

Profitability between Subsurface Drip and Center Pivot Irrigation Systems in Oklahoma Panhandle

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OK Panhandle Production

- The irrigated area in the Oklahoma Panhandle area (OPA) agriculture includes 106,236 acres of corn and 19,457 acres of sorghum, and 64,671 acres of winter wheat (NASS, 2012)
- OWRB (2012) well data shows that OPA counties Texas, Cimarron, and Beaver have 1640, 680, and 400 irrigation wells respectively
- Almost all of the irrigation in OPA is pumped from Ogallala aquifer, the major problem faced by the producers is prolonged droughts and steady groundwater levels
- OPA groundwater levels are declining at a rate of 1 to 3 feet per year. The estimated recharge is 0.25 inches per year
- Recent irrigation research initiated by OSU, studied the possible alternative crops (grain sorghum) and sub-surface drip irrigation (SDI) could increase benefits for Panhandle producers

Features of the SDI

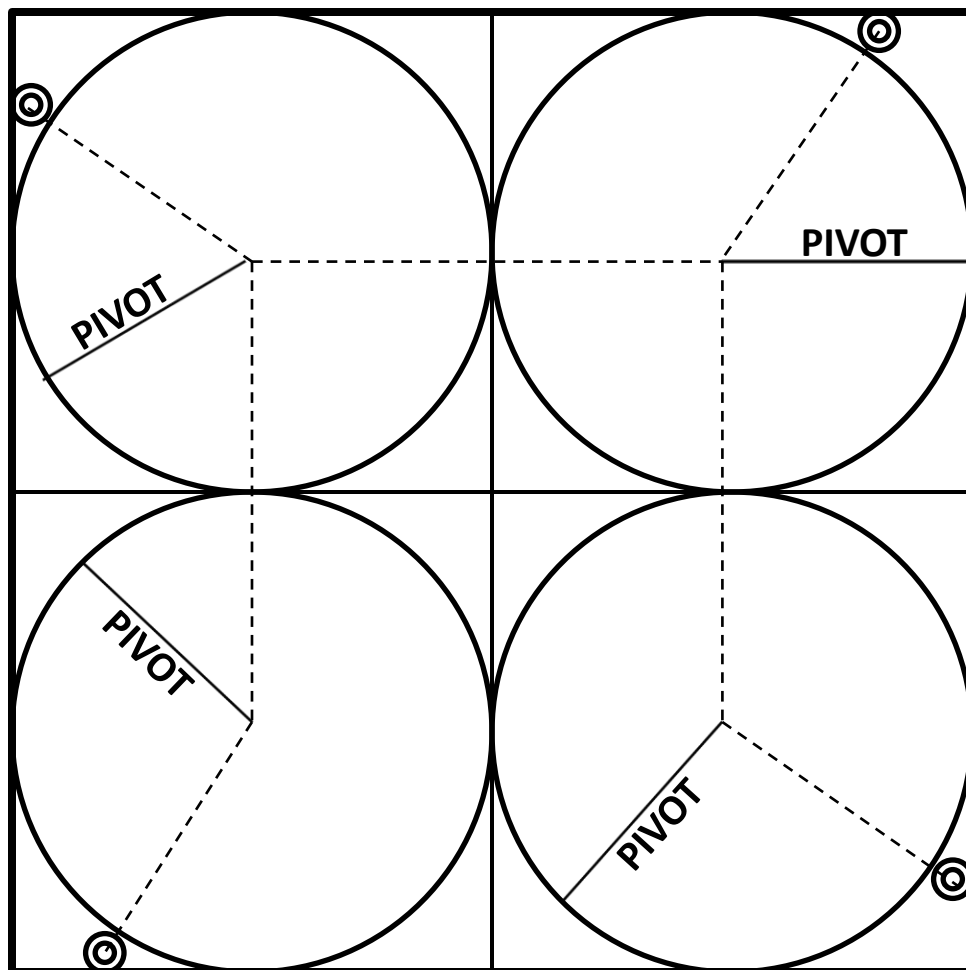
- The subsurface drip irrigation system (SDI) has high application efficiency, uniform application, and localized delivery method
- The major disadvantage of the drip systems is the high investment and maintenance cost

OBJECTIVES

In this study, the main objectives are,

- To extend the experiments trials by determining expected yields possible under a wide range of weather conditions and irrigation application ranges
- To estimate the pumping cost by calculating drawdown using USGS aquifer characteristics
- To compare the economics of investing subsurface drip (SDI) and conventional pivot system (CPS) irrigation systems
- To determine cropland choice and irrigation size (number of pivots and drip size) that will maximize net discounted benefits from the remaining groundwater

