Managing with Limited Well Capacity

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K-STATE Research and Extension

Knowledge for Life

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

Shooting for top end, but I can also hide a lot of mistakes with water

Effects on
- Yield Potential
- Inputs
- Water Management Strategy
- Economics

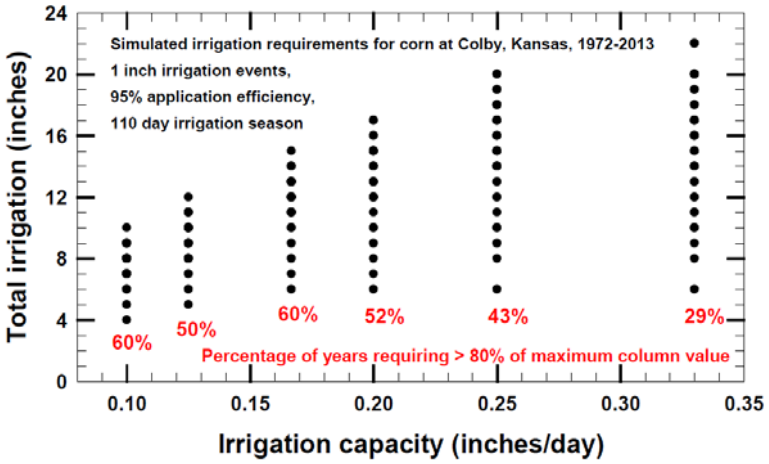
"If only I could time 1 good rain"

What drives how we can respond to declining well capacity

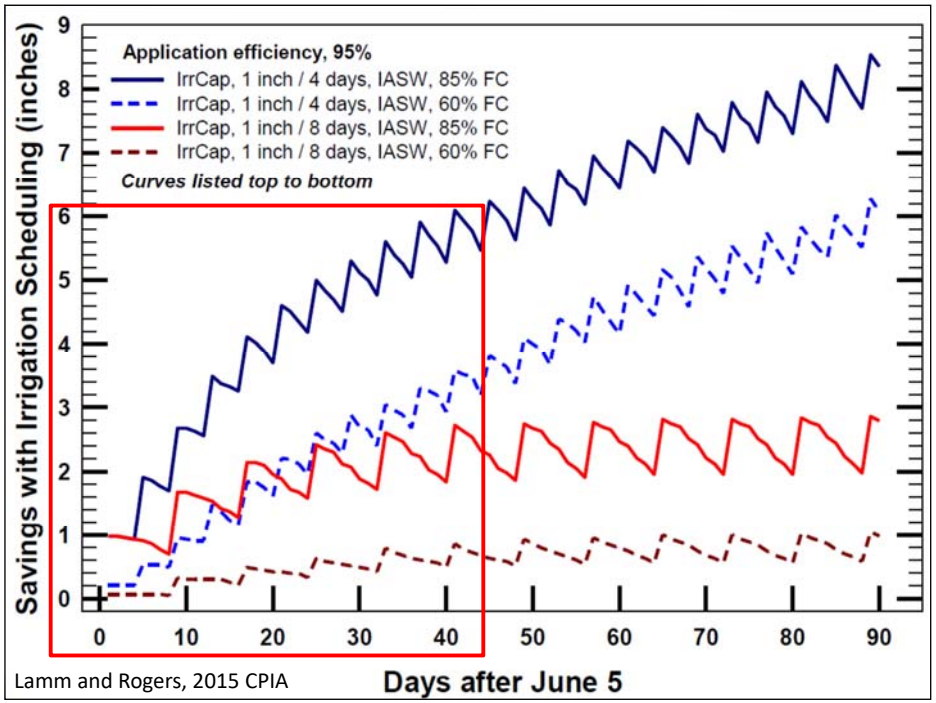
- Soil Texture and Depth
  - Margin of error
  - Efficiency of preseason
- Flexibility in moving water
  - Multiple wells tied to multiple sprinklers vs. one well one sprinkler

Basics Still Matter
Irrigation Scheduling

Irrigation Scheduling Relevant at any Well Capacity



Lamm and Rogers, 2015 CPIA



Lamm and Rogers, 2015 CPIA

Year	Date of Anthesis	Date of Maturity	Irrigation Season Termination Date For		
			80% Max Yield	90% Max Yield	MaxYield
1993	20-Jul	30-Sep	5-Aug	5-Aug	15-Aug
1994	20-Jul	15-Sep	5-Aug	15-Aug	15-Aug
1995	20-Jul	29-Sep	5-Aug	13-Aug	18-Aug
1996	20-Jul	3-Oct	17-Jul	17-Jul	29-Aug
1997	23-Jul	1-Oct	23-Jul	23-Jul	27-Aug
1998	20-Jul	28-Sep	20-Jul	20-Jul	24-Aug
1999	23-Jul	6-Oct	24-Jul	13-Aug	20-Sep
2000	12-Jul	20-Sep	14-Sep	20-Sep	20-Sep
2001	16-Jul	29-Sep	30-Jul	22-Sep	22-Sep
2002	22-Jul	30-Sep	4-Aug	30-Aug	7-Sep
2003	22-Jul	23-Sep	3-Aug	3-Aug	18-Aug
2004	19-Jul	28-Sep	8-Aug	21-Aug	27-Aug
2005	20-Jul	28-Sep	2-Aug	9-Aug	29-Aug
2006	17-Jul	25-Sep	30-Jul	13-Aug	13-Aug
2007	18-Jul	19-Sep	14-Aug	21-Aug	28-Aug
2008	24-Jul	10-Oct	31-Jul	6-Aug	27-Aug
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.*

