AN ECONOMIC COMPARISON OF SUBSURFACE DRIP IRRIGATION (SDI) AND CENTER PIVOT IRRIGATION FOR FIELD CORN

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SUMMARY

An economic analysis was conducted to compare subsurface drip irrigation (SDI) with center pivot sprinkler irrigigation for corn production in western Kansas. The analysis revealed that SDI systems had lower returns than in-canopy center pivot sprinkler systems. Economic returns of SDI were relatively insensitive to typical pumping costs and application efficiencies, but were very sensitive to initial investment, system longevity, and corn yield.

INTRODUCTION

The economy of western Kansas relies heavily on irrigated crop production. Irrigated acres in western Kansas represented 11.2% of the total acres planted to the five major crops in the state in 1992. However, the crop production accounted for 22.3% of the total production in the state. Irrigated crop production also supports the feedlot industry which plays a major role in the economy of the region and state. Because irrigation is so critical to the economy of Kansas, it is important that groundwater resources be used as efficiently as possible.

Irrigation water use reports from the Kansas Division of Water Resources (DWR) indicate there was more irrigated acres under center pivot sprinkler than surface irrigation in 1992. However, in western Kansas where irrigation water use is higher than other areas of the state, there were more acres irrigated with surface systems than with center pivot sprinkler systems. The three Groundwater Management Districts in western Kansas accounted for 73.2% of the state's irrigated acres in 1992. This indicates that the western region of the state offers the greatest potential for water savings through improved application and water use efficiency.

The trend in recent years has been towards conversion of surface to center pivot sprinkler systems which are considered to be more efficient delivery systems. As producers consider converting to more efficient systems, they need to consider all of their alternatives and determine which will be the most economical for their production and management capabilities. Center pivot sprinkler systems are currently

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the most commonly considered alternative, but subsurface drip irrigation (SDI) is also a possibility.

Subsurface drip irrigation is a highly efficient delivery system requiring less overall water compared to other irrigation delivery systems due to more uniform water application, reduced evaporation losses, and decreased percolation. While the annual pumping costs of SDI can be lower than other irrigation delivery systems, the initial capital investment is often higher. Because of this, SDI has typically been associated with high-value crops such as fruits and vegetables. However, as parts of the Ogallala Aquifer continue to experience varying levels of overdraft, SDI may become a viable alternative to present irrigation systems.

ECONOMIC ANALYSIS METHODOLOGY

The economic profitability of SDI was compared to a low pressure center pivot sprinkler irrigation system using partial budgeting. Partial budgeting analyzes the profitability of an investment, but unlike whole-farm budgeting it does not indicate whether or not the farm as a whole is profitable. It is recognized that SDI may have some whole-farm implications due to management and labor requirements. For example, if managing the SDI system takes time away from other enterprises, production and profitability might fall. This "cost" of SDI does not show up in a partial budget. Managing a SDI system is not necessarily more difficult than managing other systems, but it does require a different set of management procedures.

The first step in the economic analysis was to determine the investment requirements of the SDI and center pivot sprinkler systems. The SDI system investment was based on irrigating 160 acres with 5.0 foot dripline spacings and 660 foot dripline lengths (Table 1). The SDI system design was based on research in Kansas from the Northwest Research-Extension Center (NWREC) and Southwest Research-Extension Center (SWREC). The center pivot sprinkler system investment was based on a low pressure system with drops on 5.0 foot spacings irrigating 126 acres (Table 2). A dealer survey was conducted in the spring of 1994 to estimate investment costs.

Annual ownership costs of the irrigation systems were calculated by amortizing the system cost over its estimated useful life - 10 years for the SDI system and 15 years for the center pivot sprinkler system, at 9 percent interest. The SDI system would most likely have a lower salvage value than a center pivot sprinkler system. However, due to the uncertainties associated with depth to water, energy costs and potential obsolescence at the end of the payback period, a zero salvage value was assumed for both systems in the analysis. Water conservation and water quality protection are both important and valuable. However, the value of these benefits is difficult to quantify, thus they were not factored into the analysis.

