Make the Most Out of Your Irrigation Water

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K-State Southwest Research and Extension

Crop Talk
18 February 2025

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Overview

- Why Irrigate?
- Irrigation Management
- Planning Tools
- Scheduling Tools

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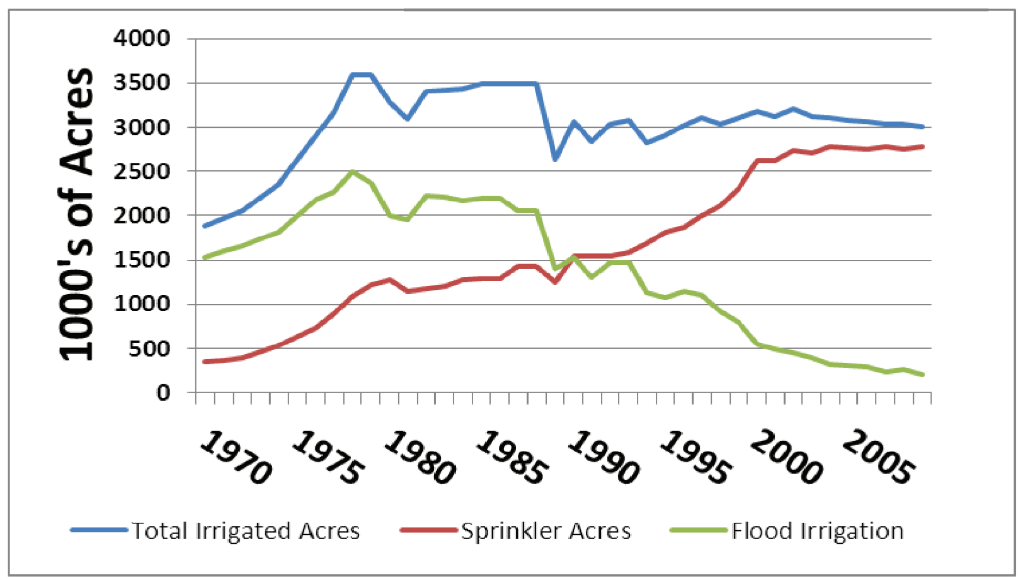
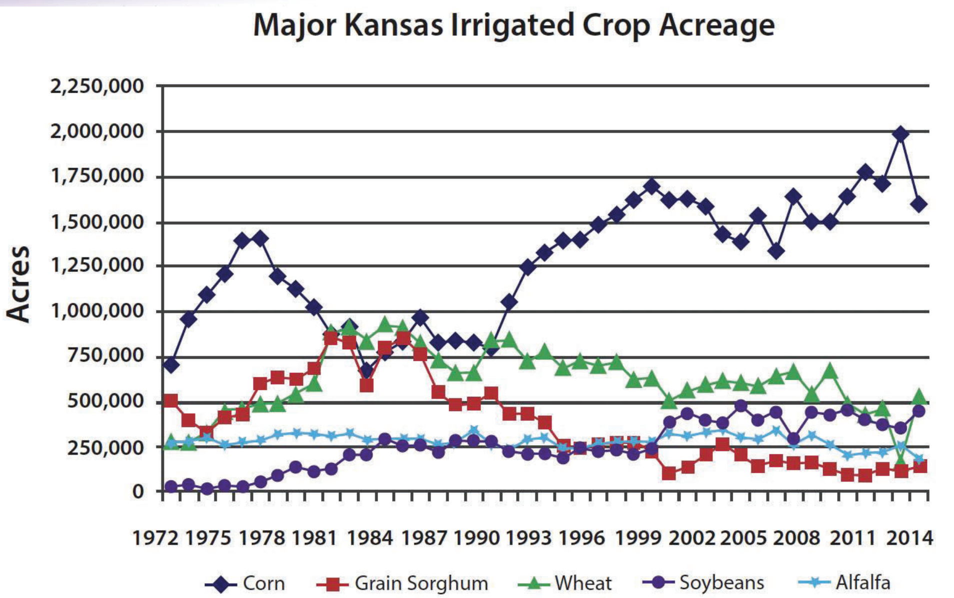
Kansas: 1989 – 2017 Irrigated Acres

Reporting Unit	1989 acres	2012 acres	2017 acres	Change in acres	% Change since 1989
GMD 1	291,574	198,377	177,528	-114,046	-39.1
GMD 3	1,572,470	1,424,923	1,393,101	-179,369	-11.4
GMD 4	359,016	387,286	392,003	32,987	9.2
Rest of Region 1 (West)	106,915	109,220	113,022	6,107	5.7
Total of Region 1 (West)	**2,329,975**	2,119,806	**2,075,654**	**-254,321**	**-10.9**
GMD 2	94,683	136,543	150,786	56,103	59.3
GMD 5	429,133	456,746	458,119	28,986	6.8
Rest of Region 2 (Central)	192,664	248,916	273,152	80,488	41.8
Total of Region 2 (Central)	**716,480**	842,205	**882,057**	**165,577**	**23.1**
Total of Region 3 (East)	**52,375**	80,070	**100,809**	**48,434**	**92.5**
State	**3,098,830**	3,042,081	**3,058,520**	**-40,310**	**-1.3**

Total irrigated land area, sprinkler systems, and flood Irrigation system in Kansas





Why irrigate?

Why water the crops?

Why water plants?

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Top reason why you irrigate

- Increase yield
- Improve soil health
- Reduce impact of drought
- Increase profit
- Improve grain/product quality
- Keep land value high

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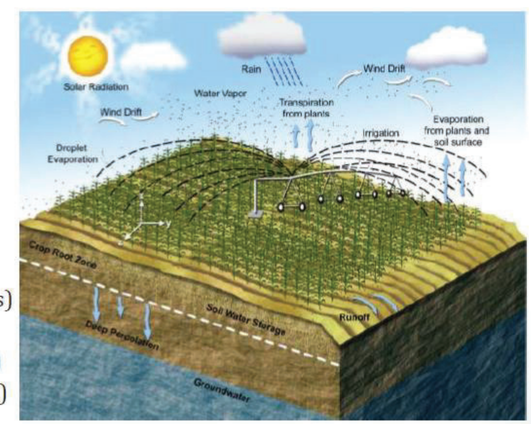
Why do we Irrigate???

When precipitation and stored soil water in the crop root zone are insufficient to meet crop evapotranspiration (ET) demand, irrigation is required.

Insufficient Irrigation can reduce:
- Total Biomass
- Grain Yield
- Grain Quality
- Net Return ($ per ha)

Excessive irrigation can result in:
- Runoff
- Soil Erosion
- Deep Percolation of Water (and Nutrients)
- Environmental Degradation
- Anaerobic Soil Conditions (Yield Penalty)
- Increased Pumping Cost (i.e., energy cost)



Source: Irmak (2009), Rudnick and Irmak (2015)

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Reasons we irrigate

- **Increase crop yield**
- **Stabilize / ensure yield**
- **Improve crop/product quality**
- **Improve economy**

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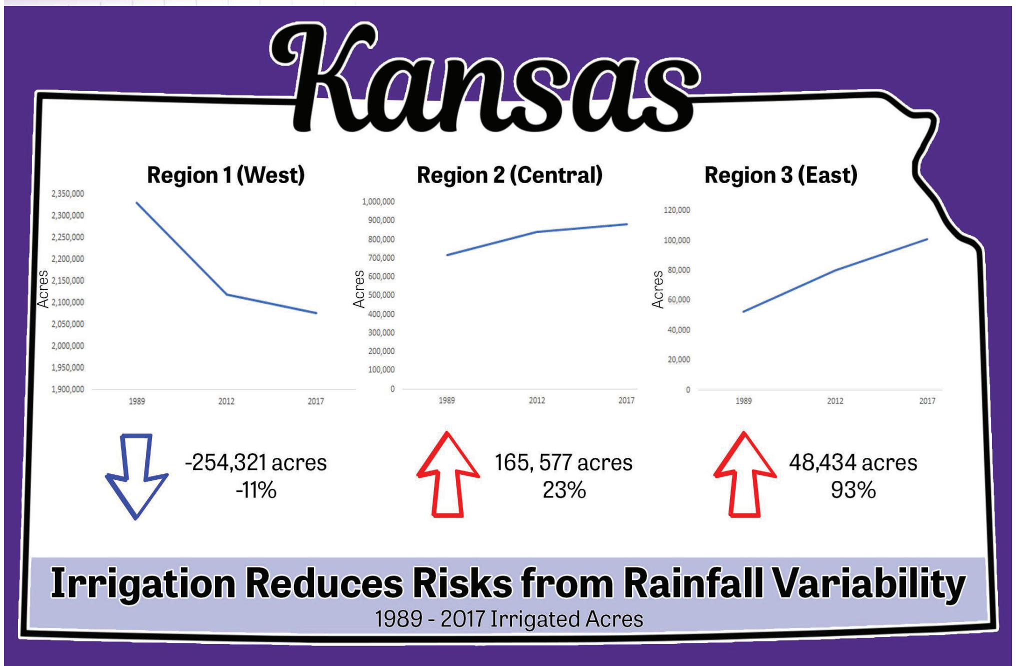

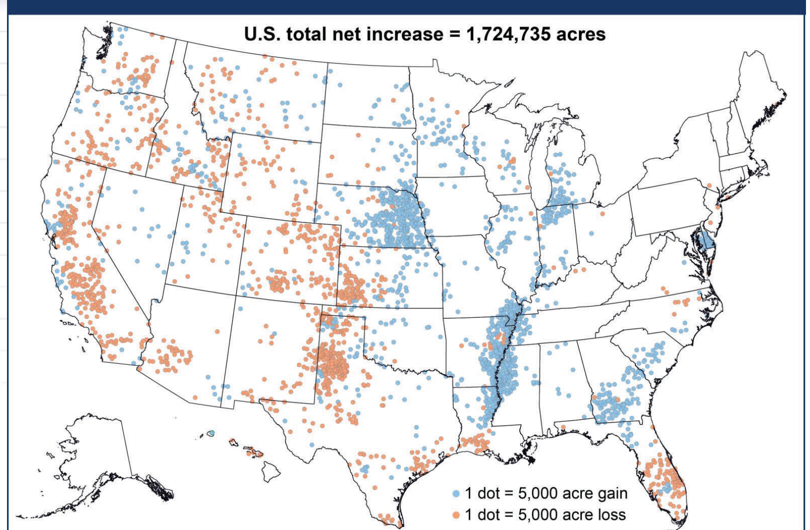

Source: USDA, Economic Research Service using data from USDA, National Agricultural Statistics Service, 1997 and 2017 Census of Agriculture.