Irrigation Termination

Stage of Growth	Approximate number of days to maturity	Water use to maturity (inches)
Corn		
Blister	45	10.5
Dough	34	7.5
Beginning dent	24	5
Full dent	13	2.5
Black layer	0	0
Grain Sorghum		
Mid bloom	34	9
Soft dough	23	5
Hard dough	12	2
Black layer	0	0
Dry Beans		
One pod w/fully developed seeds	35	7.0
50% pods have full developed seeds	25	4.2
One pod changed to mature color	15	2.0
80% of pods changed to mature color	0	0

Adapted from K-State MF2174, Rogers and Sothers and High Plains Dry Bean Guide

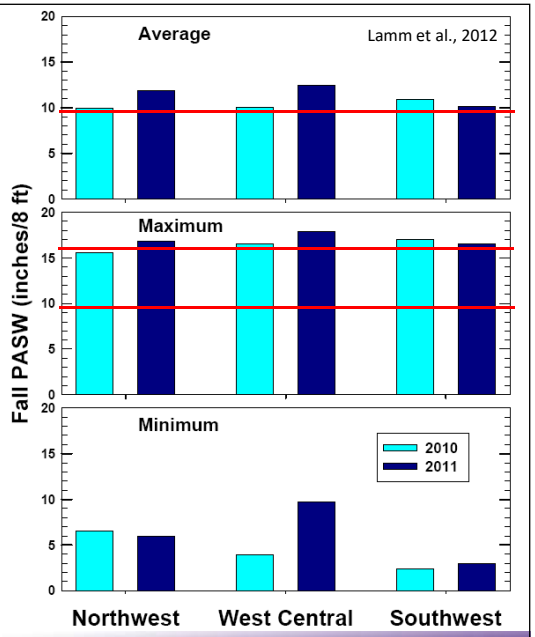
Timing of the final irrigation:

- 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

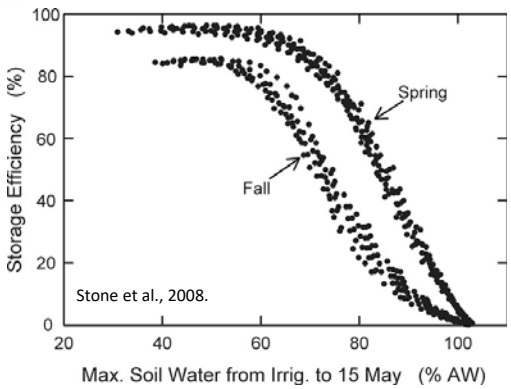
In an 8' profile, 60% available soil water would be approximately 9.6" in a Western Kansas silt-loam soil

Storage efficiency of additional water approaches zero at 100% ASW, or 16" in this case



Water Loss to Drainage

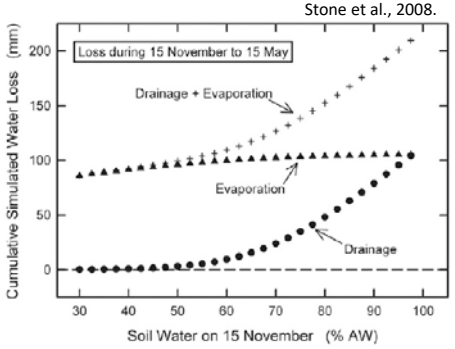
If the profile is at or above 60% full the storage efficiency of fall or spring precipitation or preseason irrigation diminishes rapidly