The second step in the economic analysis was to decide upon three key production parameters; crop area breakdown, crop yields and the amount of irrigation water applied. These figures are correlated and vary with well capacity, irrigation system, field size, soil type and location. The SDI system was assumed to irrigate 160 acres versus 126 acres for the center pivot sprinkler system. The corners of the center pivot sprinkler system, 34 acres, were assumed to be in a wheat-fallow rotation with 17 acres planted to wheat each year. Well capacity was assumed adequate to support either system at full capacity. Thus, irrigated corn yields were equal for both systems at 175 bu/acre. The amount of irrigation necessary for optimal yields will vary by year, location, management, and system. For the analysis, 18.5 acre inches of irrigation was assumed for the SDI system, which represented the economic optimal irrigation level from water use requirement studies conducted at the NWREC (Lamm, 1992) and SWREC (Weis et al., 1992). It is generally assumed that center pivot sprinkler systems are not as efficient as SDI systems, and as a result require higher levels of irrigation for equal yields. Initially, it was assumed the center pivot sprinkler system had an application efficiency of 90% compared to an application efficiency of 100% for the SDI system.

Based on the production assumptions used, income and production expenses were similar for corn irrigated by either the SDI or center pivot sprinkler systems (Table 3). Income per irrigated acres was constant because it was assumed yields were equal for both systems. Government program payments were assumed to be equal for both systems so they were not included in the analysis. Production expenses for the center pivot sprinkler system were slightly greater than SDI because of the increased water applied and higher operating pressure. However, this additional cost was partially offset by the increased labor assumed for the management of the SDI system. Machinery ownership costs (depreciation, interest, and insurance) were not included in the analysis. It was assumed there would be no difference in machinery requirements between the two systems.

RESULTS AND DISCUSSION

The center pivot sprinkler system had an annual economic advantage of \$22.51/a over the SDI system (Table 4). The SDI system irrigated more acres and generated greater returns to management and investment (\$22,293 versus \$17,731) than the center pivot sprinkler system; however, it could not overcome the greater annual ownership costs associated with the higher initial investment. Annual ownership costs were calculated as the initial investment cost of the system (\$90,995 versus 48,490) amortized over the expected life of the system (10 versus 15 years) at 9% interest.

The returns of both the SDI and center pivot sprinkler systems were very sensitive to changes in certain variables. A sensitivity analysis was done to determine how changes in major variables affected the relative returns of the two systems. The application efficiency of the center pivot sprinkler was initially assumed to be 90% compared to 100% for the SDI system. Even if the center pivot sprinkler application efficiency was 70% compared to 100% for the SDI system and the pumping cost of water was \$4.00/inch, the advantage of center pivot sprinkler over SDI was still about

$4/a (Fig. 1). This indicates that irrigation pumping costs are not a major determinant of relative profitability of the two systems in western Kansas.

Variation in the amortization period was also evaluated to determine its impact on returns. As the system longevity increases, the advantage of the center pivot sprinkler system decreases. With a payback of 15 years for both systems, the returns from SDI were slightly less than the returns from the center pivot sprinkler system (Fig. 2). However, the expected useful life of the SDI system is more uncertain than for the center pivot sprinkler system.

Because the initial investment cost of the SDI system is considerably higher than the center pivot sprinkler system ($90,995 vs. $48,490), changes in the relative investment cost of one or both systems will impact returns. If the initial investment of the SDI system was decreased 25% ($90,995 to $68,246) and the center pivot sprinkler investment remained unchanged ($48,490), the returns of the two systems would be equivalent (Fig. 3).

An additional economic comparison was made varying corn yields. This analysis was conducted to determine the potential income advantage the SDI system had over the center pivot sprinkler system due to more irrigated acres (160 vs 126). These comparisons found that overall returns between the two systems were equal with relatively small changes in annual corn yields. For example, annual returns of the two systems were equal with a 10 bu/a increase in SDI system corn yields compared to those of the center pivot sprinkler (185 vs 175), holding all other variables constant (Fig. 4). Yields might be higher under SDI due to more uniform water application, but currently little data exists comparing yield potential in a side-by-side comparison of the two systems. Even with equal corn yields, the SDI system will be more economical than the center pivot system with corn yields in excess of 225 bu/a.

This analysis indicates that center pivot sprinkler systems are currently more profitable than SDI for corn in western Kansas. This is primarily due to the large difference in initial investment. However, the analysis also indicates the relative returns of the two systems are highly sensitive to variables such as useful life of system, initial investment, and relative crop yield. Irrigation pumping costs did not have a major impact on the relative profitability of the two systems.

