ECONOMIC COMPARISON OF SDI AND CENTER PIVOTS FOR VARIOUS FIELD SIZES

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Subsurface drip irrigation (SDI) systems are feasible for some field crops and field arrangements using current levels of technology. Sprinkler irrigation systems have an economic advantage over SDI systems for the typical case where full-size center pivots can be used. However, center pivots lose important economies of scale as fixed investment costs are concentrated onto smaller acreages. Thus, the cost advantage for a center pivot system diminishes as field size is reduced.

This analysis assumes an existing flood-irrigated field with an existing well or water supply that is centrally located at the edge of the field. This flood-irrigation system is to be converted to either a center pivot or SDI system. The well is fully depreciated, but not in need of replacement. Investment cost estimates for alternative irrigation systems and estimated crop budgets for irrigated corn and summer fallow wheat in western Kansas are used to project annual profitability for the alternative irrigation and cropping systems. The objective is to compare center pivot and SDI system costs and net returns per acre for several field sizes.

FIELD INVESTMENT COSTS

Six field sizes were considered, starting with a standard quarter section (160 acres) on which a standard sized (125 acre) center pivot could be installed. The center pivot size was reduced in 25 acre increments from 125 acres down to 25 acres. The corresponding SDI field is assumed to be fully irrigated, whereas the center pivot field is assumed to have a combination of irrigated acres under the irrigated circle and non-irrigated acres on the center pivot corners. The exception is in the last comparison which assumes a typically shaped 80 acre field (a quarter section split into two equal rectangular parts) on which a standard sized center pivot could "windshield wipe" a semicircle of 64 acres, leaving 16 acres in dryland wheat-fallow rotation.

Investment costs and acreages used to compare the profitability of these two alternative irrigated cropping systems are shown in Table 1. Irrigation system investment costs were estimated using information from private industry and Kansas State University. In this analysis, the system life is projected to be 20 years for the center pivot and 10 years for of the SDI system. Additionally, all the components of each irrigation system are assumed to have no salvage value at the end of their projected life. Regular annual repair and maintenance expenses are assumed for each system. Per acre investment cost for center pivots increase as field size decreases in comparison to more stable SDI per acre investment costs. Figure 1 graphically illustrates the proportional cost reduction of a SDI system as compared to the less-adjustable cost structure of a center pivot. For example, as field size decreases by 50 percent, the SDI system cost also decreases by approximately 50 percent. In comparison, as field size decreases by 50 percent, the center pivot system cost is about 80 percent of the full sized system.

Table 1. Investment costs for various size center pivot and SDI systems.

	Center Pivot		**SDI**	**Center Pivot**		**SDI**	
Field Scenario	Irrigated Acres	Dryland Corners	Irrigated Acres	Total Cost $/Field*	Cost/Acre $/Acre	Total Cost $/Field**	Cost/Acre $/Ac
O	125	35	160	$40,782	$326	$86,210	$539
A	100	27	127	$37,948	$379	$72,258	$569
B	75	20	95	$34,527	$460	$54,388	$573
C	50	14	64	$29,909	$598	$34,836	$544
D	25	7	32	$24,459	$978	$21,251	$664
Wiper	64	16	80	$34,050	$532	$45,606	$570

* Includes underground pipe and electrical service & generator

** 5' dripline spacing

PROFITABILITY ANALYSIS

Partial budgeting was used to compare the profitability of the alternative irrigation and cropping systems. Unlike a whole-farm budget, a partial budget does not indicate whether the entire operation is profitable, but only if one enterprise or investment has a net returns advantage over another. Partial budgeting may not recognize all costs to the whole farm. For example, management of newly installed SDI systems may take more time than for the more familiar center pivot systems. The extra time is taken from other farm enterprises, which could affect their production efficiency and profitability. This is a SDI cost factor not accounted for in these partial budgets. Management of SDI systems is not necessarily more difficult than other irrigation systems, but does require a different set of management procedures.

