Center Pivot Sprinkler and SDI Economic Comparisons

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INTRODUCTION

In much of the Great Plains, the rate of new irrigation development is slow or zero. However, as the farming populace and irrigation systems age, there has been a continued momentum for conversion of existing furrow-irrigated systems to modern pressurized irrigation systems. These systems, including center pivot sprinkler irrigation (CP) and subsurface drip irrigation (SDI), can potentially have higher irrigation efficiency and irrigation uniformity while at the same time reducing irrigation labor. SDI is a relatively new irrigation system alternative for corn production on the Great Plains. Producers converting from furrow-irrigated systems to a pressurized system are faced with economic uncertainty about whether to convert to center pivot sprinklers (CP) or SDI. This paper presents economic comparisons of CP and SDI and the sensitivity of these comparisons to key factors. A Microsoft Excel[1]spreadsheet template also will be introduced for making these comparisons.

ANALYSES METHODS AND ECONOMIC ASSUMPTIONS

Field & irrigation system estimates

An existing furrow-irrigated field with a working well and pumping plant is being converted to either center pivot sprinkler irrigation or SDI. The pumping plant is located at the center of one of the field edges and is at a suitable location for the initial SDI distribution point (i.e. upslope of the field to be irrigated). Any necessary pump modifications (flow and pressure) for the CP or SDI systems are assumed to be of equal cost and thus are not considered in the analysis.

Land costs are assumed to be equal across systems for the overall field size with no differential values in real estate taxes or in any government farm payments. Thus these factors "fall out" or do not economically affect the analyses.

An overall field size of 160 acres (square quarter section) was assumed for the base analysis. This overall field size will accommodate a 125 acre CP system and a 155 acre SDI system. It was assumed that there would be 5 noncropped acres consumed by field roads and access areas. The remaining 30 acres under the CP system are available for dryland cropping systems.

Irrigation system costs were obtained from KSU estimates (O'Brien et al., 2001). The 125 acre CP system was assumed to cost $48,375 or $387.00/irrigated acre, while the 155 acre SDI system was assumed to cost $126,015 or $813/irrigated acre. In the base analyses, the life for the two systems are assumed to be 25 and 15 years for the CP and SDI systems, respectively. No salvage value was assumed for either system. This assumption of no salvage value may be inaccurate, as both systems might have a few components that may be reusable or available for resale at the end of the system life. However, relatively long depreciation periods of 15 and 25 years makes the zero salvage value a minor issue in the analysis.

When the overall field size decreases, thus decreasing system size, there are large changes in cost per irrigated acre between systems. SDI costs are nearly proportional to field size, while CP costs are not proportional to field size (Figure 1). Quadratic equations were developed to calculate system costs when less than full size 160 acre fields were used in the analysis:

$$\text{CPcost\%} = 44.4 + (0.837 \times \text{CPsize\%}) - (0.00282 \times \text{CPsize\%}^2) \quad \text{(Eq. 1)}$$

$$\text{SDIcost\%} = 2.9 + (1.034 \times \text{SDIsize\%}) - (0.0006 \times \text{SDIsize\%}^2) \quad \text{(Eq. 2)}$$

where CPcost% and CPsize%, and SDIcost% and SDIsize% are the respective cost and size % in relation to the full costs and sizes of irrigation systems fitting within a square 160 acre block.