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Table 1. Capital Requirements: Subsurface Drip Irrigation (160 ac.)[1]

Item	Items by Foot: Feet	Price/ft	Subtotal	Single Items	Total
8" mainline pipe	1,980	$1.30	$2,574		$2,574
8" submain pipe	2,640	$1.30	$3,432		$3,432
6" submain pipe	1,360	$0.70	$952		$952
4" submain pipe	1,280	$0.61	$781		$781
4" flushline pipe	10,560	$0.61	$6,442		$6,442
Driptape	1,399,200	$0.0318	$44,495		$44,495
Driptape connectors (supply tubing & sleeve lock)				$3,168	$3,168
2– 8" PIP crosses				$147	$147
4– 8" PVC butterfly wafer valves				$1,336	$1,336
4– 8–6" PVC reducers				$70	$70
4– 6–4" PVC reducers				$38	$38
12– 4" PVC elbows				$117	$117
12– 4" PVC removable endcaps				$190	$190
PVC glue & solvent				$250	$250
Filter– 900 Gpm, automated sand media				$7,974	$7,974
26– Pressure gauges (0 – 30 Psi)				$390	$390
Trenching	15,180	$0.6750	$10,247		$10,247
Producer labor (995.4 hrs @ $8/hr)				$7,960	$7,960
Producer provided tractors (62 hrs)				$433	$433
Total					$90,995
System Costs Per Irrigated Acre					$569

[1] All charges based on producer installation

Table 2. Capital Requirements: Center Pivot Sprinkler Irrigation (126 ac.)[1]

Item	Items by Foot: Feet	Price/ft	Subtot	Single Items	Total
Standard 8 tower pivot system base price (1320 ft.)				$32,500	
Drops on 60" spacing				$2,100	
Low drift nozzles				$2,400	
32" x 11.2 tires				$3,000	
Sprinkler system total					$40,000
8" underground pipe	1,320	$2.40	$3,168		$3,168
Electrical wiring	1,320	$2.10	$2,772		$2,772
Connectors				$350	$350
12 KVA generator				$2,200	$2,200
Total					$48,490
System Costs Per Irrigated Acre					$385

[1] All charges on an installed basis

Table 3. Crop Income and Production Expenses Per Acre

	Corn-SDI[1]	Corn-Pivot[1]	Wheat[2]
INCOME			
Crop yield	175	175	35
Crop price/bushel	$2.30	$2.30	$2.90
Crop sales/acre	$402.50	$402.50	$101.50
PRODUCTION EXPENSES			
Labor	$24.00	$20.00	$9.60
Seed	$32.00	$32.00	$3.12
Herbicide	$26.25	$26.25	$9.40
Insecticide	$49.04	$49.04	$0.00
Fertilizer	$33.45	$33.45	$3.60
Fuel and oil	$8.05	$8.05	$5.55
Machinery repairs	$21.50	$21.50	$11.90
Pumping energy	$38.79	$46.63	$0.00
Irrigation repairs & maintenance	$3.13	$3.97	$0.00
Crop consulting	$6.00	$6.00	$0.00
Interest on production expenses	$12.11	$12.34	$2.16
TOTAL CROP EXPENSES/ACRE	$254.32	$259.23	$45.33

[1] All expenses, except pumping energy and irrigation repairs and maintenance, are from: "Center Pivot-Irrigated Corn", MF-585, Kansas State University.

[2] All expenses are from: "Summer Fallow Wheat in Western Kansas", MF-257, Kansas State University

Table 4. Subsurface Drip Irrigation (SDI) Feasibility Comparison

	SDI		Center Pivot
NET INVESTMENT	$90,995		$48,490
Interest rate on investment	9.0%		9.0%
Years for payback/useful life	10		15
IRRIGATION MANAGEMENT			
Annual repairs[1]	$500		$500
Pumping cost/inch of water[2]	$2.10		$2.27
Inches of water pumped/acre[3]	18.5		20.6
Pumping energy cost/acre	$38.79		$46.63
ACREAGE BREAKDOWN			
Irrigated corn acres	160		126
Nonirrigated wheat acres	0		17
Fallow acres	0		17
TOTAL ACRES	160		160
RETURNS ANALYSIS[4]			
Crop Income:			
Irrigated acres	$64,400		$50,715
Nonirrigated acres	$0		$1,726
TOTAL INCOME	$64,400		$52,440
Crop Expenses:			
Irrigated acres	$40,691		$32,663
Nonirrigated acres	$0		$771
Total property taxes[5]	$1,416		$1,276
TOTAL EXPENSES	$42,107		$34,709
Return to Management and Total Investment	$22,293		$17,731
Annual Cost of Irrigation Equipment (P&I)[6]	$14,179		$6,016
Returns to Mgmt, Land and Mach. Investment	$8,114		$11,716
DIFFERENCE		−$3,602	
Returns to Mgmt, Land and Mach. Investment/Acre	$50.71		$73.22
DIFFERENCE		−$22.51	

[1] Because little is known concerning annual repair costs, they are assumed equal for this analysis.