Representative Farm for Pivot Irrigation



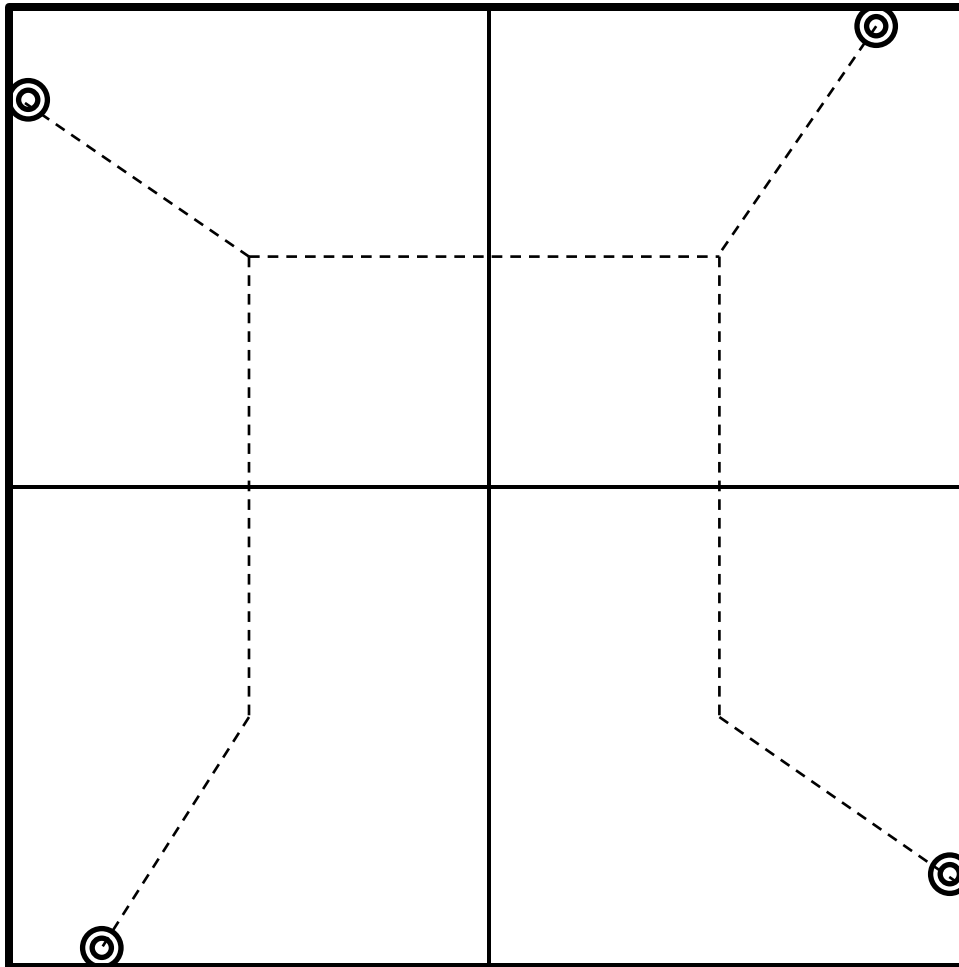
- 640-acre field
- 4 existing wells tied
- 120-acre Pivot Circle
- Irrigates maximum up to 480 acres

INPUTS FOR EPIC SIMULATION

Well Capacity	Application Rate	Irrigation Frequency	Stress Levels
GPM	Acre-inch	Days	Percent
800	1.4	4	90-30%
700	1.4	5	90-30%
600	1.4	6	90-30%
500	1.4	7	90-30%
400	1.4	8	90-30%
300	1.4	11	90-30%
200	1.4	16	90-30%
100	1.4	32	90-30%

 Irrigation Wells
  Underground Pipe

Representative Farm for Drip Irrigation



- 640-acre farm
- 4 existing wells tied
- 50 acre, 75 acre, 100 acre, 125, and 150 acre Drip system size.
- Irrigates maximum up to 600 acres