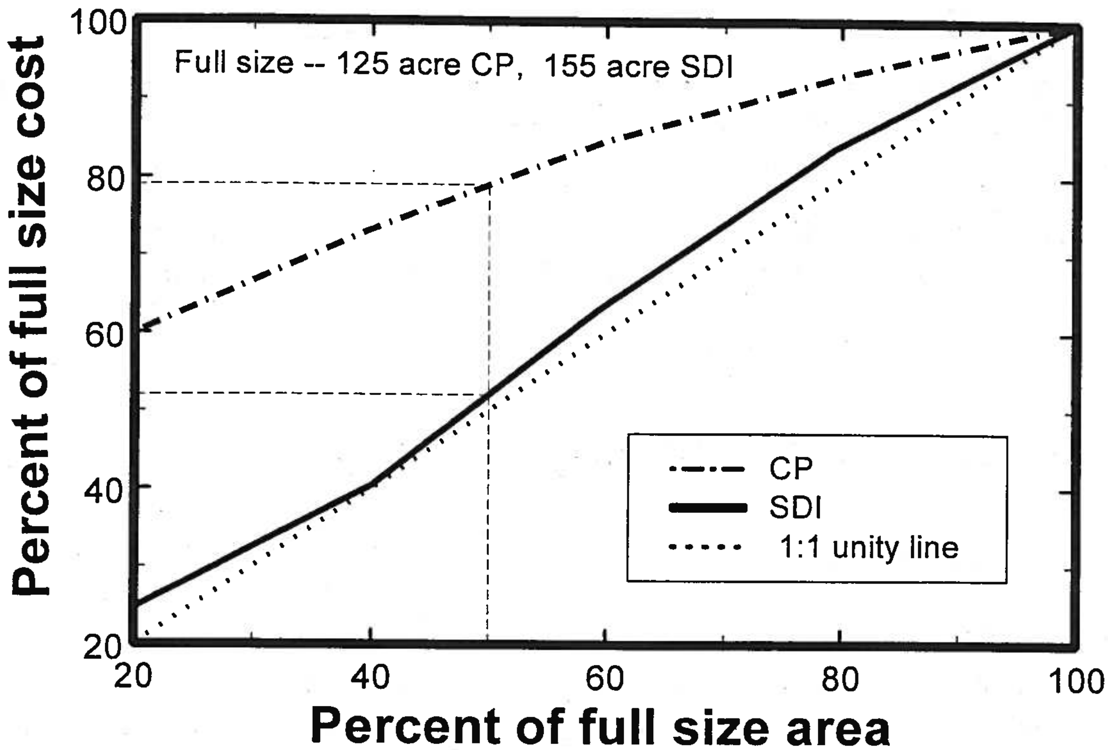

Figure 1. CP and SDI system costs as related to field size. (O'Brien et al., 1997)

Investment interest costs were assumed to be 8% and total interest costs were converted to an average annual interest cost for this analysis. Annual insurance costs were assumed to be 0.25% of each total system cost. It is unclear whether insurance can be obtained for SDI systems and if SDI insurance rates would be lower or higher than CP systems. Many of the SDI components are not subject to the climatic conditions that are typically insured hazards for CP systems. However, system failure risk is probably higher with SDI systems which might influence any obtainable insurance rate.

A summary of field and system estimates is provided in Table 1.

Table 1. Field description and irrigation system estimates

	Total	CP	SDI
Field area, acres	160	125	155
Non-cropped field area (roads and access areas), acres	5	-	-
Cropped dryland area, acres		30	0
Irrigation system investment cost, total $		$48,375	$126,015
Irrigation system investment cost, $/irrigated acre		$387	$813
Irrigation system life, years		25	15
Interest rate for investment, %	8		
Annual Insurance rate, % of total system cost		0.25	0.25

Production cost estimates

The following economic analysis expresses the results as an advantage or disadvantage of CP systems over SDI in net returns to land and management. Thus, many fixed costs do not affect the analysis and can be ignored. Additionally, the analysis does not indicate if either system is ultimately profitable for corn production under the assumed current economic conditions.

Production costs are adapted from KSU estimates (Dumler, et al., 2001). CP variable costs are estimated to be $334.73/acre in the baseline analysis while SDI variable costs are slightly lower at $319.47/acre. The reduction in variable costs for SDI is attributable to an assumed 25% net water savings that is consistent with research findings by Lamm et al., 1995. This translates into a 17 and 13 inch gross application amount for CP and SDI, respectively, for this analysis. The estimated production costs (Table 2.) are somewhat high considering the gross revenues are only approximately $500/irrigated acre. This may be reflecting the overall profitability issue during these economic conditions, but producers might also try to reduce these variable costs somewhat to cope with low crop prices. This fact is pointed out because a lowering of overall variable costs favors SDI, since more irrigated cropped acres are involved, while higher overall variable costs favors CP production. The variable costs for both irrigation systems represent typical practices for western Kansas.