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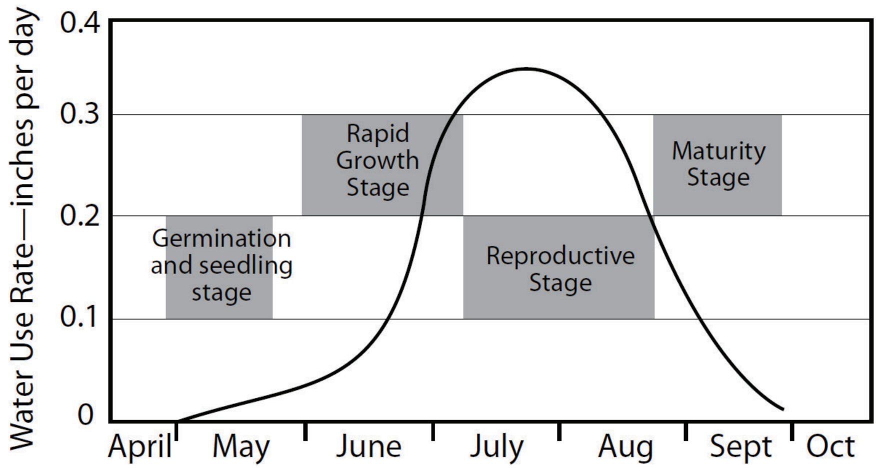
Characteristic growth and water use pattern of corn



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Precision Irrigation

Time of Irrigation Study at Scandia Exp. Farm	1991 Yield MT/ha	1991 Irrigation Date	1980-1991 MT/ha
No Irrigation	**0.2**	None	**3.5**
Tassel	**7.8**	7/8	**8.9**
Tassel + 1 week	9.3	7/8, 7/15	10.0
Tassel + 1 + 2 week	9.8	7/8, 7/15, 7/25	10.3
65% depletion	10.0	7/1, 7/23	10.8

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KNOWLEDGE CHECK:
WHAT'S THE HIGHEST RECORDED YIELD FOR CORN (*BU/AC*) A FARMER GOT?

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YIELD GAP

Solar Radiation, Temperature, Rainfall

Insects, Pests and Diseases

Water Mngt.

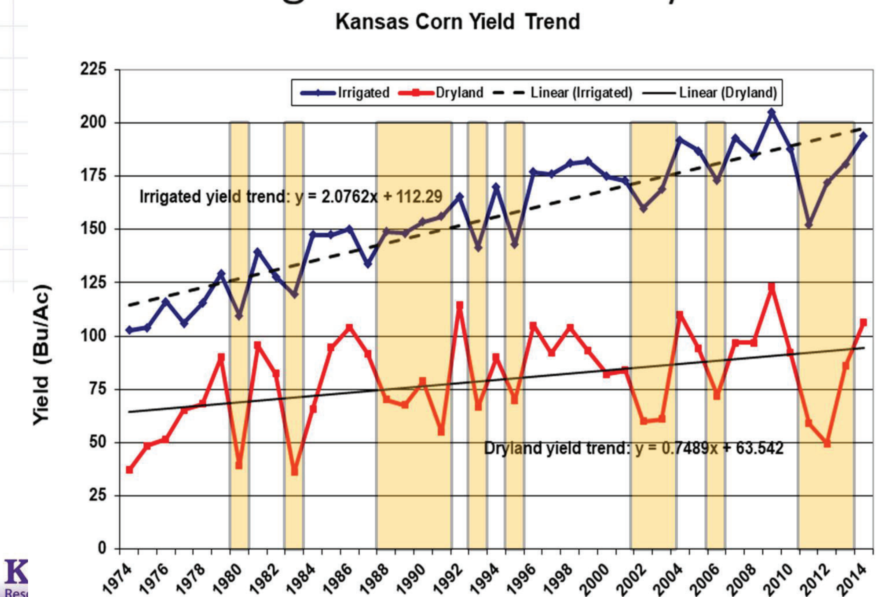
Nutrients

Seeding

Weeds

Why Irrigate?

Irrigation Stabilizes yield



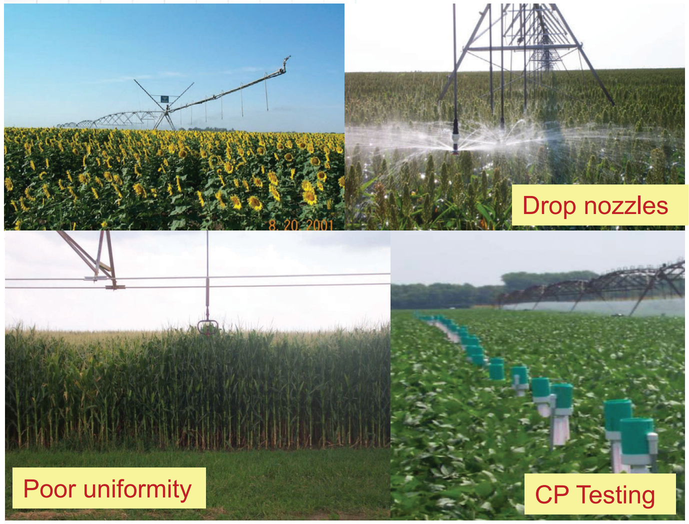
Seven Points to Consider

1. Keep irrigation system at optimum condition
2. Evaluate opportunities to be better
3. Apply water evenly in the field
4. Soak the water in where it is placed
5. Slow down pivot speed
6. Make better use of rainfall
7. Properly schedule your irrigation

1. MAKE SURE THAT YOUR IRRIGATION SYSTEM IS RUNNING AT ITS OPTIMUM CONDITION

a. Do a baseline testing of well, pump and irrigation system
b. Compare flow rate and pressure (psi) with Sprinkler Package Design
c. Don't assume regulators perform as new
d. Re-orifice package, adjust impellers, speed up pump engine, modify generator pulley as needed to get 480 Volts
e. If the well can sustain the yield, reduce pivot flow rate to 5.4-6.7 gpm/acre (~0.27-0.33 in/day) for most row crop application

Off-season adjustments



Check your irrigation systems for operational, maintenance and uniformity problems

Adapted from F. Lamm, 2014

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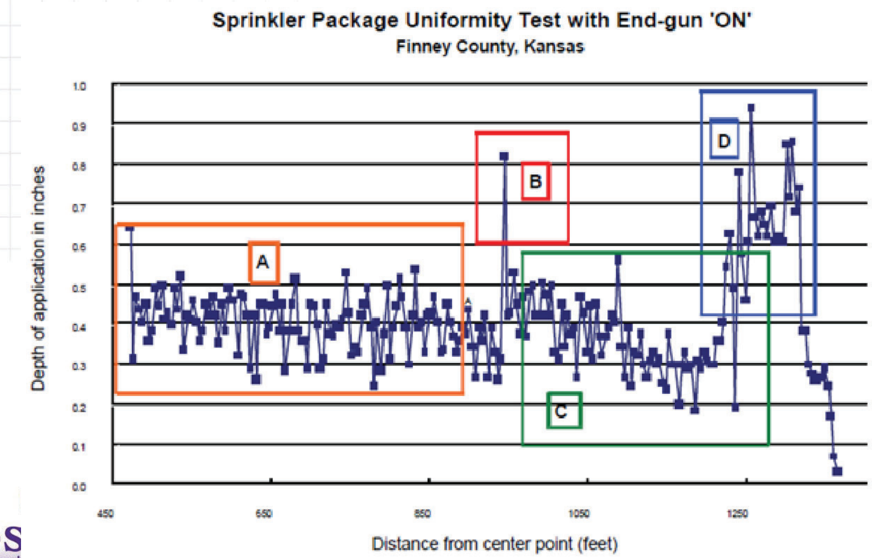
Uniformity test result

(Rogers et al. 2008).