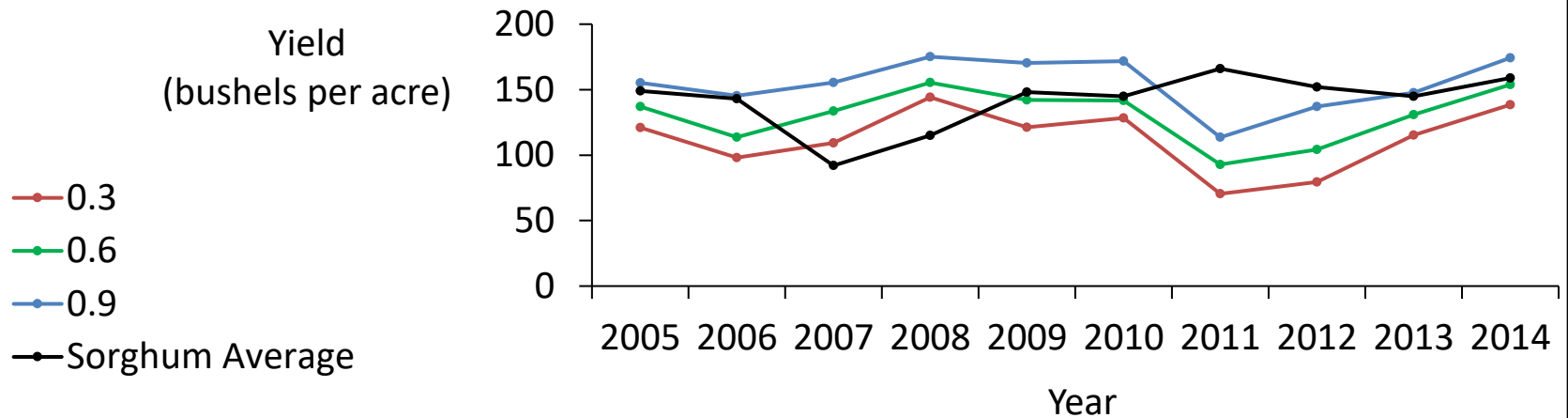
INPUTS FOR 125-acre SDI EPIC SIMULATION

Well Capacity	Application Rate	Irrigation Frequency	Stress Levels
GPM	Acre-inch	Days	Percent
800	0.35	daily	90-30%
700	0.31	daily	90-30%
600	0.28	daily	90-30%
500	0.24	daily	90-30%
400	0.20	daily	90-30%
300	0.16	daily	90-30%
200	0.12	daily	90-30%
100	0.08	daily	90-30%