[2] Based on 25 psi for SDI and 35 psi for center pivot sprinkler.

[3] Based on an application efficiency of 100% for SDI and 90% for center pivot sprinkler.

[4] Acres x income and expenses from Table 4.

[5] Calculated as 1% of the value of land (irrigated = $885/ac and nonirrigated = $472/ac).

[6] Annual payment based on the net investment value amortized over the years for payback at 9% interest.

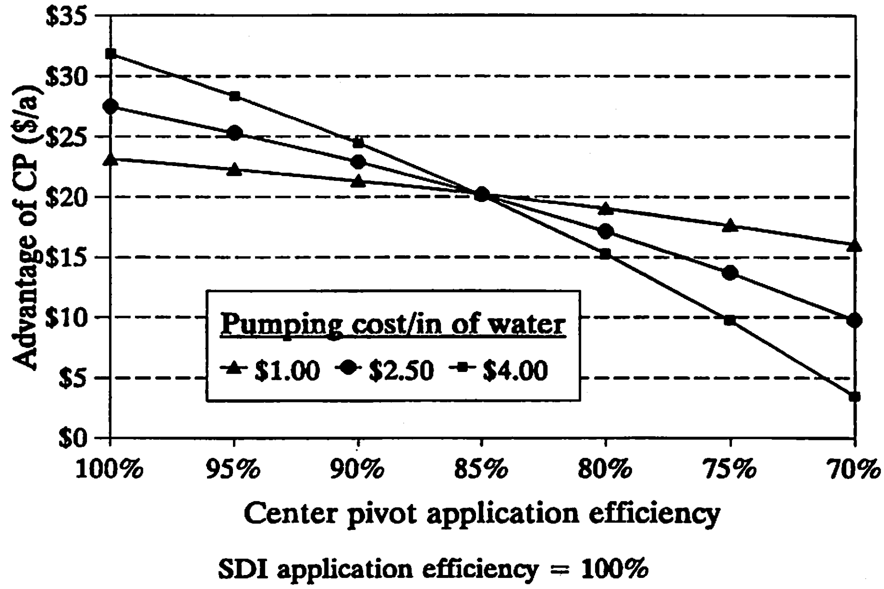


Figure 1. Annual Economic Advantage of Center Pivot Irrigation over SDI vs. Pumping Costs and Center Pivot Application Efficiencies.

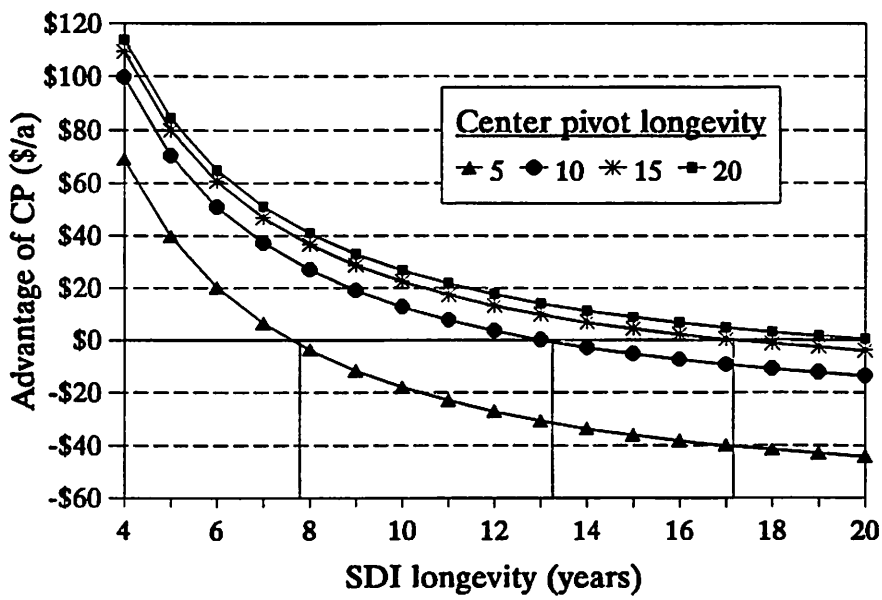
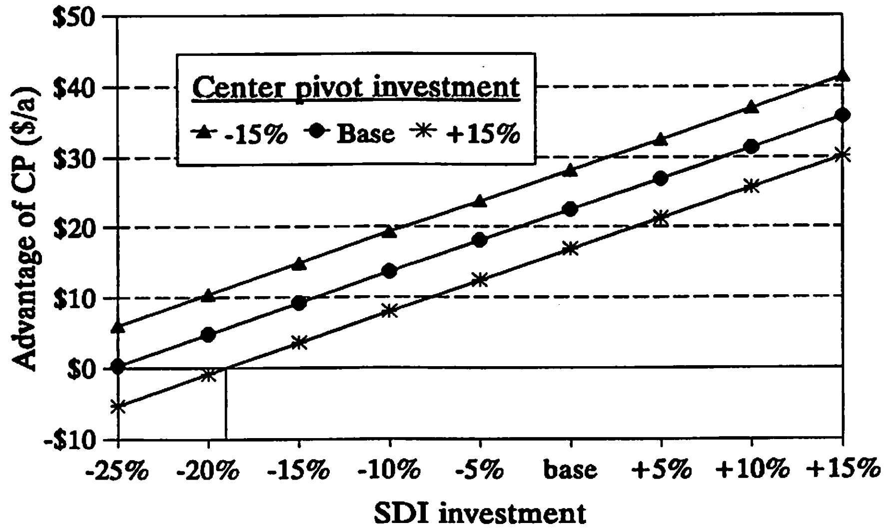