Table 2. **Variable costs factors for corn using CP and SDI.**

Factor	CP	SDI
Corn seeding rate, seeds/acre	30000	30000
Corn seed costs at $1.16/1000 seeds, $/acre	$34.80	$34.80
Herbicide, $/acre	$30.48	$30.48
Insecticide, $/acre	$38.54	$38.54
Nitrogen fertilizer, lb/acre	225	225
Nitrogen fertilizer at $0.13/lb, $/acre	$29.25	$29.25
Phosphorus fertilizer, lb/acre	45	45
Phosphorus fertilizer at $0.22/lb, $/acre	$9.90	$9.90
Crop consulting, $/acre	$6.50	$6.50
Custom hire/machinery expenses, $/acre	$105.00	$105.00
Irrigation labor, $/acre	$5.00	$5.00
Irrigation amounts, inches	17	13
Fuel and oil for pumping, $/inch	$3.34	$3.34
Fuel and oil for pumping, $/acre	$56.78	$43.42
Irrigation maintenance and repairs, $/inch	$0.33	$0.33
Irrigation maintenance and repairs, $/acre	$5.61	$4.29
1/2 year interest on variable costs with 8% rate	$12.87	$12.29
Total Variable Costs	**$334.73**	**$319.47**

Yield and revenue stream estimates

Corn grain yield was estimated at 210 bushels/acre in the base analysis and a corn selling price of $2.35/bushel. Net returns for the 30 cropped dryland acres for the CP system (corners of field) were assumed to be $32.50/acre which is essentially the current dryland crop cash rent estimate for Northwest Kansas. Government payments related to irrigated crop production are assumed to be spread across the overall field size and thus do not affect the economic comparison of systems.

Sensitivity analyses

In any economic analyses the results depend greatly on the initial economic assumptions. In this analyses, changes in the economic assumptions can affect which system is most profitable and by how much. Thus, a major effort of this paper as indicated in the title was to examine the economic sensitivity of the baseline results to key economic factors. The factors examined were:

- Size of CP irrigation system
- Shape of field (full vs. partial circle CP system)
- Life of SDI system
- SDI system cost
- Any additional production cost savings with SDI
- Corn yield
- Corn price
- Yield/price combinations
- Yield advantage for SDI

Microsoft Excel spreadsheet template

A Microsoft Excel[1]spreadsheet template was created to perform the economic analyses. Additionally, this template can serve as an easy tool for users to perform their own comparisons using their own estimates. The template has five worksheets, the Main, CF, Field size & SDI life, SDI cost & life, Yield & price tabs. Most of the calculations and the result are shown on the Main tab (Figure 2.). The Main tab requires 18 user inputs to perform the comparison. However, current KSU suggestions are indicated for all 18 inputs in case the user does not have a better estimate. The user is responsible for entering and checking the values in the unprotected input cells. All other cells are protected on the Main tab. Some error checking exists on overall field size and some items (e.g. overall results and cost savings) are highlighted differently when different results are indicated. The CF tab represents the costs of production and is provided to the user for informational purposes. It is suggested to the user that rather than changing the baseline assumptions on the CF tab, the user should just input differential production costs between the systems on the Main tab. This will help maintain integrity of the baseline production cost assumptions. KSU plans to maintain the CF tab and update it at least annually. The essence of the CF tab is represented by Table 2. The last three tabs are sensitivity analyses for selected key factors. Figures 3, 4, and 5 restate most of the results of these three additional tabs in graphical form. These sensitivity analysis tabs automatically update when different assumptions are made on the Main tab.

This template determines the economics of converting existing furrow-irrigated fields to center pivot sprinkler irrigation (CP) or subsurface drip irrigation (SDI) for corn production.