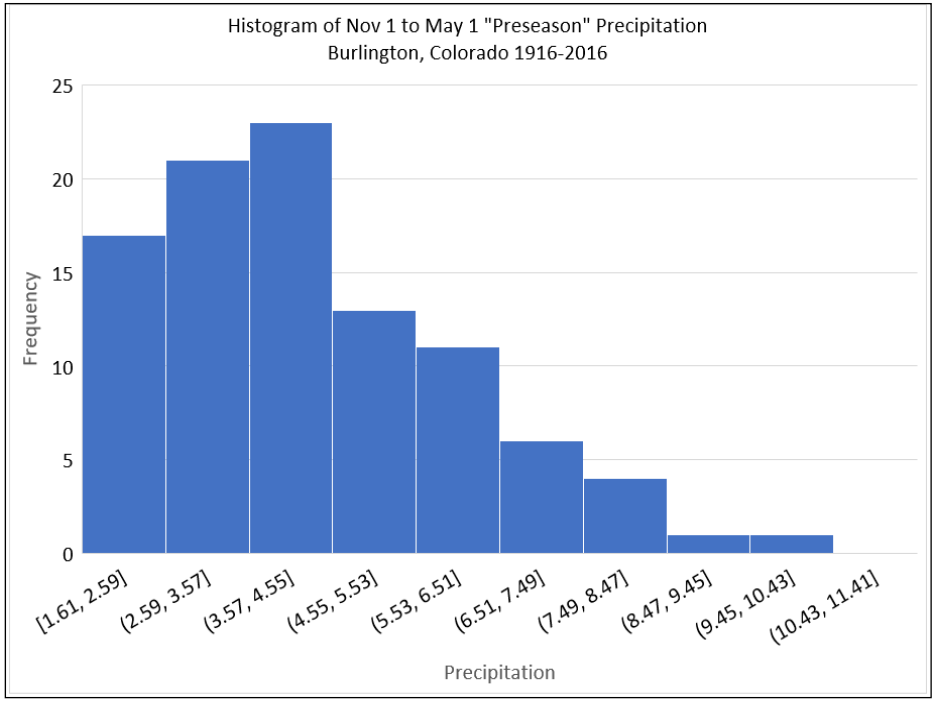


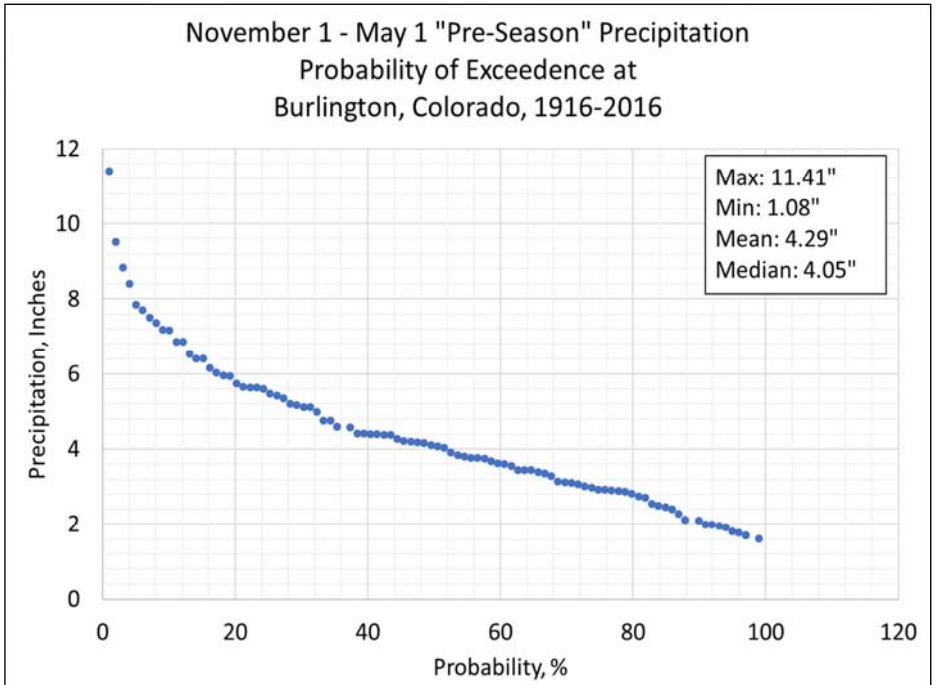
Potential Water Loss

- 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

Stone et al., 2008.







Preseason Irrigation – When?

- Tradeoffs
  - Fall preseason is less efficient, especially if you don't leave room for precipitation, lets 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
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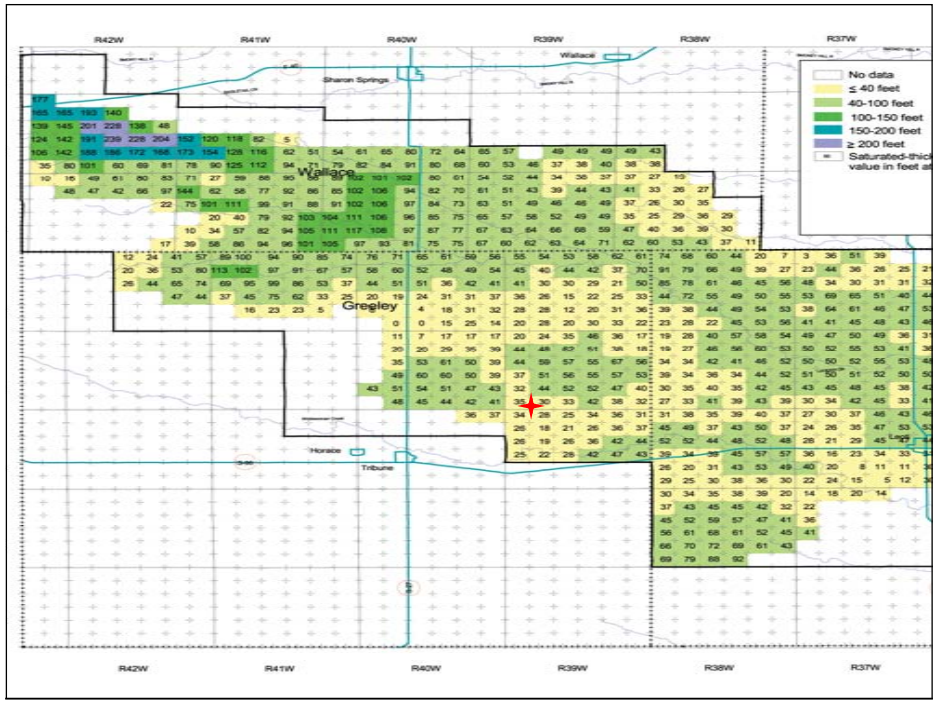
Knowledge for Life



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.