CROP INCOME AND EXPENSES

The crop enterprises for the center pivot cropping system will be irrigated corn with dryland wheat-fallow on the nonirrigated corners. The SDI cropping system area will be in irrigated corn. The irrigation well capacity is assumed adequate for production of irrigated corn in all scenarios. Net revenue from the irrigated areas are projected assuming a corn yield of 190 bushels per acre, a price of $2.50 per bushel, average annual production flexibility contract (PFC) payments of $35 per acre, and production costs based on 1996 KSU Farm Management Guides. The net revenue from nonirrigated wheat acres is based on 40 bushel per acre yields, a price of $3.65 per bushel, PFC payments of $10 per acre, and 1996 KSU production cost estimates. Because land costs and management expenses over and above base labor expenses are not accounted for in these partial budgets, the net revenue projections represent per acre net returns to land and management for each irrigated cropping system.

Table 2 reflects the income and Table 3 shows line-by-line variable and fixed expenses for the baseline comparison of the quarter section (160 acre) field. In this analysis, SDI systems were assumed to have slightly less irrigation fuel and repair expenses due to lower pumping requirements. Center pivot irrigated corn was assumed to require 18 inches of applied water while SDI-irrigated corn was assumed to require 16 inches. Large differences exist in irrigation equipment depreciation and interest costs between alternative irrigation systems (Table 3).

Table 2. Crop revenue assumptions for SDI and center pivot systems.

Income	Corn-SDI	Corn-Pivot	Wheat
Crop yield (bu / acre)	190	190	40
Crop price ($ / bu)	$2.50	$2.50	$3.65
PFC payment ($ / acre)	$35	$35	$10
Total income ($ / acre)	$510	$510	$156

Crop production expenses do not vary on a per acre basis with changes in field size. Similarly, irrigation equipment depreciation and interest costs do not vary appreciably with field size for SDI on a per acre basis. However, drastic increases occur in irrigation equipment depreciation and interest costs on a per acre basis as field size decreases for center pivot systems. Table 4 summarizes these cost and return differences for all the field size scenarios for both SDI and center pivot systems.

Table 3. Corn and wheat-fallow expenses and net returns for SDI and center pivot on a per acre basis for a 160 acre field (base scenario O)

COST ITEMS	CROPPING SYSTEM ENTERPRISES		
	Corn - SDI	**Corn - Pivot**	**Wheat**
Variable costs			
Labor	$21.15	$21.15	$10.80
Seed	33.60	33.60	10.00
Herbicide	33.12	33.12	14.82
Insecticide	41.57	41.57	0.00
Fertilizer	46.20	46.20	15.20
Fuel & oil - crop	10.45	10.45	6.95
Fuel & oil - pumping	43.36	48.78	
Crop machinery repairs	23.20	23.20	10.92
Irrigation repairs and maintenance	4.80	5.40	
Crop insurance	6.75	6.75	4.89
Drying	19.00	19.00	0.00
Consulting	6.50	6.50	0.00
Miscellaneous	7.00	7.00	5.00
Interest on 1/2 variable costs	14.83	15.14	3.93
Total variable costs	**$311.53**	**$317.85**	**$82.51**
Fixed costs			
Depreciation	$15.34	$15.34	$12.35
Interest on machinery	15.93	15.93	12.83
Irrigation equipment depreciation	61.03	23.46	
Interest on irrigation equipment	29.44	18.81	
Insurance	2.06	1.53	0.48
Total fixed costs	**$123.80**	**$75.07**	**$25.65**
Total costs	**$435.33**	**$392.92**	**$108.16**
Net returns to land & management	**$74.67**	**$117.08**	**$47.84***

* Wheat-fallow rotation net returns are on an annual wheat acre basis. Annual net returns over all acres (wheat and fallow) are $23.92.

Projected center pivot cropping system income and expenses are less than for SDI cropping systems for all field-size scenarios. However, the differences in net returns (income minus expenses) for the two systems vary on a scenario by scenario basis. Center pivot systems have a $17 to $23 net returns advantage for larger size fields (95 to 160 acres). Returns for the two systems are essentially the same for the 64 acre scenario, but clearly favor SDI for smaller sized fields (32 acres). In comparing center pivot wiper and SDI systems on 80 acre tracts, the center pivot wiper cropping system (64 irrigated corn acres plus 16 dryland wheat-fallow acres) retains a small net return advantage ($12 per acre) over the SDI system with 80 acres of irrigated corn.