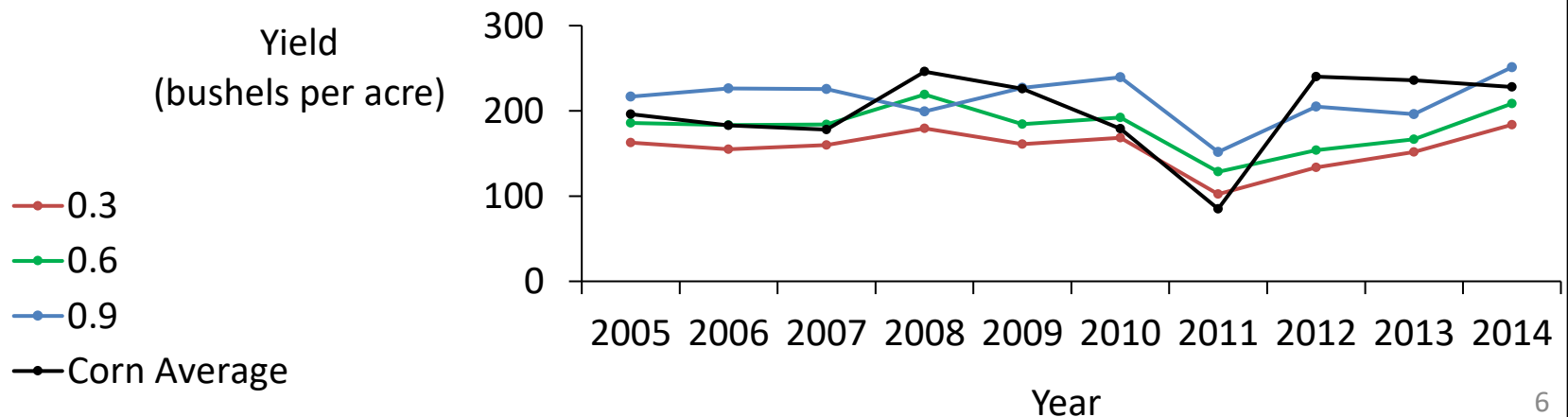
 Irrigation Wells
  Underground Pipe

EPIC Validation with Irrigation Research

Sorghum Yields Validation



Corn Yields Validation

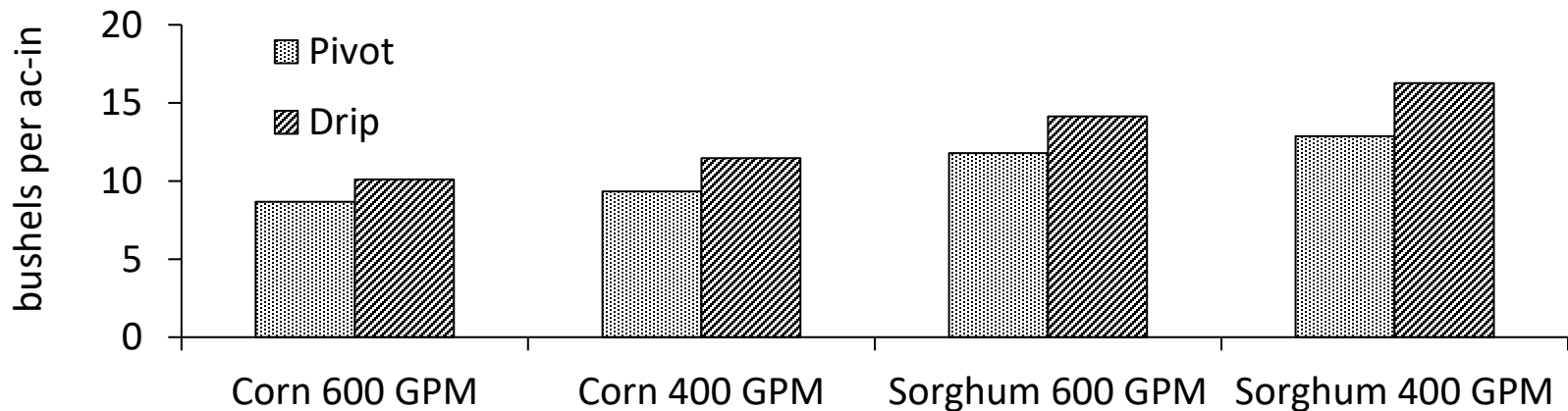


Simulation Results

50-year EPIC simulation results of irrigated corn and sorghum using pivot and drip system at 10 percent stress

		Corn				Sorghum			
Well Capacity (GPM)		Pivot		Drip		Pivot		Drip	
GPM	GPM per ac	bu.	in.	bu.	in.	bu.	in.	bu.	in.
800	6.7	213	23	215	23	163	16	167	13
600	5.0	187	22	202	20	148	13	161	11
400	3.3	164	18	179	16	134	10	147	9
200	1.7	122	10	144	10	92	4	97	3

Water use efficiency between Pivot and Drip irrigation



Budget Analysis

- Net revenue was calculated using the EPIC results and current market prices. In OPA, ten year average corn price is \$4.5 per bushel and sorghum price is \$4.2 per bushel.

Crop, GPM	Yield	Net Rev	Cost	ac-ft	Pumping Cost/ ac-ft	Pumping Cost	Net returns
Corn 800 GPM	213	\$956	583	1.9	63.5	\$122	\$250
Sorghum 800 GPM	162	\$679	405	1.3	63.5	\$83	\$190

Crop, GPM	Yield	Net Rev	Cost	ac-ft	Pumping Cost/ ac-ft	Pumping Cost	Net returns
Corn 400 GPM	164	736	519	1.5	62.8	92	125
Sorghum 400 GPM	134	558	364	0.9	62.8	54	139

- To ease the calculation, efficiency of the pump and motor were kept constant.
- Discounted crop budgets were prepared for all possible crop activities