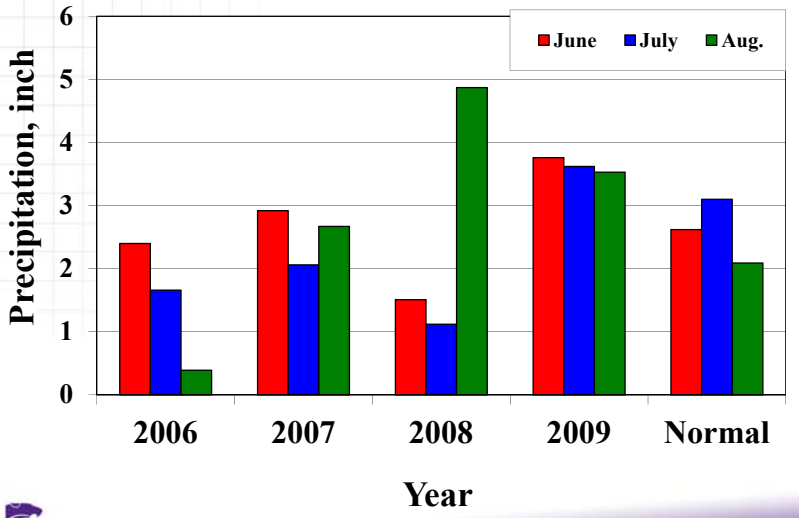
Treatments

- 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

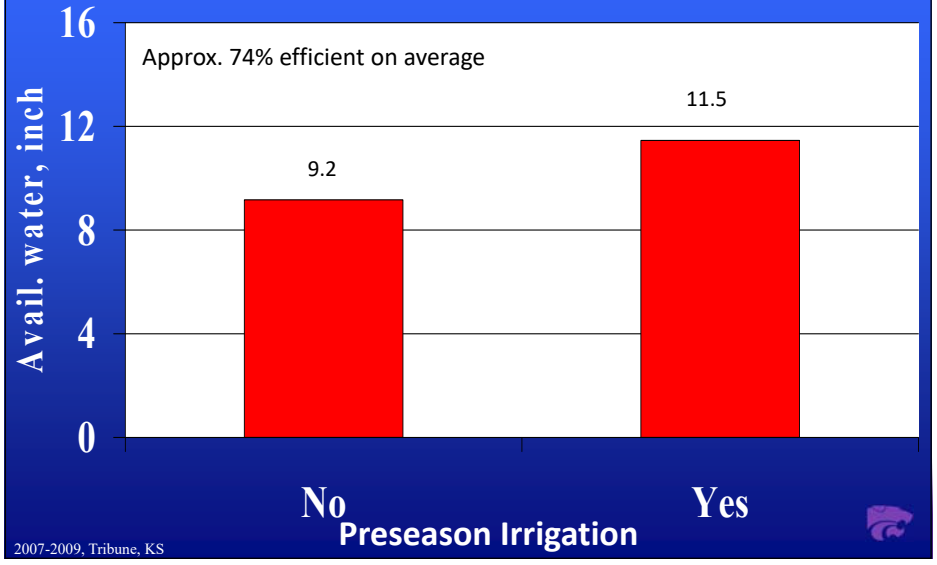
Summer Rainfall

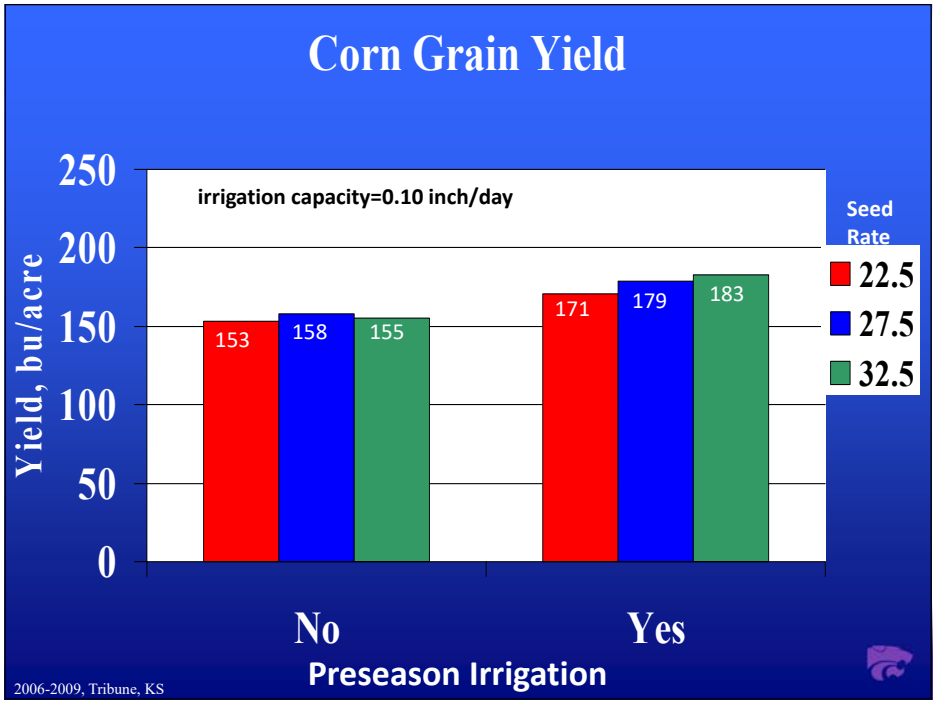


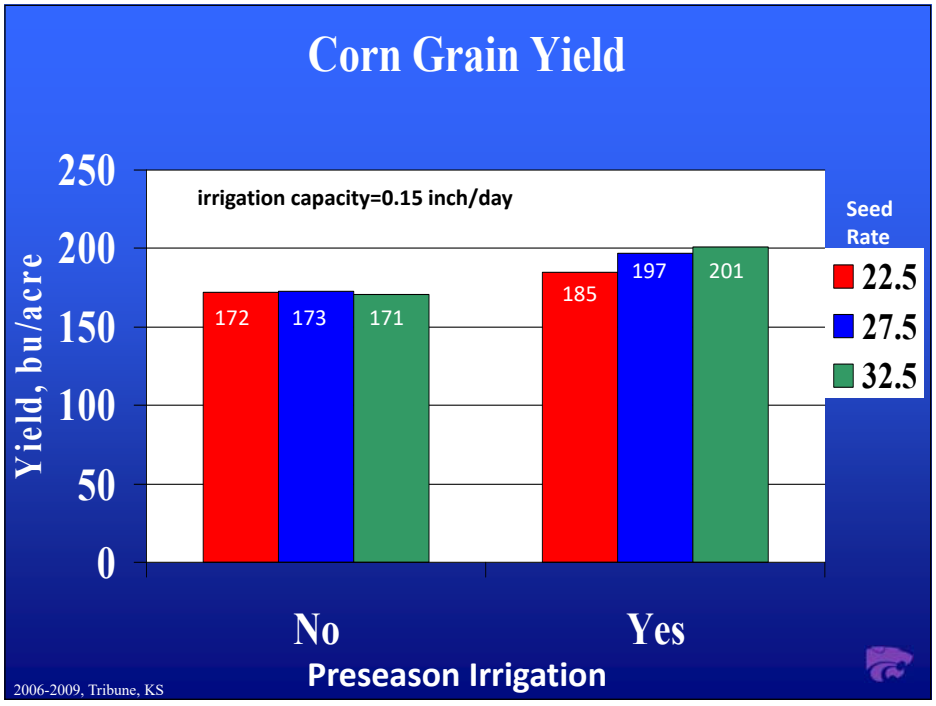
Water Inputs