Table 4. Center pivot (CP) and SDI economic comparison across various field size scenarios.

Item	Base Scenario O		Scenario A		Scenario B		Scenario C		Scenario D		"Wiper" Scenario	
	160 acres		127 acres		95 acres		64 acres		32 acres		80 acres	
	Pivot	SDI	Pivot	SDI	Pivot	SDI	Pivot	SDI	Pivot	SDI	Pivot	SDI
Cropping system												
Irrigated acres	125 ac	160 ac	100 ac	127 ac	75 ac	95 ac	50 ac	64 ac	25 ac	32 ac	64 ac	80 ac
Non-irrigated acres	35 ac	0 ac	27 ac	0 ac	20 ac	0 ac	14 ac	0 ac	7 ac	0 ac	16 ac	0 ac
A. Crop income												
Irrigated corn	$63,750	$81,600	$51,000	$66,770	$38,250	$48,450	$25,500	$32,640	$12,750	$16,320	$32,640	$40,800
Dryland wheat	$2,730	---	$2,106	---	$1,560	---	$1,092	---	$546	---	$1,248	---
Total income	$66,480	$81,600	$53,106	$64,770	$39,810	$48,450	$26,592	$32,640	$13,296	$16,320	$33,888	$40,800
Income difference per acre (SDI – pivot)	***$94.50 /ac***		***$91.84 /ac***		***$90.95 /ac***		***$94.50 /ac***		***$94.50 /ac***		***$86.40 /ac***	
B. Crop costs												
Variable costs	$41,176	$49,845	$32,899	$39,565	$24,664	$29,596	$16,470	$19,938	$8,235	$9,969	$21,003	$24,923
Fixed costs	$9,833	$19,808	$8,399	$16,306	$6,918	$12,249	$5,327	$7,977	$3,638	$4,573	$6,359	$10,285
Land, mgmt costs	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total costs	$51,008	$69,633	$41,298	$55,871	$31,582	$41,844	$21,797	$27,915	$11,873	$14,542	$27,362	$35,208
Cost difference per acre (SDI – pivot)	***$116.53 /ac***		***$114.75 /ac***		***$108.03 /ac***		***$95.59 /ac***		***$83.42 /ac***		***$98.07 /ac***	
Variable cost	*$54 /ac*		*$52 /ac*		*$52 /ac*		*$54 /ac*		*$54 /ac*		*$49 /ac*	
Fixed cost	*$62 /ac*		*$62 /ac*		*$56 /ac*		*$41 /ac*		*$29 /ac*		*$49 /ac*	
C. Net Returns	$15,472	$11,947	$11,808	$8,899	$8,228	$6,606	$4,795	$4,725	$1,423	$1,778	$6,526	$5,592
Return difference												
Total (SDI – pivot)	*– $3,525*		*– $2,909*		*– $1,623*		*– $70*		*+ $286*		*– $934*	
per acre (SDI – pivot)	***– $22.07 /ac***		***– $22.90 /ac***		***– $17.08 /ac***		***– $1.09 /ac***		***+ $11.08 /ac***		***– $11.67 /ac***	

SENSITIVITY OF RESULTS TO CHANGES IN KEY FACTORS

A series of sensitivity analyses were conducted to determine how sensitive these results are to changes in certain key economic factors. These key factors are corn yield and price, irrigation system life, and SDI dripline costs. The sensitivity of projected net returns to these factors was determined for scenarios O (160 acres), D (32 acres), and the wiper scenario (80 acres). These scenarios were selected because they represent the extremes in field size (scenarios O and D) and a difference in center pivot point location and field shape (wiper scenario).