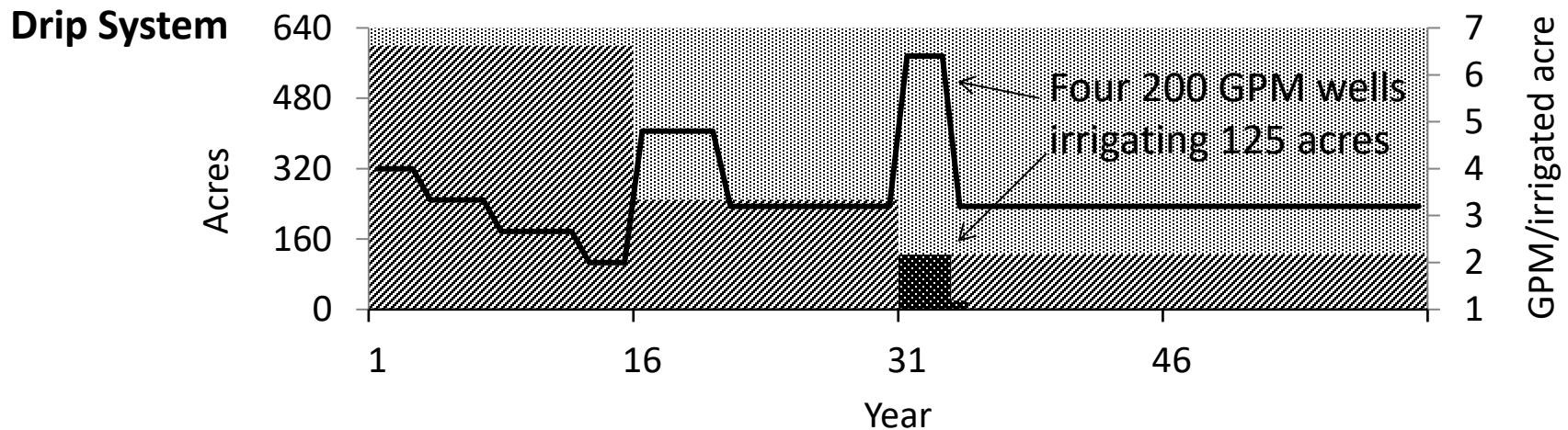
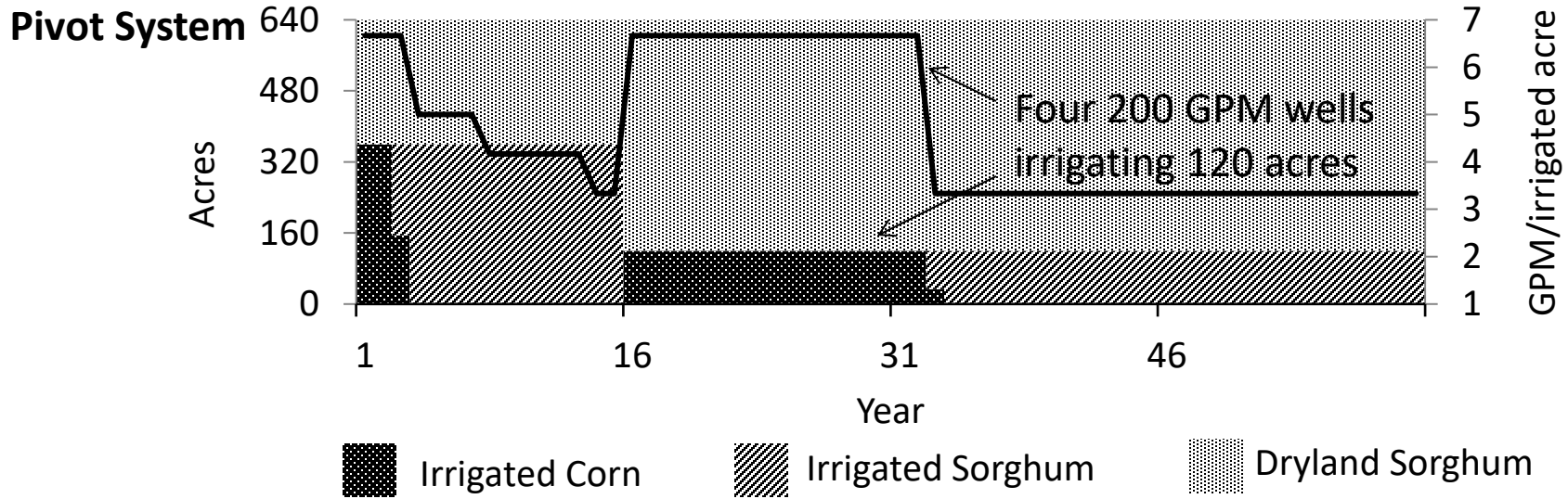
Present value of a crop activity

$$= \frac{\text{price} \times \text{yield} - \text{variable cost} - \text{pumping cost}}{(1+4\%)^t}$$