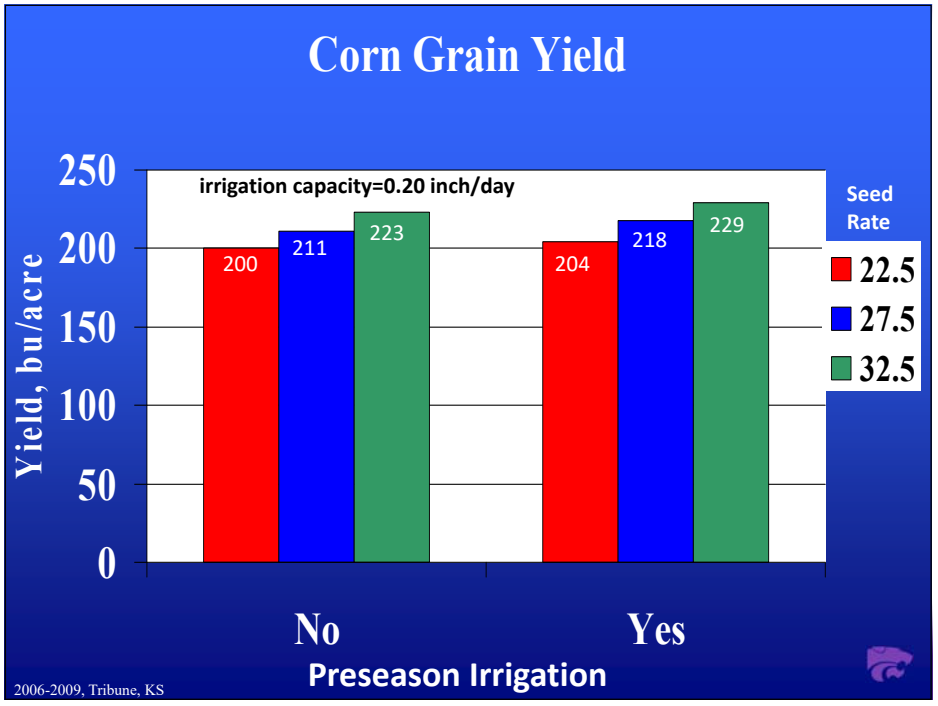
	2006	2007	2008	2009
		inch		
Precipitation				
Growing season	6.93	8.08	9.36	14.35
Preseason Irrigation	3.23	2.96	3.01	3.15
Irrigation Capacity				
2.5 mm/day	9.55	7.21	8.22	8.84
3.8	12.61	10.10	10.96	11.77
5.0	19.01	15.62	14.77	17.85