Version 03, modified by F.R. Lamm, 1-12-03

Field description and irrigation system estimates	Total	Suggested	CP	Suggested	SDI	Suggested
Field area, acres	160 ←	160	125 ←	125	155 ←	155
Non-cropped field area (roads and access areas), acres	5 ←	5				
Cropped dryland area, acres (= Field area - Non-cropped field area - Irrigated area)			30		0	
Irrigation system investment cost, total $			$48,375.00 ←	$48,375	$126,015.00 ←	$126,015
Irrigation system investment cost, $/irrigated acre			$387.00		$813.00	
Irrigation system life, years			25 ←	25	15 ←	15
Interest rate for system investment, %	8% ←	8%				
Annual insurance rate, % of total system cost			0.25% ←	0.25%	0.25% ←	0.25%
Production cost estimates			CP	Suggested	SDI	Suggested
Total variable costs, $/acre (See CF Tab for details on suggested values)			$334.73 ←	$334.73	$319.47 ←	$319.47
Additional SDI variable costs (+) or savings (-), $/acre			Additional Costs →		$0.00 ←	$0.00
Yield and revenue stream estimates			CP	Suggested	SDI	Suggested
Corn grain yield, bushels/acre		Suggested	210 ←	210	210 ←	210
Corn selling price, $/bushel	$2.35 ←	$2.35				
Net return to cropped dryland area of field ($/acre)	$32.50 ←	$32.50				
Advantage* of CP over SDI, $/total field each year		**$3,612.30**				
$/acres each year		**$22.58**	* Advantage in *Net returns to land and management*			

Figure 2. ***Main*** **worksheet (tab) of CP_SDI Excel template used to compare CP and SDI for corn production. Available for free at http://www.oznet.ksu.edu/sdi/ on the SDI software page.**

RESULTS AND DISCUSSION OF THE ECONOMIC ANALYSES

Baseline analysis

Using the baseline assumptions (Table 1 and Table 2), the CP system has a $3,612.30/year ($22.58/acre-year) advantage over the SDI system (Figure 2.) These results match the general conclusions of O'Brien et al., 1998 indicating that CP systems generally have an advantage for large field sizes. Although, SDI systems can generate more gross revenue by having a higher percentage of irrigated acres in a given field, the much lower cost and longer assumed system life for full sized 125 acre CP systems offsets the higher SDI revenue advantage.

Sensitivity to field and irrigation system assumptions

The economic comparison is very sensitive to the size of the CP system and to the shape of the field (full vs. partial circle CP system). Smaller CP systems and systems which only complete part of the circle are less competitive with SDI than full size 125 acre CP systems (Figure 3). This is primarily because the CP investment costs ($/ irrigated acre) increase dramatically as field size decreases (Figure 1) or when the CP system cannot complete a full circle.