Sensitivity to Corn Yield and Price

Increases in corn yield and/or price will increase SDI net returns relative to those for the center pivot cropping system (Table 5). The trend is illustrated in Figure 2 for the full size field, scenario O. Figure 2 illustrates that at a corn price of $2.75 per bushel, SDI system net returns are competitive with center pivot cropping systems when corn yields exceed 210 bushels per acre. The wiper center pivot system remains more profitable in all cases except for high yield and price combinations. However, the differences in net returns between the systems are much less for the 80 acre wiper scenario than for the 160 acre full circle (base scenario O). In the small acreage scenario D, SDI has higher net returns in all cases except where both yields and prices are notably below the assumed averages in the preceding analysis. When corn prices and yields are low, center pivot cropping systems generally have a larger net return advantage. As corn prices and yields increase, SDI systems become more competitive economically.

Sensitivity to Irrigation System Life

Irrigation system life has a major effect on projected net returns (Table 6). Changes in the life of the SDI system from 5 to 10 to 15 years have a more dramatic effect on net returns than do changes in center pivot system life from 15 to 20 to 25 years. For example, in Base scenario O, the net returns advantage of a center pivot system with a life of 15 years over a SDI system with a life of 10 years is $18 per acre. The net returns advantage of center pivot systems in this scenario increases by $6 per acre to $22 if the center pivot has a 20 year life.

While a change in the life of a center pivot from 15 to 25 years increases projected net returns per acre from $6 to $21 per acre across the three field size scenarios considered here, an increase in SDI system life from 5 to 15 years increases projected net returns per acre from $71 to $89 per acre, or from at least 3 to 12 times the effect of a 10 year increase in center pivot life. The effect is most pronounced in scenario D where a

Table 5. Advantage of center pivot cropping systems over SDI as affected by yield and price (CP minus SDI cropping system returns per acre).

Base scenario O: (125 acre center pivot + 35 acre W-F) versus 160 acre SDI				
	Corn Cash Price			
Corn Yields	$2.25/bu	$2.50/bu*	$2.75/bu	$3.00/bu
160	$47	$38	$29	$20
175	$39	$30	$20	$11
190*	$32	$22*	$12	$1
205	$25	$14	$3	-$8
220	$18	$6	-$6	-$18
"Wiper" scenario: (64 acre center pivot + 16 acre W-F) versus 80 acre SDI				
Corn Yields	$2.25/bu	$2.50/bu*	$2.75/bu	$3.00/bu
160	$34	$26	$18	$10
175	$28	$19	$10	$1
190*	$21	$12*	$2	-$7
205	$15	$4	-$6	-$16
220	$8	-$3	-$14	-$25
Scenario D: (25 acre center pivot + 7 acre W-F) versus 32 acre SDI				
Corn Yields	$2.25/bu	$2.50/bu*	$2.75/bu	$3.00/bu
160	$13	$5	-$4	-$13
175	$6	-$3	-$13	-$22
190*	-$1	-$11*	-$21	-$32
205	-$8	-$19	-$30	-$41
220	-$15	-$27	-$39	-$51

* 190 bushel per acre irrigated corn yields and $2.50 cash price are the standard assumptions in the preceding analysis. The center pivot and SDI systems are assumed to have a life of 20 and 10 years, respectively.

change in SDI irrigation system life from 5 to 10 years while holding center pivot system life at 20 years causes a major change in the comparative net returns between the two systems. With a 5 year SDI system life in scenario D, the center pivot system has a $55 per acre net returns advantage over the SDI system. Conversely, if the SDI system has a 10 year life in this scenario, SDI has an $11 net returns advantage over the center pivot cropping system. SDI systems with a 15 year life clearly have a net returns advantage over center pivot cropping systems with a 25 year life for the wiper and 32 acre scenarios while net returns are nearly equal for the 160 acre scenario (Figure 3). SDI must have a system life approaching at least 10 years to be economically competitive with center pivot irrigation systems. Research SDI systems at Kansas State University Experiment Stations have been in use for up to nine years without any appreciable deterioration. Several commercial SDI systems in the southwestern United States have been in use for nearly 20 years. Evidence suggests that SDI systems with proper design and management should have good longevity.