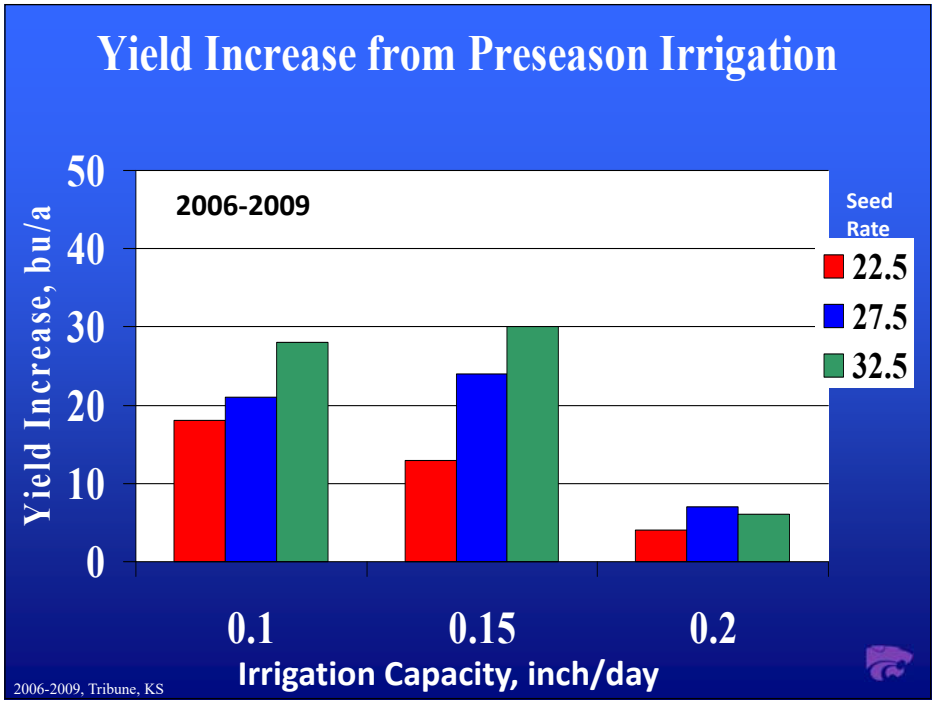
Profile Water at Planting

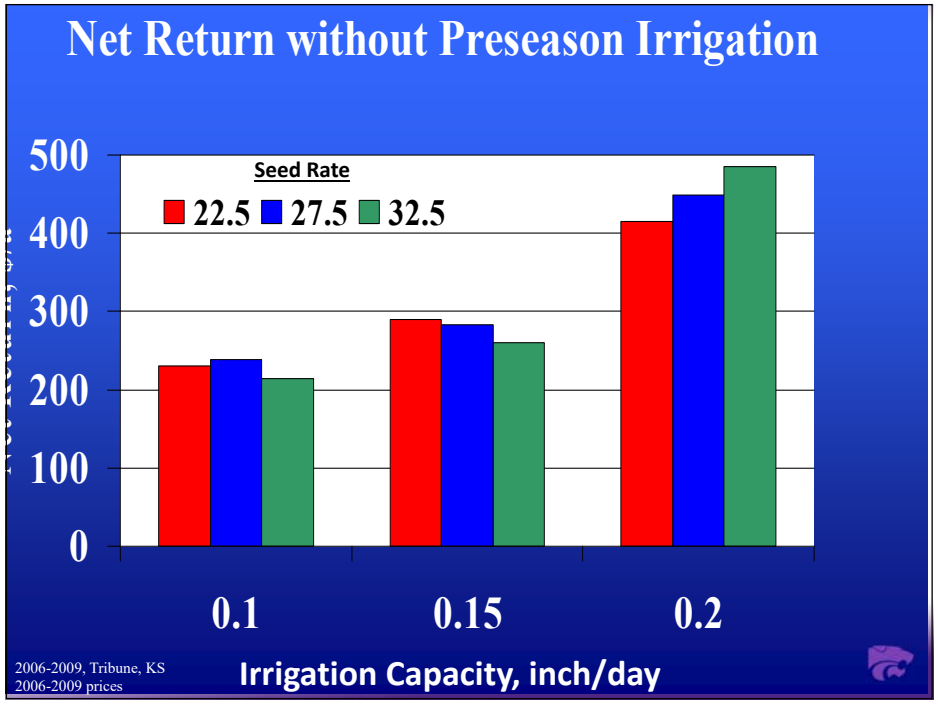


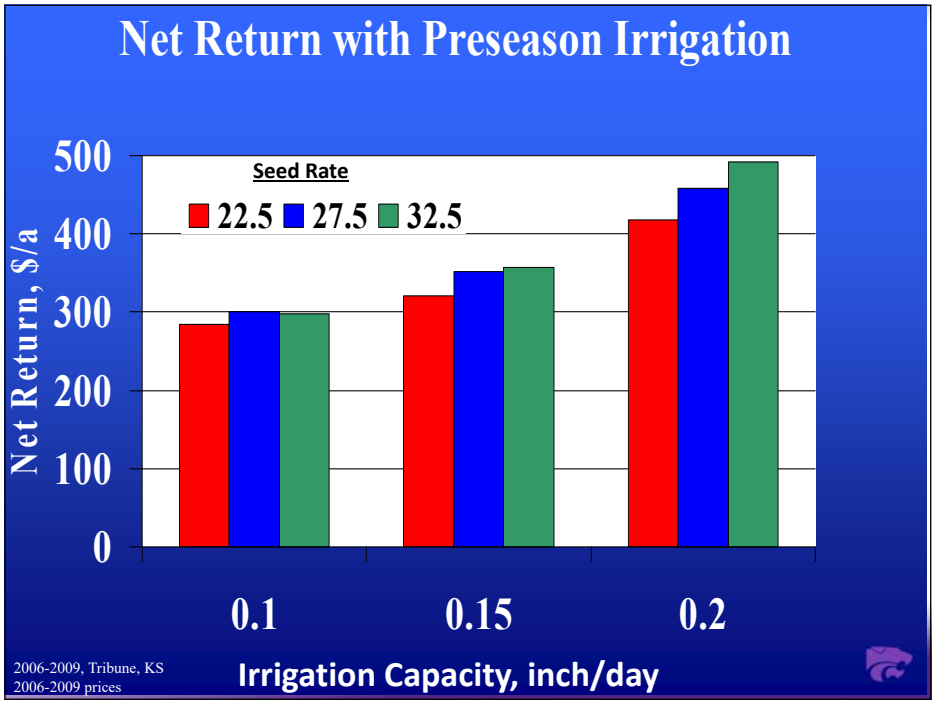

Corn Grain Yield
irrigation capacity=0.10 inch/day
Yield, bu/acre
250
200
150
100
50
0
153
158
155
171
179
183
Seed Rate
22.5
27.5
32.5
No
Yes
Preseason Irrigation
2006-2009, Tribune, KS