At the Least, Walk Your System Before Irrigation System Starts

These are what I found in a recently renozzled pivot of a Water Tech Farm

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2. EVALUATE OPPORTUNITIES FOR BETTER WATER USE

a. Create All-Farm Water Use spreadsheet
b. Group water use by crop
c. Focus on yield per unit water used(bu/ac-in) or crop water use efficiency (WUE)

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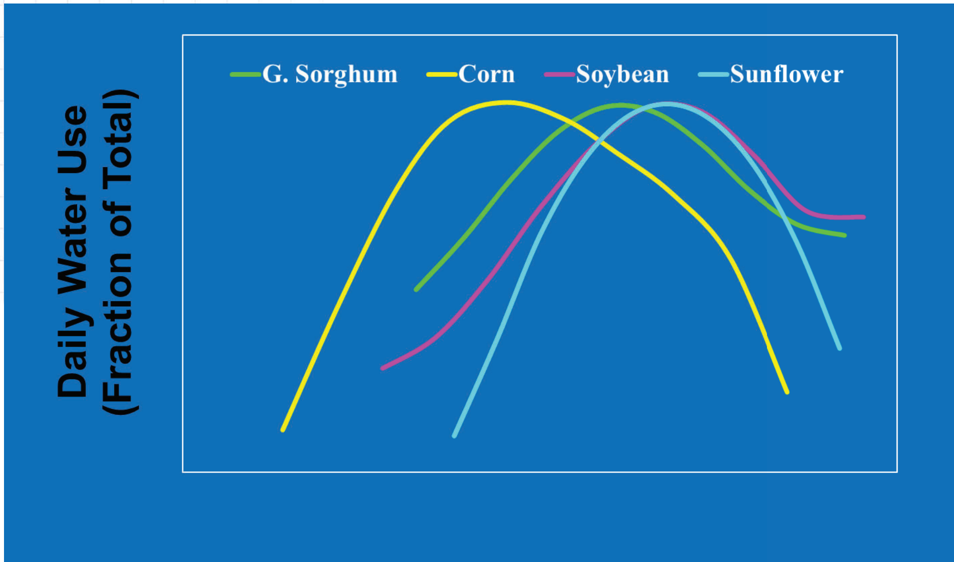
Peak Water Use Timing



Staggenborg, S. KSU Agronomy

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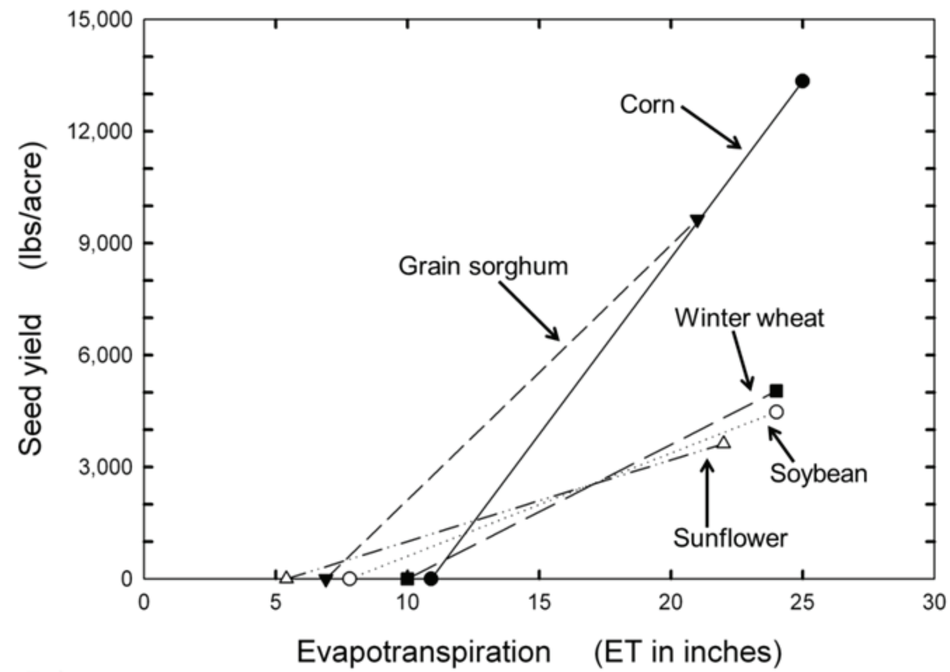
Crop Yield vs. ET Relationships



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3. APPLY WATER EVENLY IN THE FIELD

a. Maintain End Tower pressure 5 psi more than regulator setting
b. Monitor center pivot end tower pressure (e.g. Ag Sense, FieldNet, Field Wise, etc.)
c. Evaluate the seasonal graph of pressure and position (psi vs. angle 0-360)
d. Use Aerial Imagery to monitor for crop development and sprinkler patterns, soil challenges, fertility issues, runoff, excess rain, etc.
e. Increase last 3 sprinkler flow rates on overhang to apply water more evenly after removing end-gun
f. Close the drain hoses at the end of the tower when running, and add purge valve if needed
g. Avoid using butterfly valve at pump discharge

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Ideally, maybe we would like to see

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Adapted from F. Lamm, 2014

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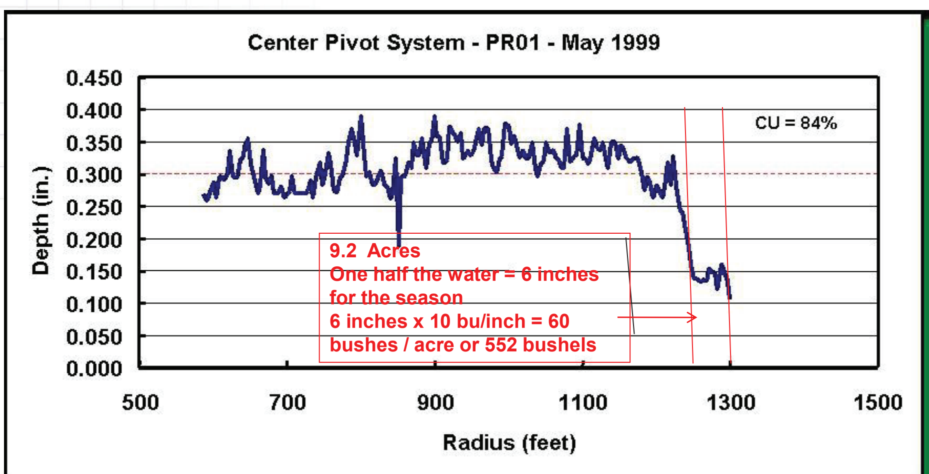
But often, we saw irrigated fields like this

Solutions to Uniformity Problems

- Use proper nozzle spacing
  (not more than twice corn row width)
- Use appropriate proper nozzle height
  (e.g., 2 or 7 ft, but not corn ear height)
- Use residue management
- Use circular rows

If runoff or uniformity problems continue, permanently raise nozzles above the crop canopy.

Center Pivot with un-installed nozzle and under sized orifices at outer edge.



IRRIGATION APPLICATION SYMMETRY

In the extreme drought years of 2000 to 2003 that occurred in the U. S. Central Great Plains, even small amounts of surface water movement affected sprinkler-irrigated corn production.

Large differences in corn plant height and ear size for in-canopy sprinkler application over a short 10-ft. distance (4 crop rows) as caused by small field microrelief differences and the resulting surface water movement during an extreme drought year, Colby, Kansas, 2002.

IRRIGATION MANAGEMENT

- System Efficiency
- Application Efficiency
- Planning Tools
- Scheduling
- Strategies

100% MAX

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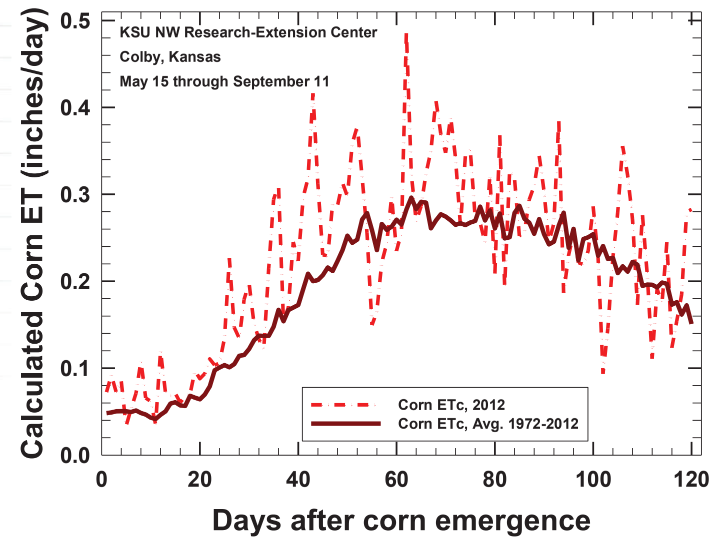
Not all days were created equal

Average daily corn ET (water use) at Colby, Kansas in 2012 was 16% greater than the long term average and on some days was nearly twice the average value.



Most regional irrigation systems are designed at less than 0.25 inches/day, and did not not cope well at critical growth stages with such large increases in daily ET.

Adapted from F. Lamm, 2014

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KNOWLEDGE CHECK:

IF DROUGHT IS IMMINENT AND YOU CANNOT CATCH-UP WITH ET, DO YOU CONTINUE IRRIGATING THE WHOLE CIRCLE OR JUST FOCUS IT ON HALF THE CIRCLE?