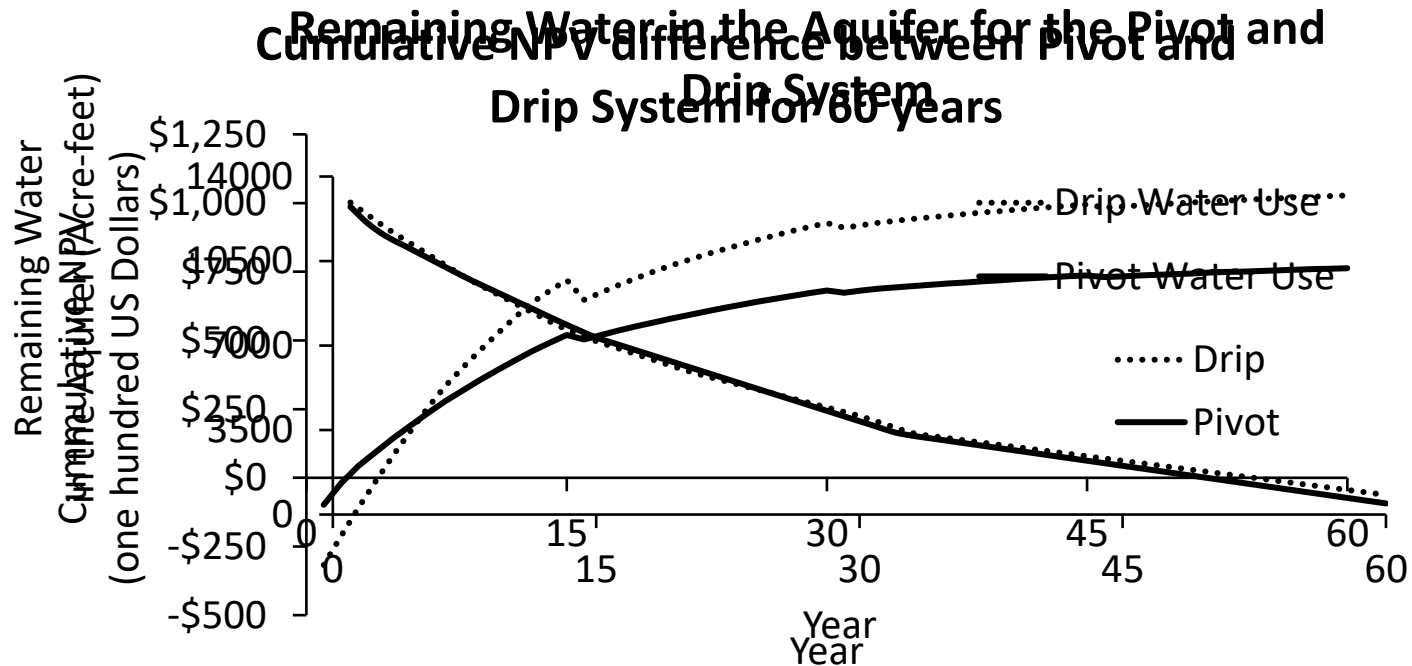
Mathematical Programming

- 60-year Mixed integer programming (MIP) was developed for Pivot and Drip Irrigation
- The model had the choice of irrigating corn or sorghum on a optimal (purchased) irrigation size. The purchase decision depends on the remaining water in the aquifer
- Both the pivot and drip system life was assumed as 15 years
- The cost of 120-acre pivot system is \$60,300, and drip system size of 50 acre is \$43,000, 75 acre is \$58,000, 100 acre is \$74,300, 125 acre is \$90,700, and 150 acre is \$107,000
- As the well capacity declines, the model combines the four wells and irrigates crop on a ideal size at higher GPM
- Pivot model had 19,480 activities and Drip model had 100,020 activities

Pivot and Drip crop allocation on a 640-acre in Oklahoma Panhandle



MIP Results



Total Bushels of Grain Produced in 60 years using Pivot and Drip System

Irrigation Method	Irrigated		Dryland	Total
	Sorghum (bu.)	Corn (bu.)	Sorghum (bu.)	Grain (bu.)
Pivot	1,092,795	629,254	1,741,560	3,463,609
Drip	2,329,903	84,990	1,399,410	3,814,304
Change (+/-)	1,237,108	- 544,264	- 342,150	- 350,695

Conclusion and Limitations

- This research suggests that replacing irrigated corn with sorghum and switching to SDI gains highest net discounted benefit or NPV over the remaining aquifer life

Limitations include:

- Sorghum research is very limited, therefore, sorghum could benefit from more research on genetics and substitute feed feasibility
- Crop rotation is not considered in this study, rotations with corn, sorghum, and wheat rotations could change the estimated yield results
- Changes in market price for corn and sorghum could also affect crop choice and system profitability

Thank you

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