Corn Grain Yield
irrigation capacity=0.15 inch/day
Yield, bu/acre
250
200
150
100
50
0
172
173
171
185
197
201
Seed Rate
22.5
27.5
32.5
No
Yes
Preseason Irrigation
2006-2009, Tribune, KS


Corn Grain Yield
irrigation capacity=0.20 inch/day
Yield, bu/acre
250
200
150
100
50
0
200
211
223
204
218
229
Seed Rate
22.5
27.5
32.5
No
Yes
Preseason Irrigation
2006-2009, Tribune, KS

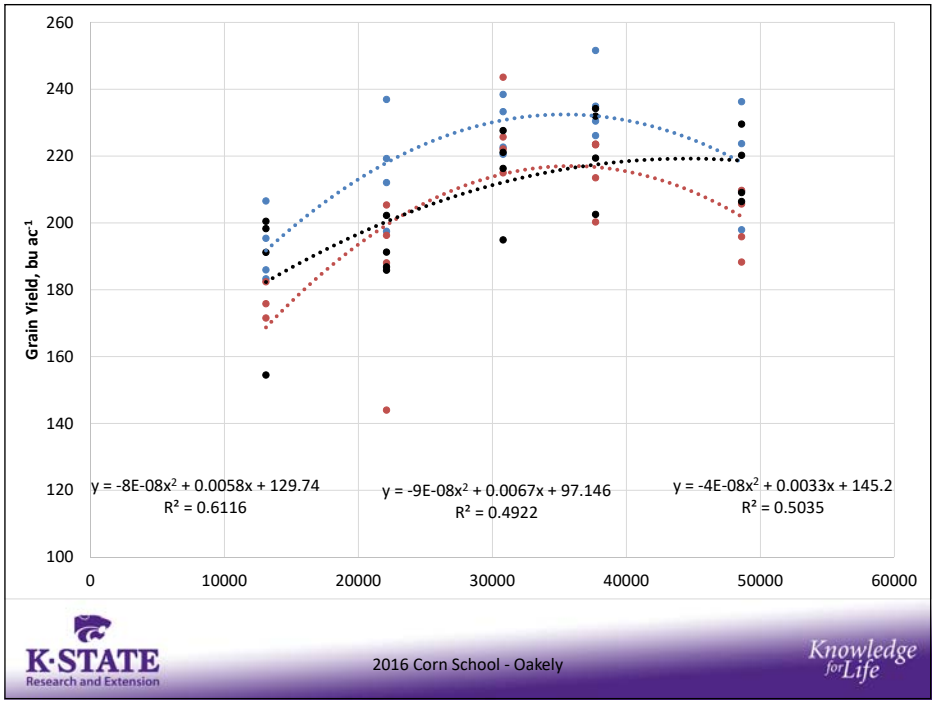






A side track on hybrids….

- 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



Grain Yield with Limited Irrigation 2008 and 2001-2008

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

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”)

Tribune, KS

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Tribune, KS

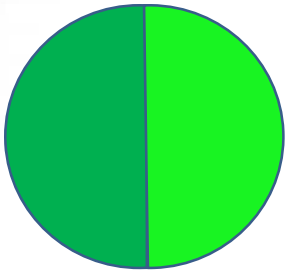
Playing the Timing Game

- 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?

Playing the Timing Game

- What about splitting the same crop in time?

Plant a short season hybrid as early as possible



Plant a full season hybrid as late as possible

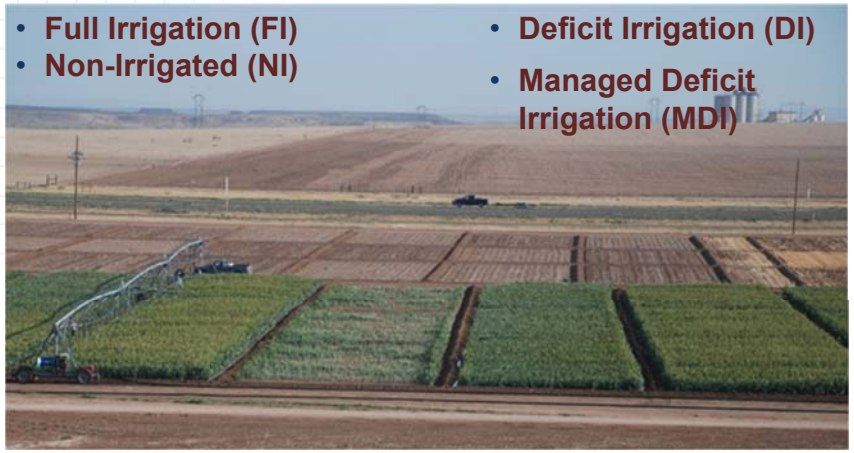
Irrigation Timing and Grain Sorghum

Tribune, KS

Time of Irrigation	Yield (bu/ac)
Preplant only	65
Pre+Boot Stage	125
Pre+Half-Bloom	115
Pre+Soft-Dough	114
Full Season Irrigation	126

Grain Sorghum Managed Deficit Irrigation Study

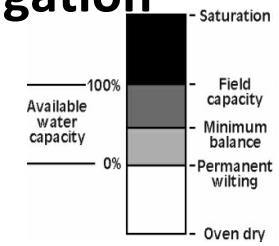
- Full Irrigation (FI)
- Non-Irrigated (NI)
- Deficit Irrigation (DI)
- Managed Deficit Irrigation (MDI)