Figure 2. Annual Economic Advantage of Center Pivot Irrigation over SDI vs. Years for System Longevity.



Base investment = $90,995 for SDI and $48,490 for center pivot.

Figure 3. Annual Economic Advantage of Center Pivot Irrigation over SDI vs. Initial Investment for Systems.

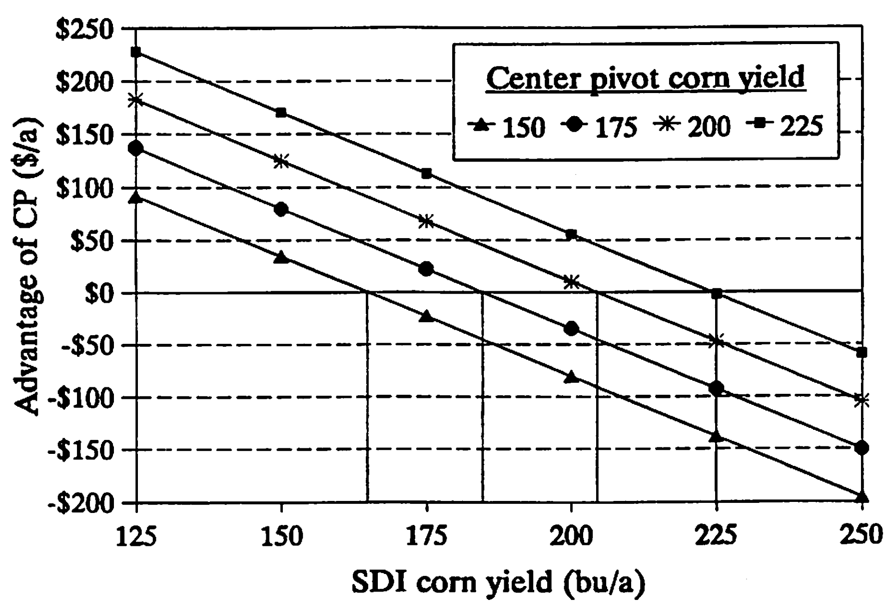


Figure 4. Annual Economic Advantage of Center Pivot Irrigation over SDI vs. Corn Yields.

DESIGN AND MANAGEMENT CONSIDERATIONS FOR SUBSURFACE DRIP IRRIGATION SYSTEMS

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INTRODUCTION

Every project must have a goal. This goal should be solidly grounded with a purpose. It makes little sense to achieve a goal if the purpose has not been satisfied. If the goal of the irrigator is to develop and operate a successful subsurface drip irrigation (SDI) system, what is the purpose? Water conservation and water quality protection have often been cited as possible purposes to consider SDI. If so, it is imperative that the SDI system be designed and operated in a manner that there is a realistic hope to satisfy those purposes. It should also be noted that an improperly designed SDI system is less forgiving than an improperly designed center pivot sprinkler system. Water distribution problems may be difficult or impossible to correct for an improperly designed SDI system.

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