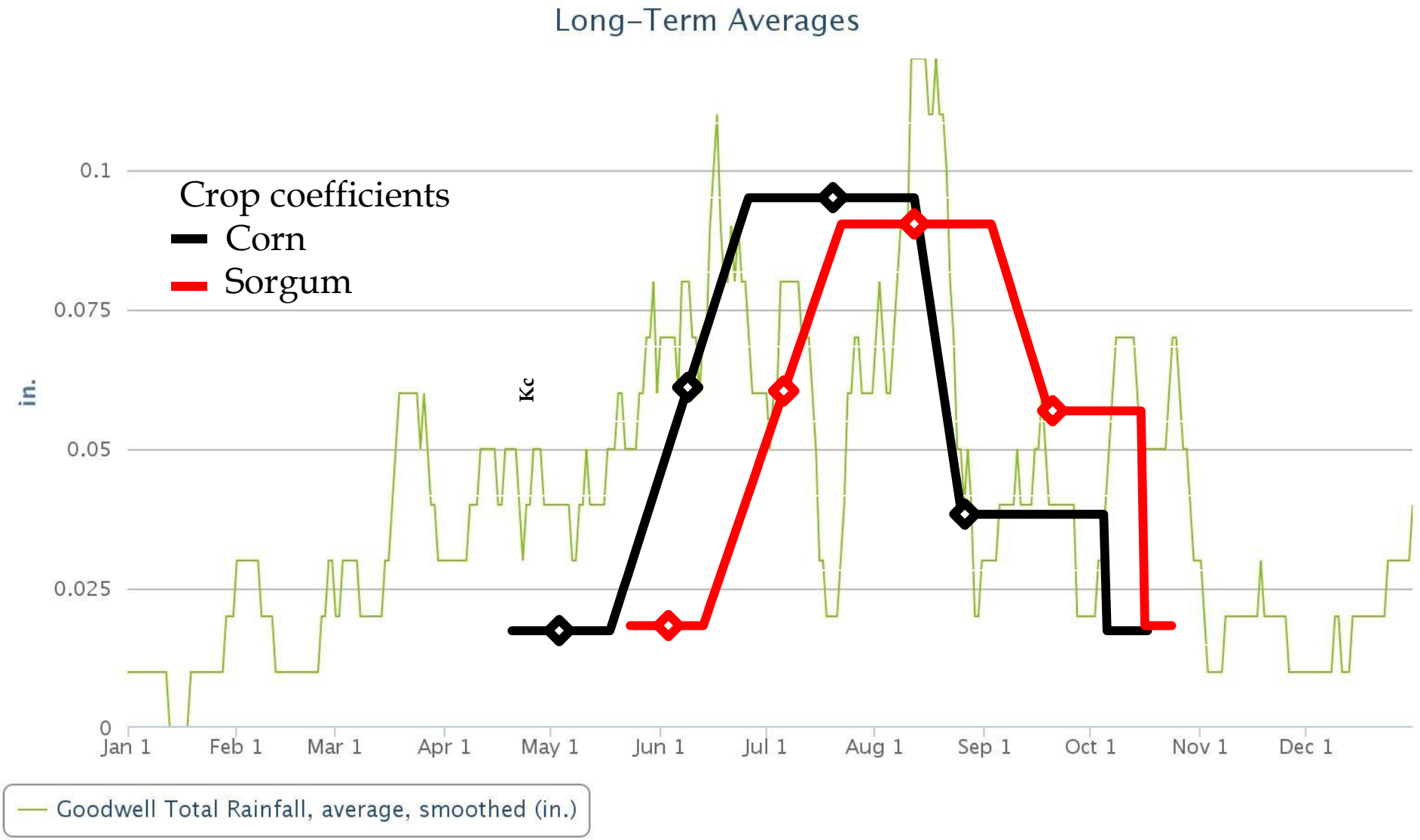
Net Revenue per Inch of Irrigation



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

	Corn	Sorghum
Price	$4.48/bu	$4.16/bu

Disc Rate 4%

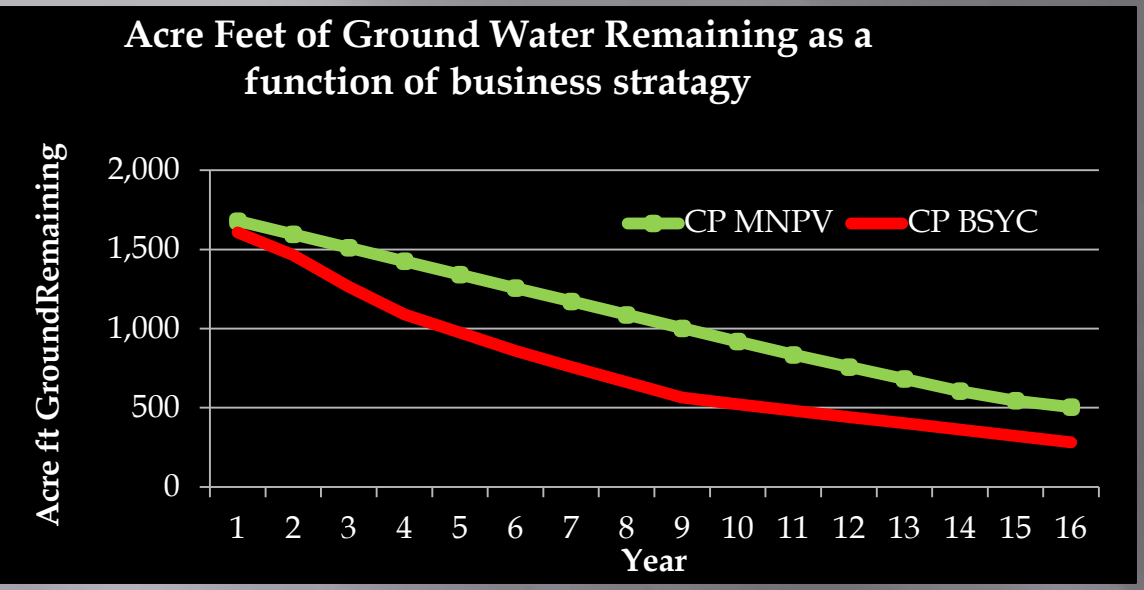