J. Bell et al., Texas AgriLife

Full and Deficit Irrigation

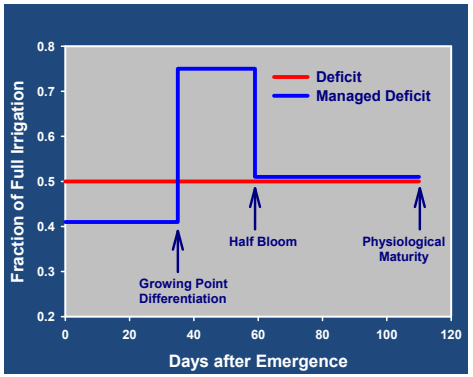
- Full Irrigation (FI)
  - 100% crop water use or based on a managed allowable depletion using soil moisture sensors



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

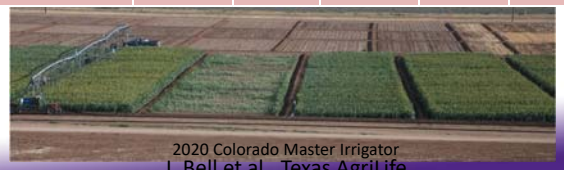
Managed Deficit Irrigation

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.

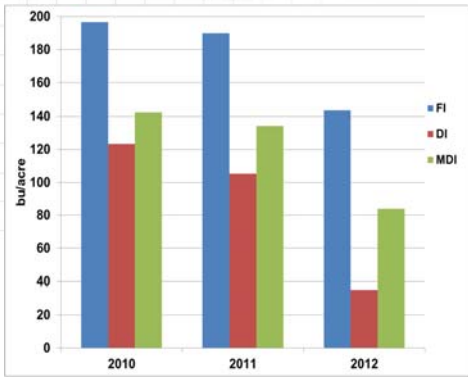


Crop water use and grain sorghum yield for an average year (2010) and an extreme year (2011) at Bushland, TX) (Bell, 2014)

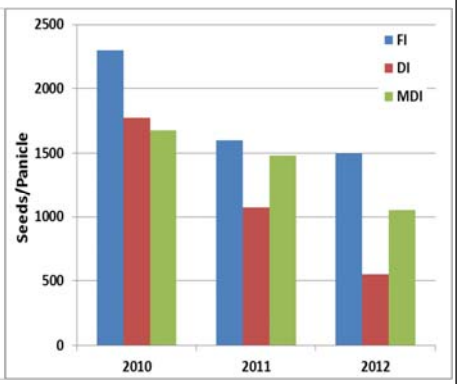
Treatment	Irrigation	Rainfall	Soil water	Total Water	Yield	WUE
2010	----------Inches of water ----------				bu/acre	bu/inch
Full Irrigation	12.7	7.1	1.8	21.6	198	9.2
Managed Deficit (MDI)	6.5	7.1	3.6	17.2	142	8.3
Deficit (DI)	5.7	7.1	3.1	15.9	123	7.7
2011						
Full Irrigation	24.0	2.4	-1.1	25.3	190	7.5
Managed Deficit (MDI)	15.3	2.4	0.2	17.9	132	7.4
Deficit (DI)	13.1	2.4	0.9	16.4	106	6.5



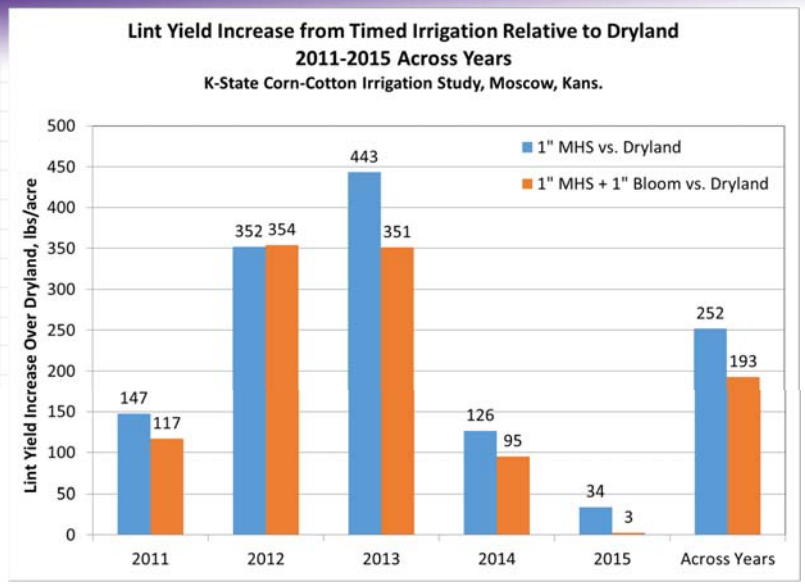
Sorghum Grain Production



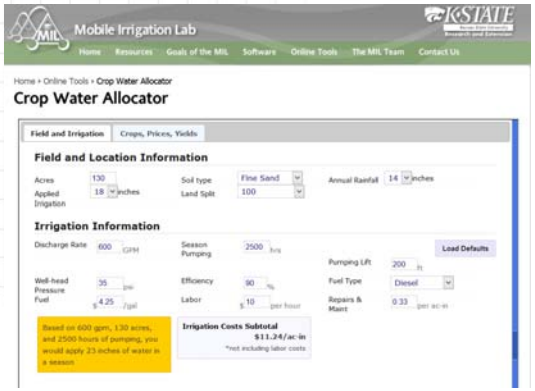
Yield



Seeds/Panicle



Crop Water Allocator



- Can include individual crop budgets
- CWA looks at multiple ways of splitting land and water to optimize net returns
- Designed for full-season strategies, not going to capture targeted strategies with cotton or sorghum

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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, <u>but</u> we must be smart with it

Questions?

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