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4. SOAK IT IN WHERE IT IS PLACED

a. Improve infiltration at soil surface
b. Increase wetted footprint where you see runoff (e.g., overhead sprinklers = 80 ft. vs. bubblers = 3 ft. wetted diameter); Use moving plates and space drops closer together whenever possible
c. Use other practices such as cover crops, green manure crops, and dammer-diking to reduce runoff
d. Minimize big droplets-impact erosion at soil surface
e. Use outrigger booms at towers and overhang to increase wetted footprint
f. In many cases do not go below 10 psi regulators to maintain moderate droplet size
g. Use truss rod hose clips to widen wetted footprint

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Off-season adjustments

- Increase irrigation system efficiency and/or uniformity

Each of these systems can be very efficient and uniform, but many producers find moving from left to right improves their own water management.

Adapted from F. Lamm, 2014

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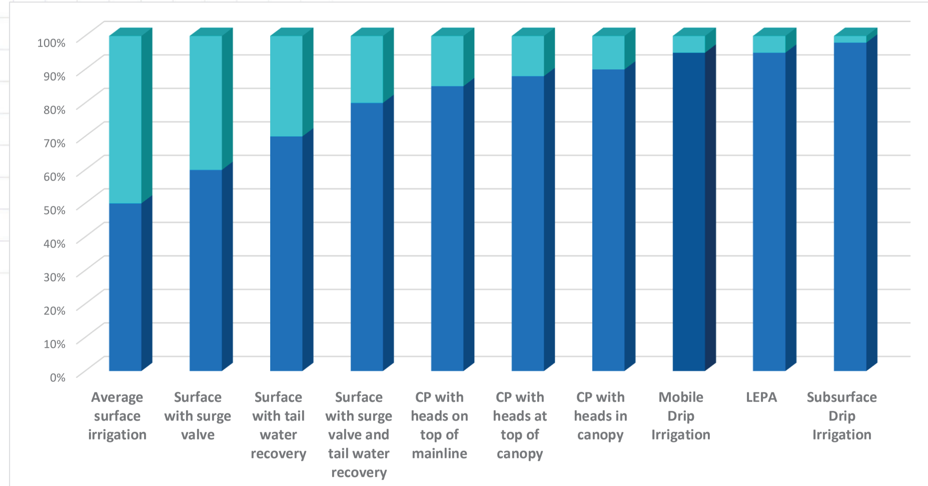
The Race for 100% Efficiency



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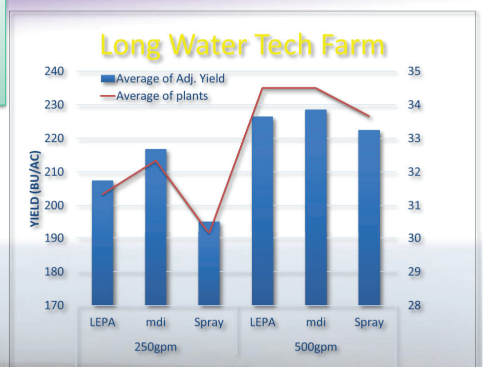
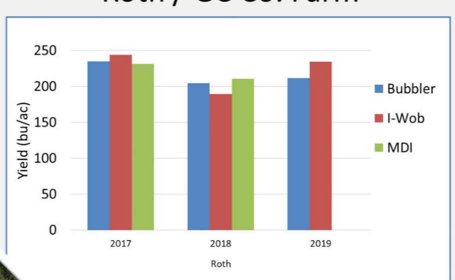
Water Tech Farms Data

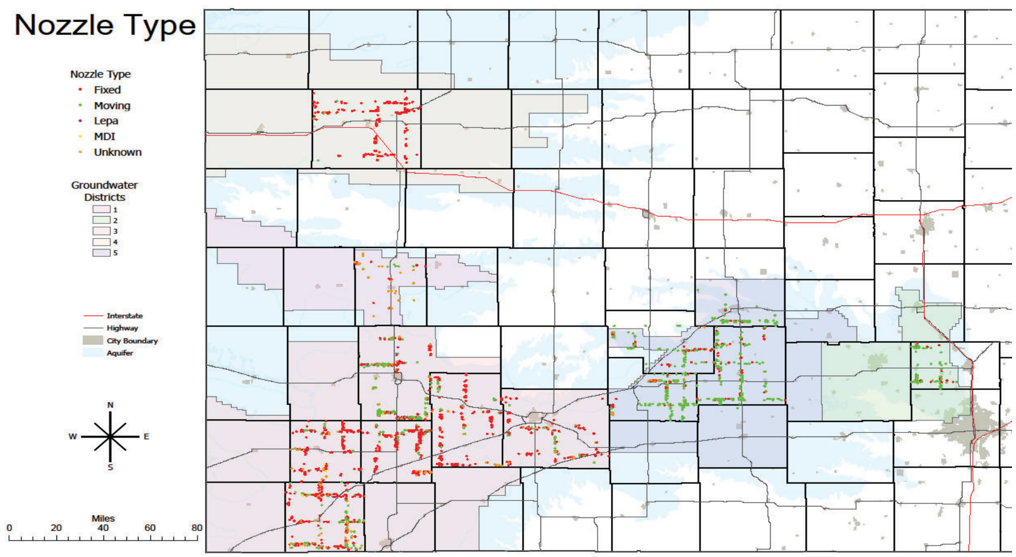
2018 ILS Farm Data

FIELD	TREATMENT	YIELD (Combine) (BU/AC)	YIELD (Hand) (BU/Ac)	IRRGN APPLIED (IN)	WATER USE EFFICIENCY (BU/Ac-IN)
NORTH 16	ALL	234	244	13.1	18.62
	MDI (70%)	231	243	9.8	24.8
	MDI (80%)		237	11.2	21.2
	SPRAY (100%)	249	259	14.0	18.5
SOUTH 15	SPRAY	232	237	15.3	15.5





Center Pivot Survey



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Irrigation System Capacity (GPM) Required to Supply 0.25 inches/day at Various Efficiency and Acreage

Irrigated System Efficiency	Acres Irrigated		
	1	128	160
100%	4.69	600	750
90%	5.21	667	833
80%	5.86	760	938
70%	6.70	857	1071
60%	7.81	1000	1250
50%	9.38	1200	1500

KNOWLEDGE CHECK:
IRRIGATION EFFICIENCY IS A FIXED VALUE.
TRUE OR FALSE?

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Myth: Irrigation efficiency is a fixed value

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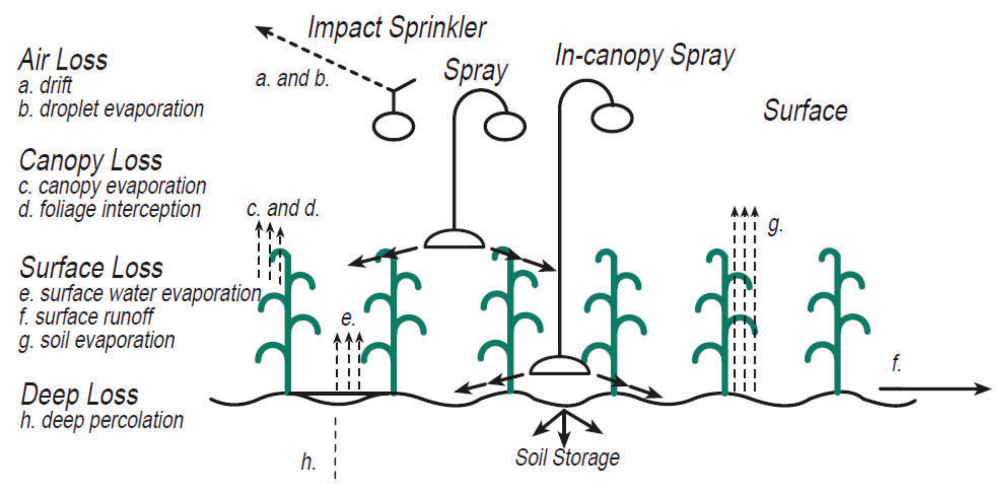
Center Pivot Sprinkler Package
Potential Water Losses



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5. SLOW PIVOT DOWN TO APPLY 0.8-1.2-IN. DEPTH IRRIGATIONS IF POSSIBLE UNLESS SIGNIFICANT RUNOFF OCCURS OR IN VERY SANDY SOILS

a. Improve portion of irrigation water entering root zone (application efficiency) by reducing “Service Factor” (i.e. loss of E on ET; can be ~0.17 in.) per irrigation event
b. Consider 3-4 days irrigation frequency, unless sandy soils, then 2-2.5 days

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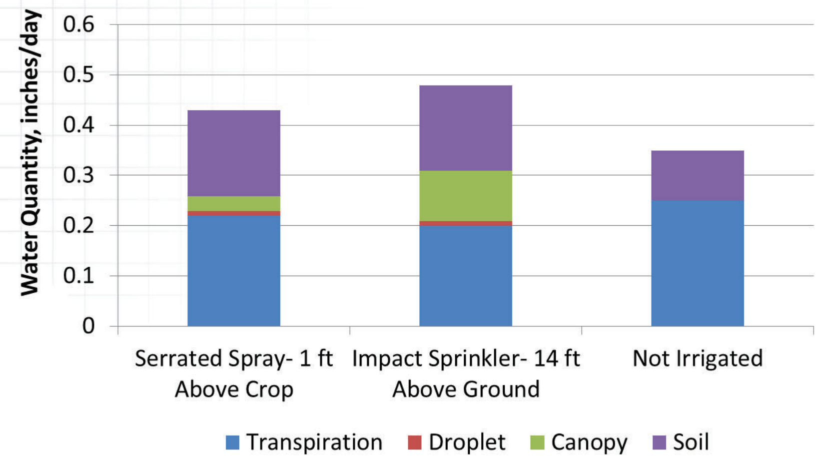
Evaporative Losses for Impact and Spray Devices