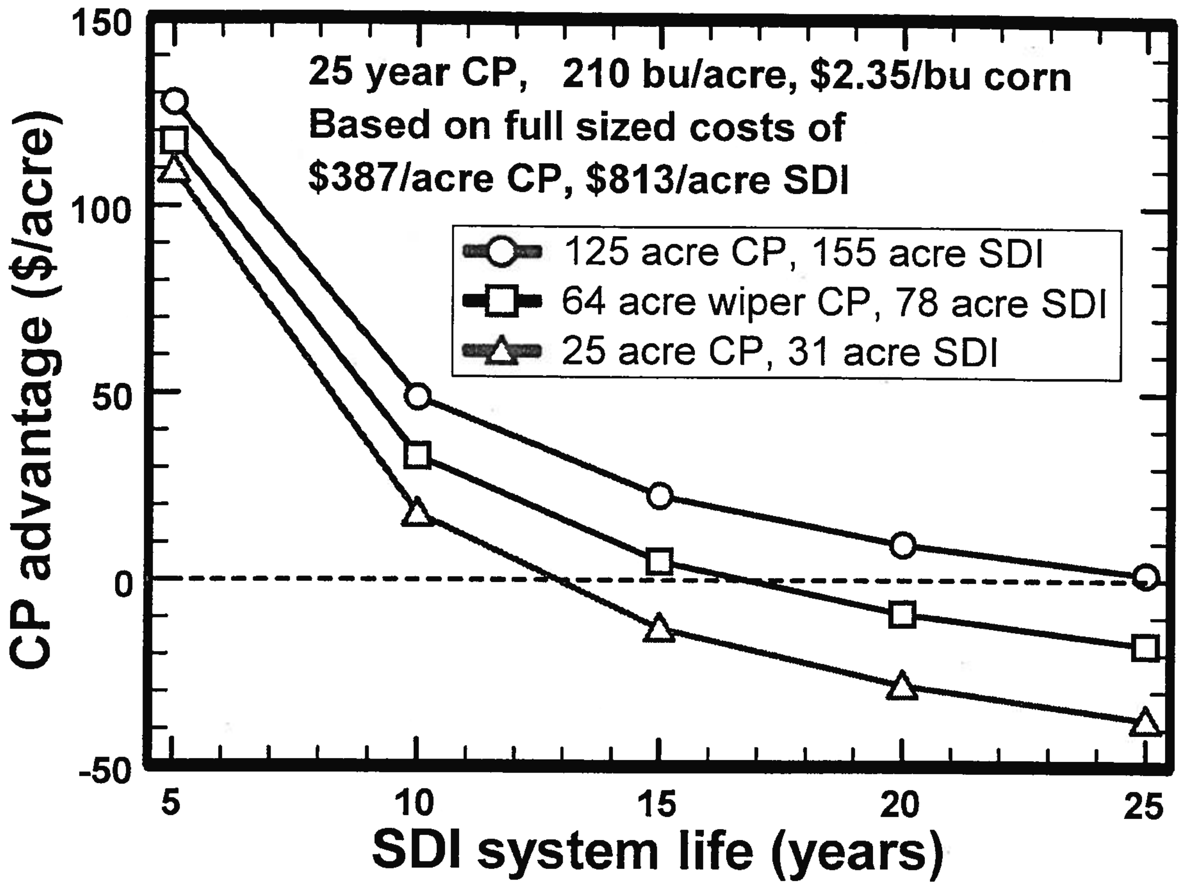

Figure 3. CP economic advantage as affected by field size, shape, and SDI system life.

The economic comparison is also very sensitive to life of the SDI system and to the SDI system cost (Figures 3 and 4). Increased longevity for SDI systems is probably the most important factor for SDI to gain economic competitiveness with CP systems. Conversely a short SDI system life that might be caused by early failure due to clogging, indicates a huge economic disadvantage that must be avoided. The sensitivity of CP system life and cost is much less (data not shown) because of the much lower initial CP cost and the much longer assumed life. In areas where CP life might be much less than 25 years due to corrosive waters, a sensitivity analysis with shorter CP life is warranted.