Center Pivot 120 acres @ $60,100, 15 year life, 85%ef

Evaluate 2 Business strategies:

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

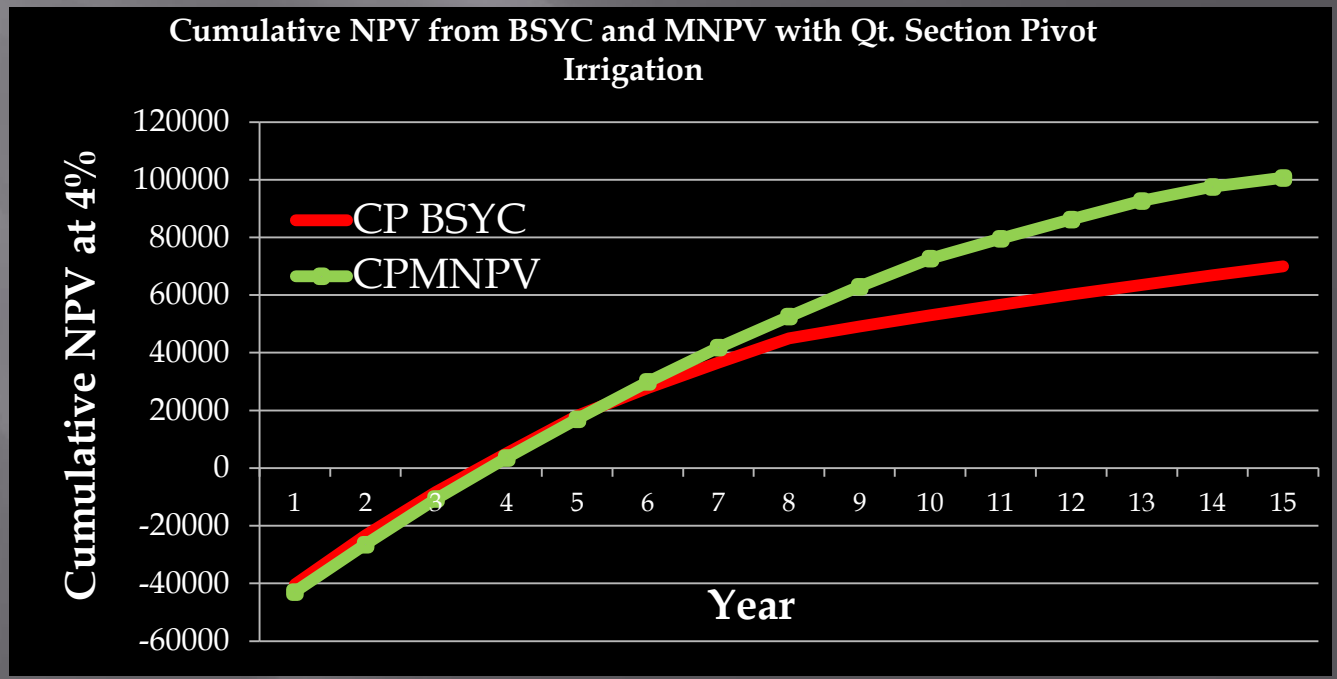
-MNPV: Select crop & irrigation to maximize discounted 15 year profits