Bushland, TX: 1992, 90 F, 15 mph, dry   Thompson, et al. (1997)

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Example of effect of application depth on efficiency

Water Loss Component	1 inch applied	1 inch applied	0.75 inch applied	1.25 inch applied
Air evaporation and drift	0.02	0.02	0.02	0.02
Net canopy evaporation	0.08	0.08	0.08	0.08
Plant interception	0.07	0.07	0.07	0.07
Evaporation from the soil	Small	Small	Small	Small
Deep percolation	None	None	None	None
Run off	None	0.10	None	None
Total Water Loss	0.17	0.27	0.17	0.17
Efficiency %	83	73	77.3	86.4

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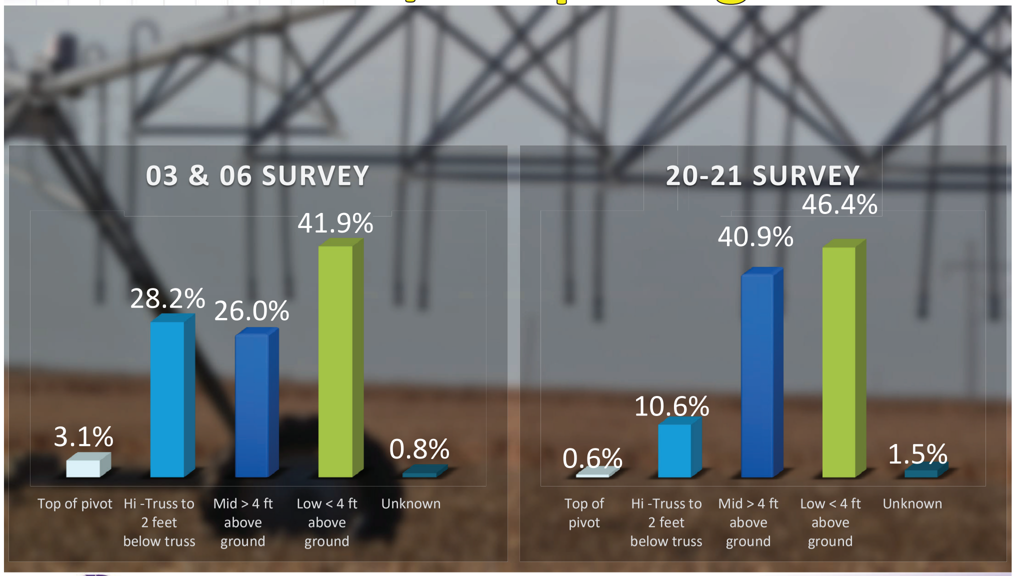
Nozzle/Drop Height



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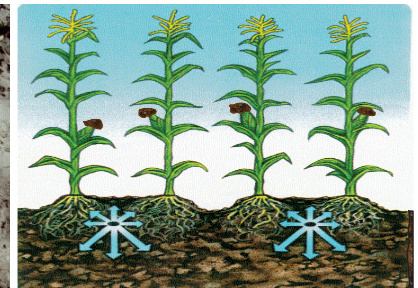
Subsurface drip irrigation (SDI) applies water below the soil surface to the crop root zone with small emission points (emitters) that are in a series of plastic lines typically spaced between alternate pairs of crop rows.



Adapted from F. Lamm, 2014

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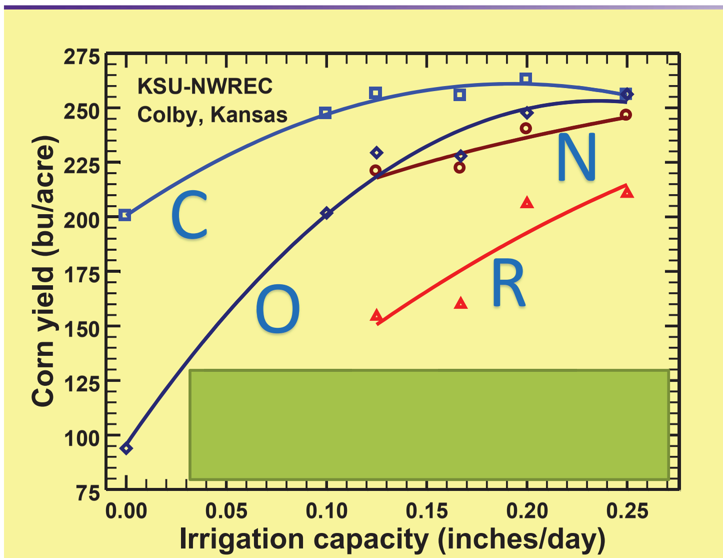

Does SDI really increase crop per drop?

There is growing evidence that subsurface drip irrigation (SDI) can stabilize yields at a greater level with less irrigation than in-canopy sprinklers.

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Adapted from F. Lamm, 2014

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SDI can be used for small, frequent, just-in-time irrigation applications directly to crop root system.

The primary ways that SDI could increase crop water productivity (WP), *More crop per drop* are:

- Reduction and/or elimination of deep drainage, irrigation runoff, and soil water evaporation
- Improved infiltration, storage, and use of precipitation
- Improved in-field uniformity and targeting of plant root zone
- Improved crop health, growth, yield, and quality

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Adapted from F. Lamm, 2014

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6. MAKE BETTER USE OF RAINFALL

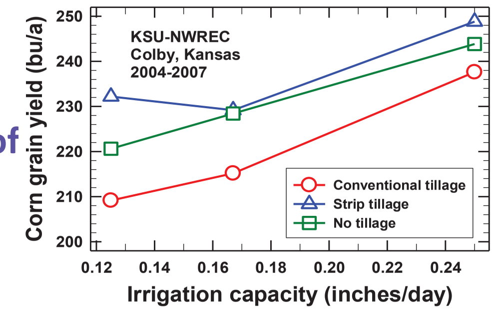
a. Measure rain at field. Use tipping rain gauge with telemetry if possible
b. After a rain event, re-establish moisture lag of 2-4 day irrigation cycle through progressive watering (i.e., move fast when starting then gradually slow down [in incremental pies] to finish the cycle)
c. If conditions allow, hold off irrigation if high probability of rainfall is in the forecast

Knowledge for Life

Off-season adjustments

- Increase irrigation efficiency and/or uniformity
- Adopt irrigation scheduling
- **Improved management of precipitation and soil water through cultural practices**

Reduction of tillage increases yields.



Great adoption of strip tillage

Increasing adoption of reduced or no tillage planting

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Adapted from F. Lamm, 2014

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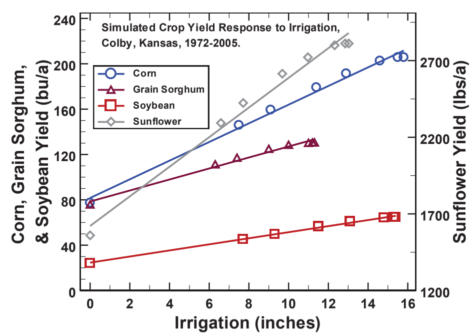
Off-season adjustments

- Increase irrigation efficiency and/or uniformity
- Adopt irrigation scheduling
- Improve management of precipitation and soil water through cultural practices
- **Change crops or mixture of irrigated crops**



Center pivot with multiple crops.

CROP WATER ALLOCATOR

K-State software that helps with decisions

Adapted from F. Lamm, 2014

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Irrigation Scheduling

***21st century definition** (Lamm, et al. 2014):*

Process of delaying any unnecessary irrigation with the hope that the cropping season will end before the next irrigation is needed.

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7. PROPERLY SCHEDULE YOUR IRRIGATION

a. Use the same start/**stop** position near pivot road
b. Use a checkbook budget like KanSched and Autonomous Pivot, to determine when to irrigate and how much
c. Use Soil Moisture or Plant Based sensors with Telemetry to “close the loop”
   1. Install on “start” side of pivot start/stop position
   2. Install on soil type with lower water holding capacity, if prevalent

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Irrigation Scheduling

Definition:

Process of determining when to irrigate and how much water should be applied.

Let’s call this a 20th century definition

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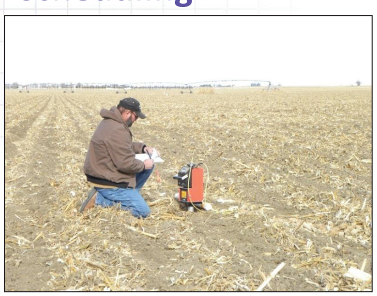
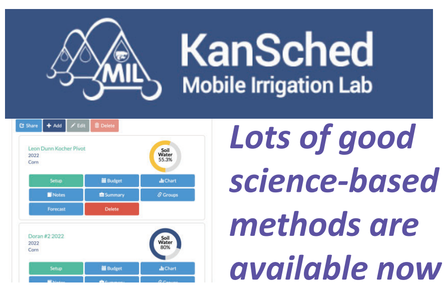
Off-season adjustments

- Increase irrigation efficiency and/or uniformity
- **Adopt irrigation scheduling**



Monitoring available soil water



Lots of good science-based methods are available now

Infrared thermometers to monitor plant water stress

and more are on the way!!