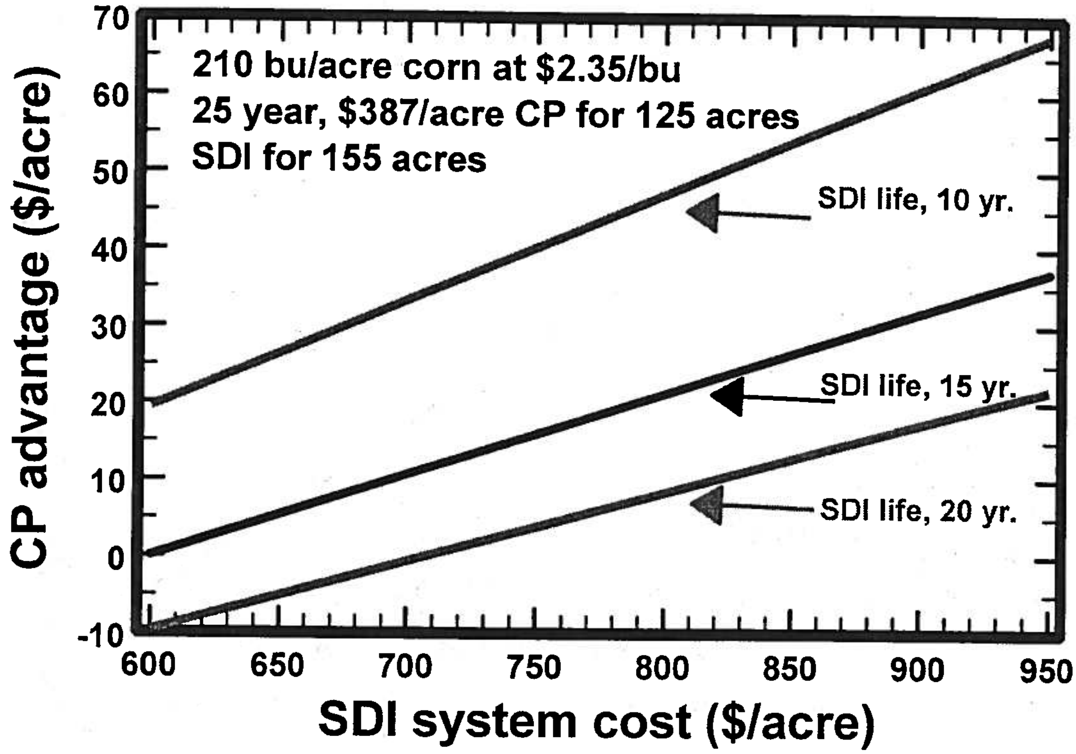

Figure 4. CP economic advantage as affected by SDI system life and cost.

<u>Sensitivity to production cost estimates</u>

The economic comparison is very sensitive to any additional cost savings with SDI (Figure 5). It should be noted that the present baseline analysis already assumes a 25% water savings with SDI. There are potentially some other production cost savings such as fertilizer and herbicides that have been reported for some crops and some locales. Small changes in the assumptions can make a sizable difference.