BSYC & MNPV Strategies for 160 Acres with C.Pivot & Limited Groundwater



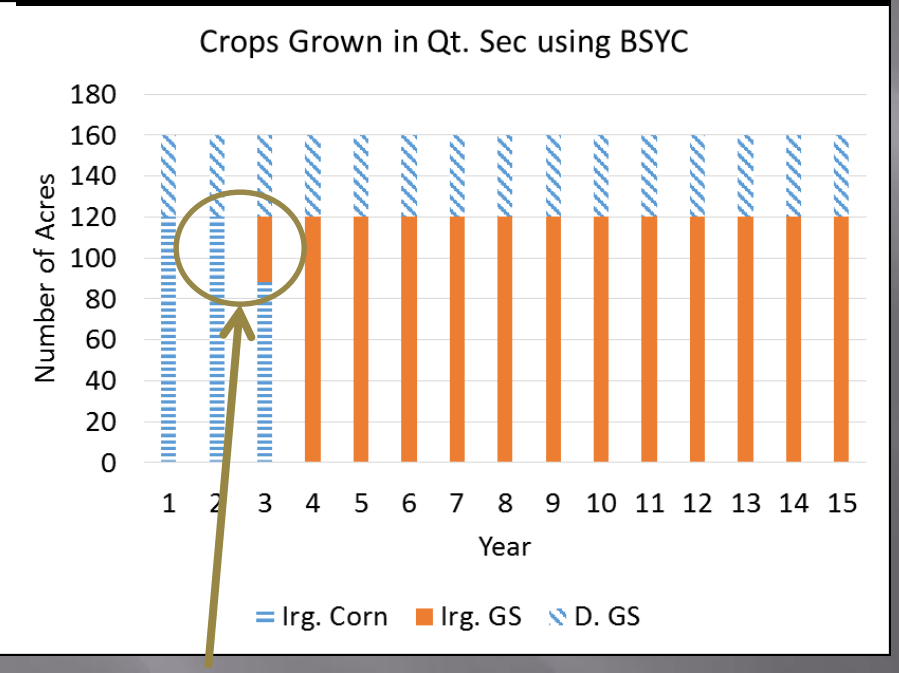
BSYC: Select crop & irrigation that maximizes current return to acre

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



Crop Selection

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



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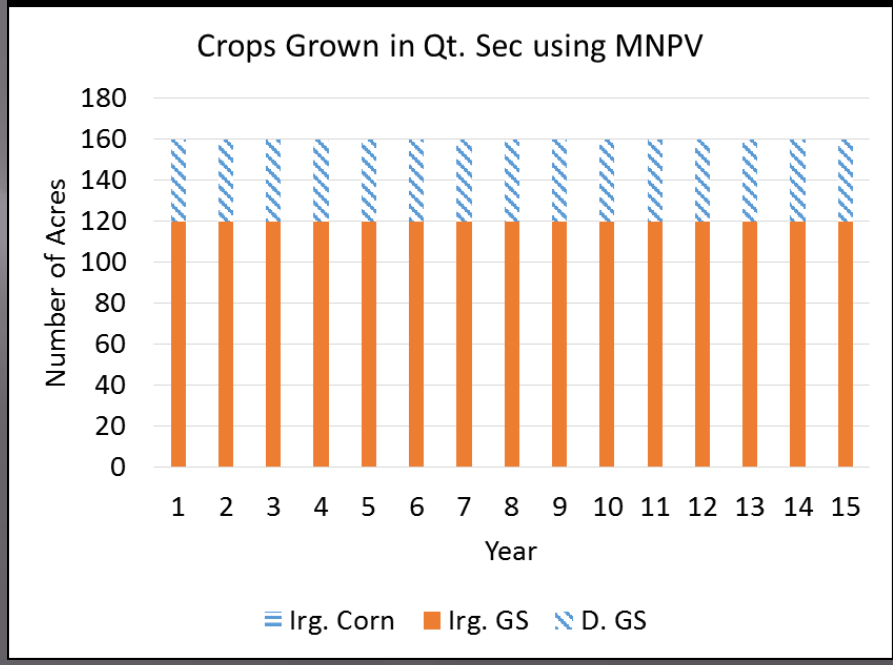

Well Capacity drops to below 5 gpm/acre

Profits are maximized by GS production as a result of extending aquifer life and maintaining irrigated sorghum yields

Summary

- Simulations of 50 years of wheather 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

Summary

- 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.

Implications

- 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