We do need to improve adoption rates!!

Adapted from F. Lamm, 2014

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THE VALUE OF SCHEDULING

- **Direct**
  - Reduce Pumping cost ($4-6 in/ac)
  - Increase Net Returns
- **Indirect**
  - Save on Input costs (N-20% ~$11/ac)
  - Invest on future value

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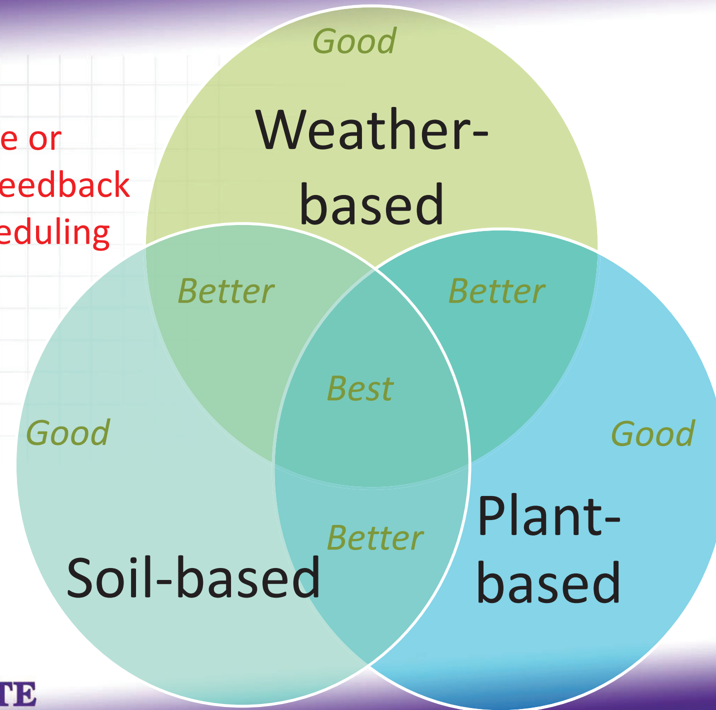
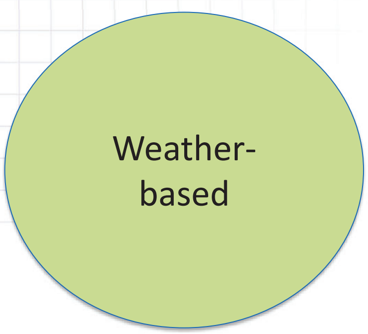
KNOWLEDGE CHECK:
WHAT IS THE BEST FEEDBACK TO SCHEDULE YOUR IRRIGATION:

A) WEATHER-BASED
B) SOIL-BASED
C) PLANT-BASED
D) ANY TWO
E) ALL OF THE THREE

Use One or More Feedback for Scheduling

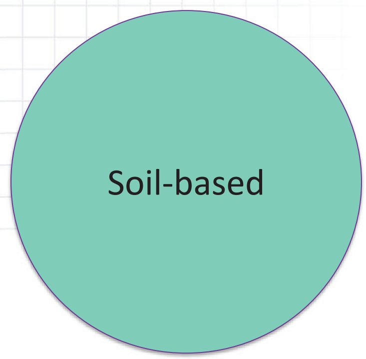


Irrigation Scheduling Tools



- KanSched
- ET Gauge/Atmometer
- Checkbook method
- DIEM - TX
- WISE - CO
- *K-State Mesonet*
- *FRET - NOAA*

Irrigation Scheduling Tools



- Gravimetric
- Tensiometer
- Soil Water Potential
- Neutron count
- Electrical Resistance
- Electromagnetic
- Hand probe / feel

Irrigation Scheduling Tools

Plant-based

- Infrared / Thermal Camera
- Dendrometer
- Micro-tensiometer
- Osmotic/water potential
- NDVI/Aerial Imagery
- Visual

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Knowledge *for* Life

IRRIGATION SCHEDULING Starts by knowing what you have to manage

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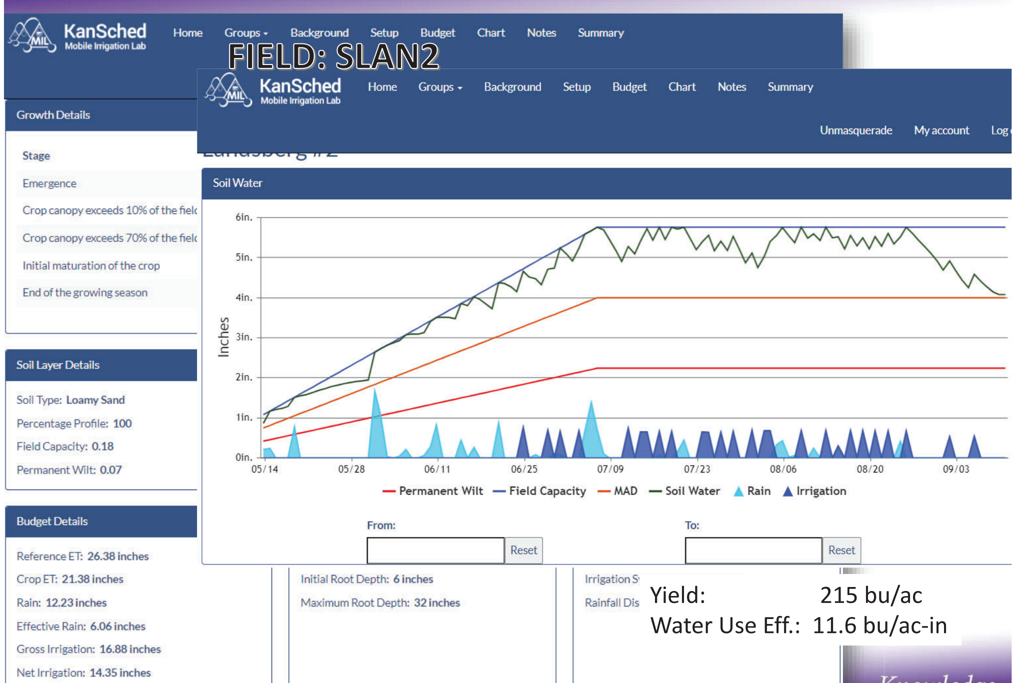

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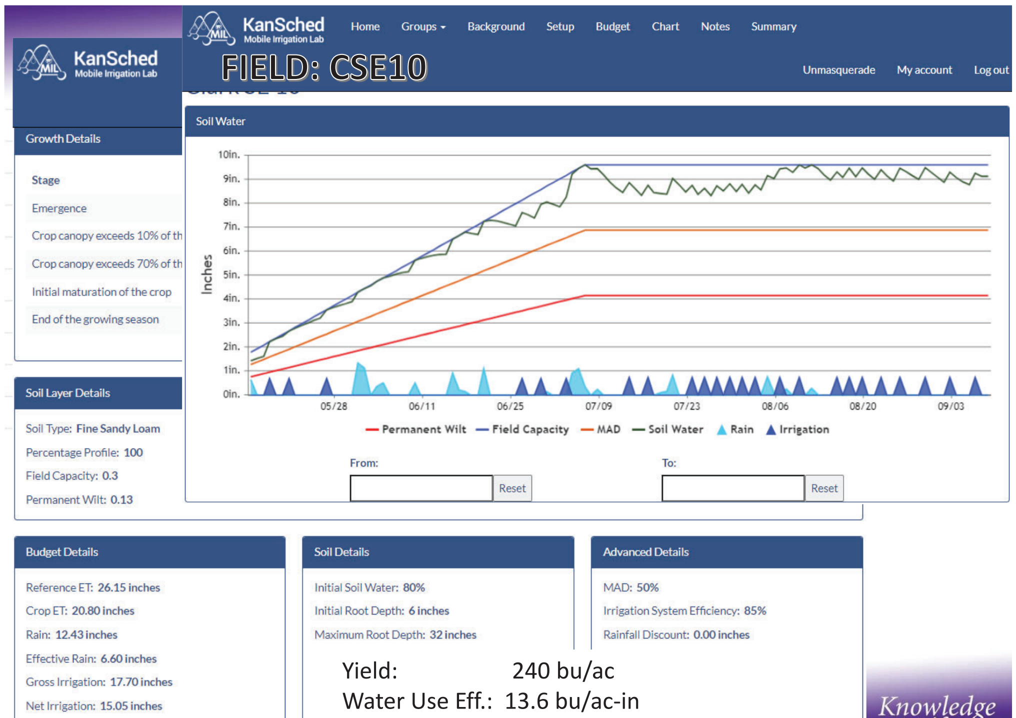