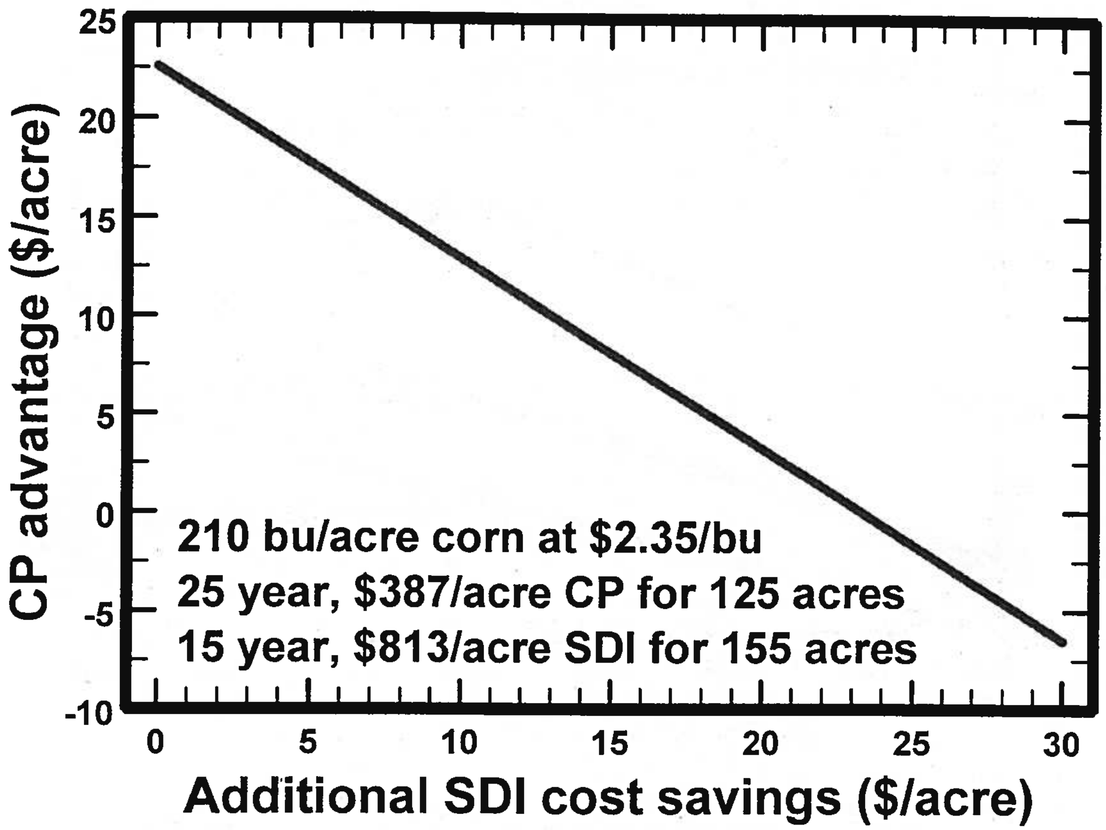

Figure 5. CP economic advantage as affected by additional SDI production cost savings.

Sensitivity to yield and revenue stream estimates

The economic comparison is moderately sensitive to corn yield and price and yield/price combinations and is very sensitive to any yield advantage for SDI. Higher yields and higher corn prices allow SDI to become more economically competitive with CP systems (Figure 6.). Combining a higher overall yield potential with an additional small yield advantage for SDI can allow SDI to be very competitive with CP systems (Figure 7.).

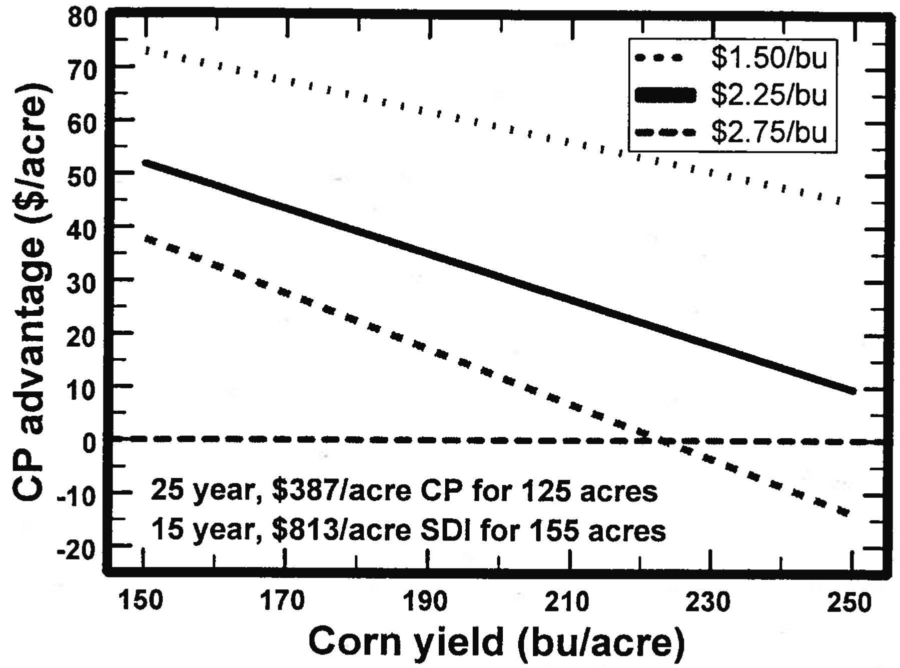

Figure 6. CP economic advantage as affected by corn yield and price.