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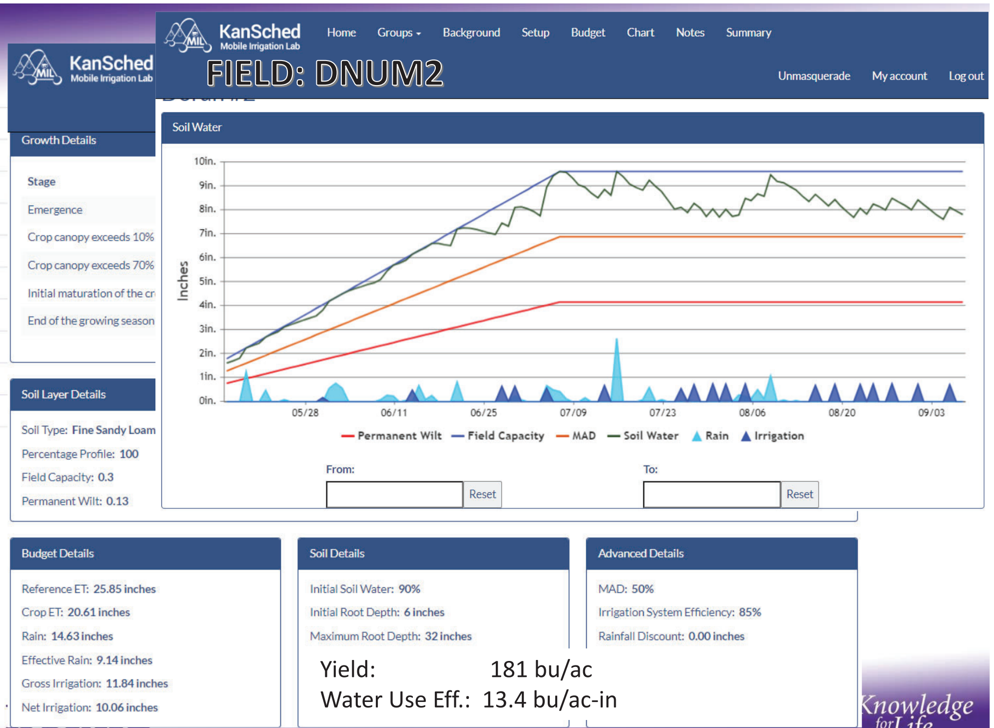

Yield: 181 bu/ac

Water Use Eff.: 13.4 bu/ac-in

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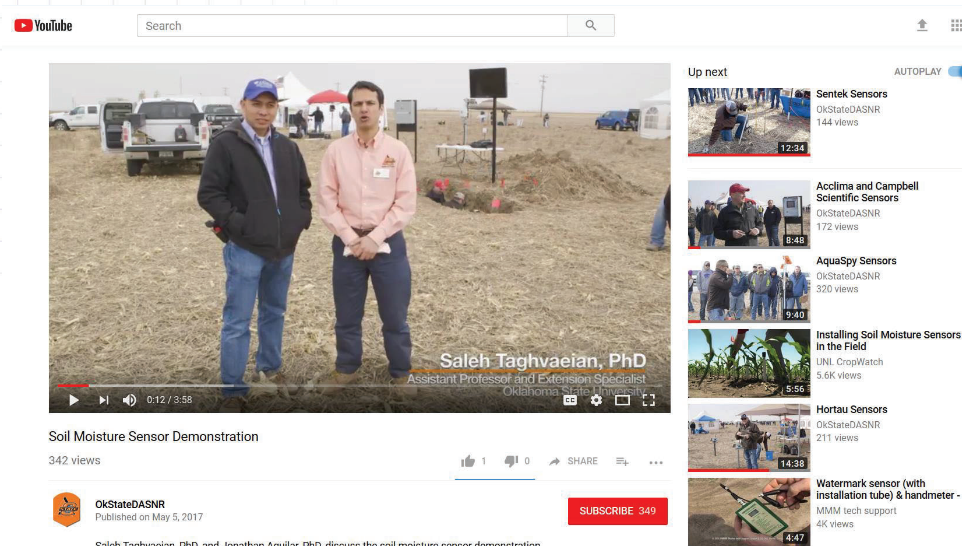
Soil Moisture Sensor Demonstration Videos



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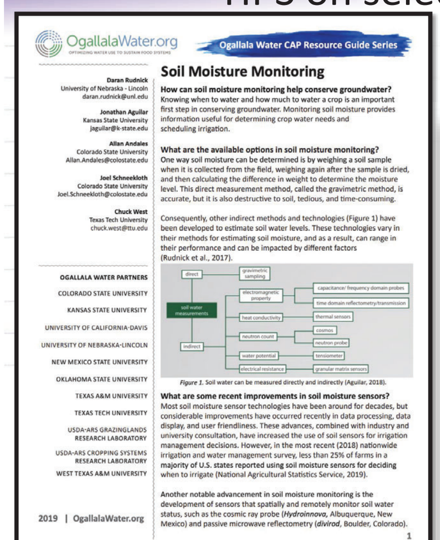
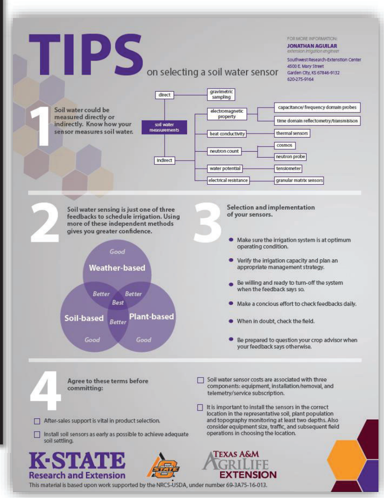
TIPS on selecting soil water sensor





- Soil Type, Location, location, location
- Costs include subscription
- After-sales support is vital
- Easy integration to your operation

Ogallalawater.org/topics

KSRE Bookstore Search: MF3707

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Seven Points to Consider

1. Keep irrigation system at optimum condition
2. Evaluate opportunities to be better
3. Apply water evenly in the field
4. Soak the water in where it is placed
5. Slow down pivot speed
6. Make better use of rainfall
7. Properly schedule your irrigation

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Suite of Management Tools

Pre-season → **In-season** → **Daily**

Crop Water Allocator	Crop Yield Predictor	KanSched
• Standalone • Online • *NEW* – Multi-Year CWA	• Standalone • Online (Mobile-device Friendly)	• MS Excel (1) • ~~Standalone (KanSched2)~~ • Online (KanSched3 – beta) • Mobile App (4 – beta)

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www.milab.ksu.edu

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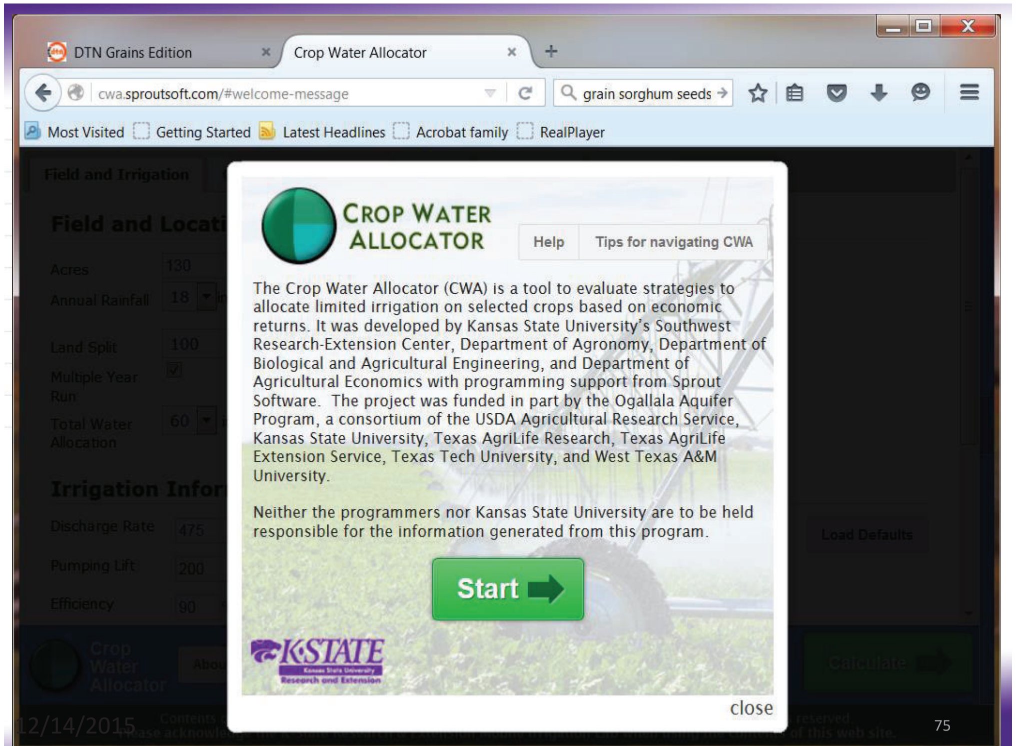