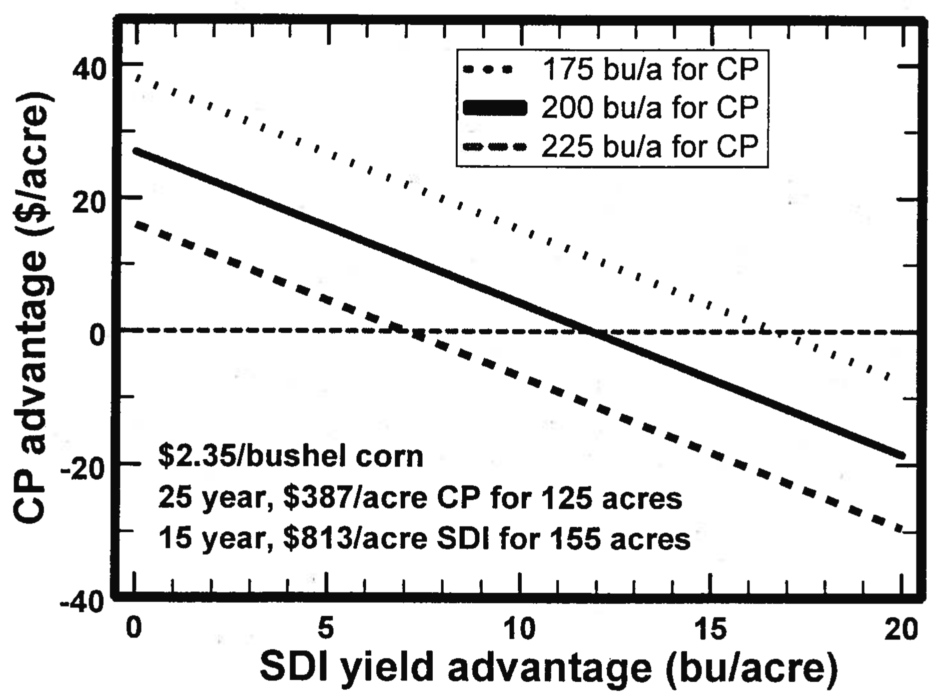

Figure 7. CP economic advantage as affected by overall corn yield potential and SDI yield .

CONCLUSIONS

Economic comparisons of CP and SDI systems are sensitive to the underlying assumptions used in the analysis. These results show that these comparisons are very sensitive to

- Size of CP irrigation system
- Shape of field (full vs. partial circle CP system)
- Life of SDI system
- SDI system cost

with advantages favoring larger CP systems and cheaper, longer life SDI systems.

The results are very sensitive to

- any additional production cost savings with SDI

The results are moderately sensitive to

- corn yield
- corn price
- yield/price combinations

and very sensitive to

- higher potential yields with SDI

with advantages favoring SDI as corn yields and price increase.

The results obtained here might differ drastically from those obtained from using your own assumptions. A Microsoft Excel spreadsheet template has been developed to allow producers to make their own comparisons. It is available on the SDI software page of the KSU SDI website at http://www.oznet.ksu.edu/sdi/.

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[1] *Mention of tradename is for informational purposes and does not constitute endorsement by Kansas State University.*

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FILTRATION: A BASIC COMPONENT FOR SDI TO AVOID CLOGGING HAZARDS

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The major cause of failures in Subsurface Drip Irrigation (SDI) and other microirrigation systems worldwide is clogging. The emitters in SDI systems are small, leaving a small margin for error, so it is important to understand the filtration and maintenance requirements of SDI systems and take a proactive approach to the prevention of clogging. Fortunately, most SDI users in the Great Plains are pumping high-quality groundwater, such as from the Ogallala Aquifer. This reduces the potential for clogging. Even so, proper steps must be taken to prevent clogging and maintain effective SDI system operation. With proper selection of a filtration system and maintenance, SDI can be used with surface water and other low-quality waters. Prevention of clogging and proper maintenance of the SDI system start before it is installed. Chemical and biological analysis of the irrigation water will help in filter selection, and indicate measures required to prevent clogging. The drip tube requirements, emitter-opening size in particular, may play a role in the selection of the filtration system to use. Proper placement and use of flow meters and pressure gauges are required to provide feedback to the system operator. Monitoring the flow meters and pressure gauges over time can reveal system performance anomalies that may require attention. Air vents, check valves, and vacuum relief valves may be required at various places in the system to prevent entry of chemically treated water into the water source and soil particles into the drip tapes. Also, flush lines are required to occasionally remove the material accumulated in the drip tapes. These basic components are shown in Figure 1, and a cut away diagram of a typical emitter is shown in Figure 2. Clogging hazards for SDI systems, regardless of the water source, fall into three general categories: physical, chemical, and biological. This article will discuss prevention of clogging