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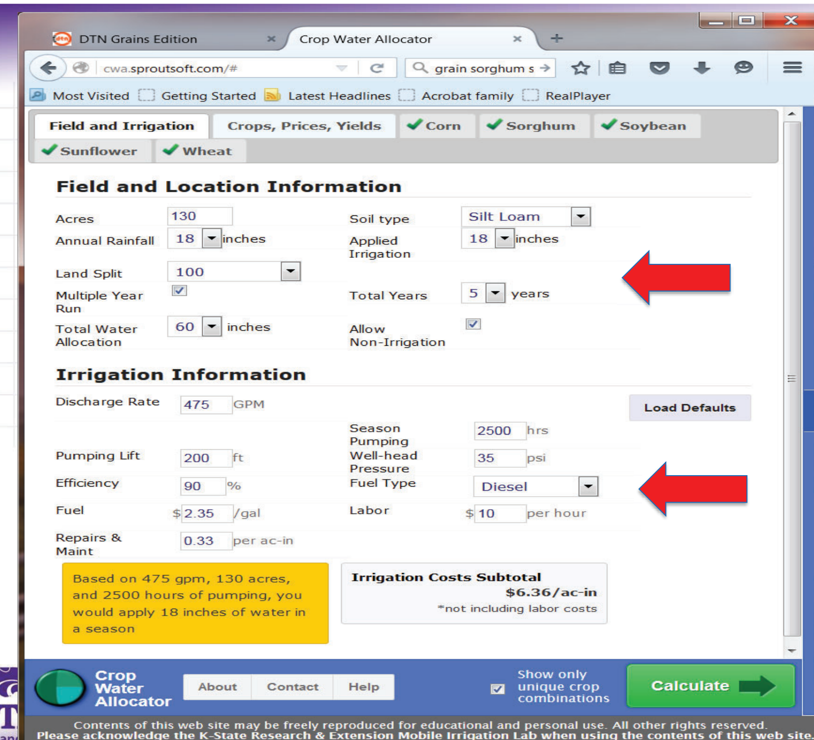

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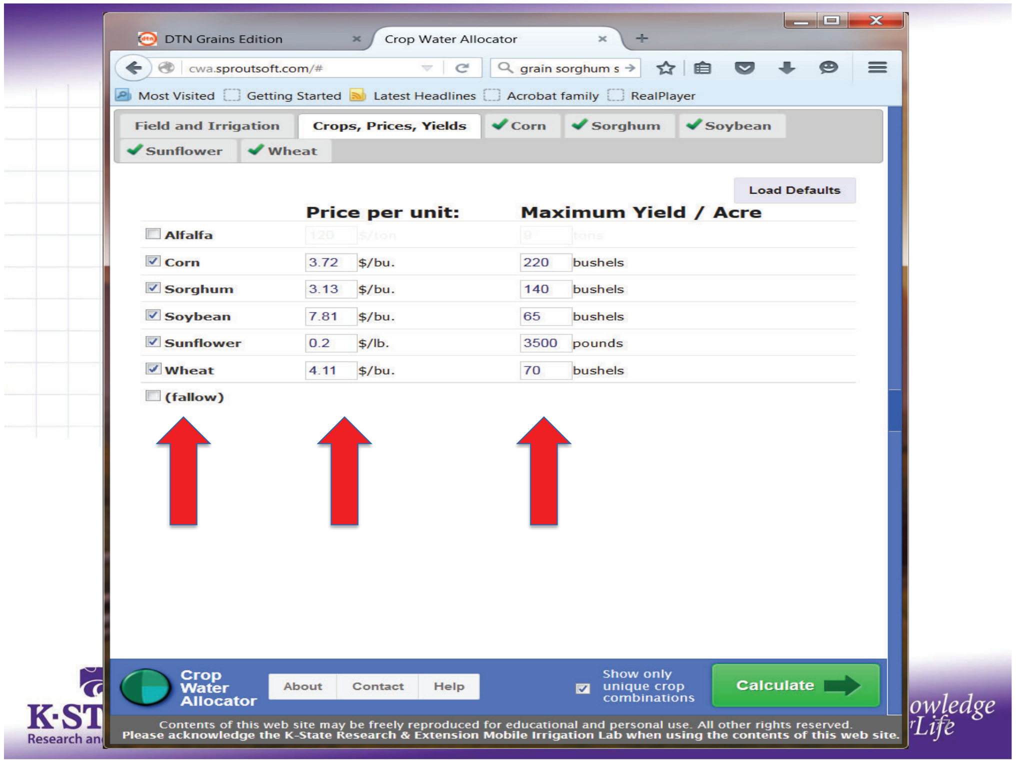

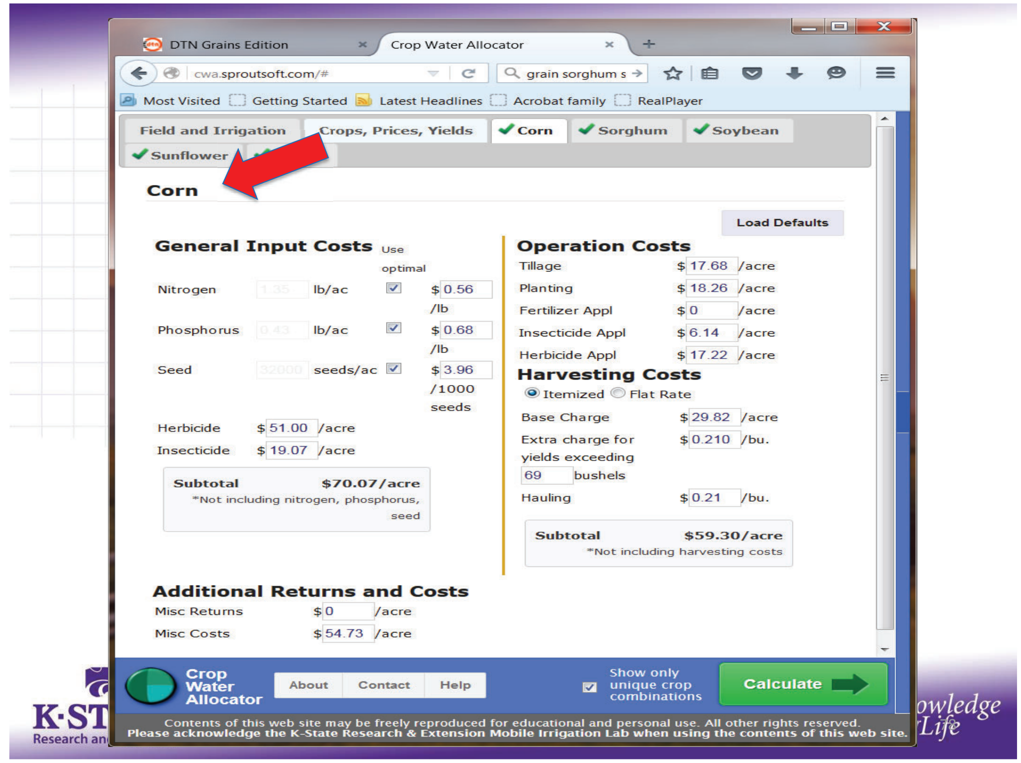

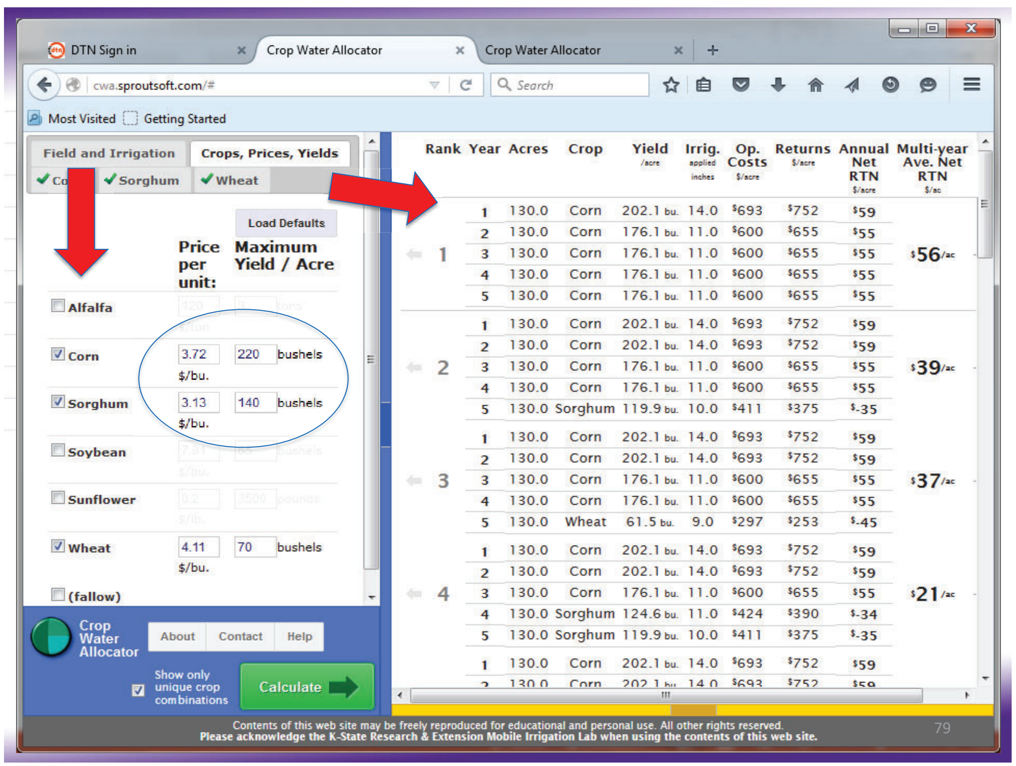

Acknowledgment

- Kansas Water Office
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- Kansas Water Office
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- Kansas Corn Commission
- K-State Global Food System
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- USDA-NIFA

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THANK YOU

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