Table 6. Advantage of center pivot cropping systems over SDI as affected by system life (CP minus SDI cropping system returns per acre)

Base scenario O: (125 acre center pivot + 35 acre W-F) versus 160 acre SDI			
	Center Pivot Life		
SDI System Life	15 years	20 years*	25 years
5 years	$72	$76	$78
10 years*	$18	$22*	$25
15 years	$0	$4	$7
20 years	-$9	-$5	-$2
"Wiper" scenario: (64 acre center pivot + 16 acre W-F) versus 80 acre SDI			
SDI System Life	15 years	20 years*	25 years
5 years	$62	$69	$73
10 years*	$5	*$12	$16
15 years	-$14	-$7	-$3
20 years	-$24	-$17	-$13
Scenario D: (25 acre center pivot + 7 acre W-F) versus 32 acre SDI			
SDI System Life	15 years	20 years*	25 years
5 years	$43	$55	$63
10 years*	-$24	-$11*	-$3
15 years	-$46	-$33	-$26
20 years	-$57	-$44	-$37

** 20 year center pivot life and 10 year SDI system life are standard assumptions in the preceding analysis. The corn yield is assumed to be 190 bushels per acre with a cash price of $2.50 per bushel.

Sensitivity to SDI Dripline Price

Dripline prices have a major impact on the total cost of SDI irrigation systems. Decreasing dripline prices increase the economic competitiveness of SDI. However, the selection of the most profitable irrigation system is not affected within the ranges of dripline prices and field-size scenarios considered (Figure 4). The center pivot system remained the most profitable system for scenario O and the wiper system across the range of dripline prices considered. Conversely, for scenario D the SDI cropping system remains most profitable system across the range of dripline prices considered except at the highest dripline price.

CONCLUSIONS

Several factors influence the relative profitability of center pivot and SDI cropping systems. According to the assumptions used in this analysis, center pivot cropping systems have higher estimated net returns than SDI cropping systems on standard quarter-section (160 acre) fields. As field size decreases, center pivot cropping system net returns eventually fall below those of SDI cropping systems. This occurs primarily because per acre investment costs for SDI remain relatively stable as field size declines, whereas center pivot irrigation system's per acre investment costs increase markedly.

SDI cropping system net returns are very sensitive to system longevity or life span. If a SDI system only lasts 5 years, it is noncompetitive in a net returns sense with center pivot cropping systems across all field-size scenarios. A SDI system with a 15-year life is economically competitive with center pivots on fields of less than full size (less than 160 acres), and even approaches economic competitiveness on full size fields.

Changes in corn yields and prices have a major effect on the projected net returns of these alternative cropping systems. Higher corn yields and prices favor fully irrigated SDI cropping systems. In this analysis corn yield and price changes generally do not affect the choice of irrigation systems across the different field-size scenarios for the range of corn yield and prices considered.

Any decrease in dripline prices results in improved SDI net returns relative to center pivot cropping systems. Still though, the selection of the most profitable irrigation and cropping system was not affected across the range of dripline prices or cropping system scenarios considered.

The results of this study are highly dependent on the assumptions made in calculating cropping system net returns for western Kansas. Producers considering an investment in either a center pivot or SDI cropping system should complete a partial budget analysis using information specific to their farm. These economic sensitivity analyses were performed by varying only one factor at a time. In practice, several factors may change simultaneously in a farm operation when a center pivot or SDI irrigation system investment is made. If these potential simultaneous factor changes are considered together, the relative profitability results may vary dramatically.

Future SDI applied research and extension efforts should focus on several areas. First, there is a need for more information on the longevity of SDI irrigation systems and on the costs of renovating them. Second, the potential water use efficiencies and uniform application benefits for SDI irrigation systems relative to center pivot irrigation systems needs further investigation. Third, the income tax management implications of alternative center pivot and SDI investments need to be accounted for in investment decisions. Because of higher system costs and associated tax deductions, SDI system investments would be expected to have an income tax management advantage over center pivot investments for comparable tracts of farmland. Fourth, an analysis is needed of how increased production risk and lower projected income for nonirrigated crop production influences a crop producer's willingness to select irrigation systems that provide higher proportions of irrigated production for a given piece of farmland. From a farm financial management perspective, potential implications of placing a center pivot or an SDI system on a furrow irrigated field may have land valuation and tax management impacts that should be understood. Finally, ongoing efforts are needed in the design and development of efficient, low cost center pivot and SDI irrigation and cropping systems.

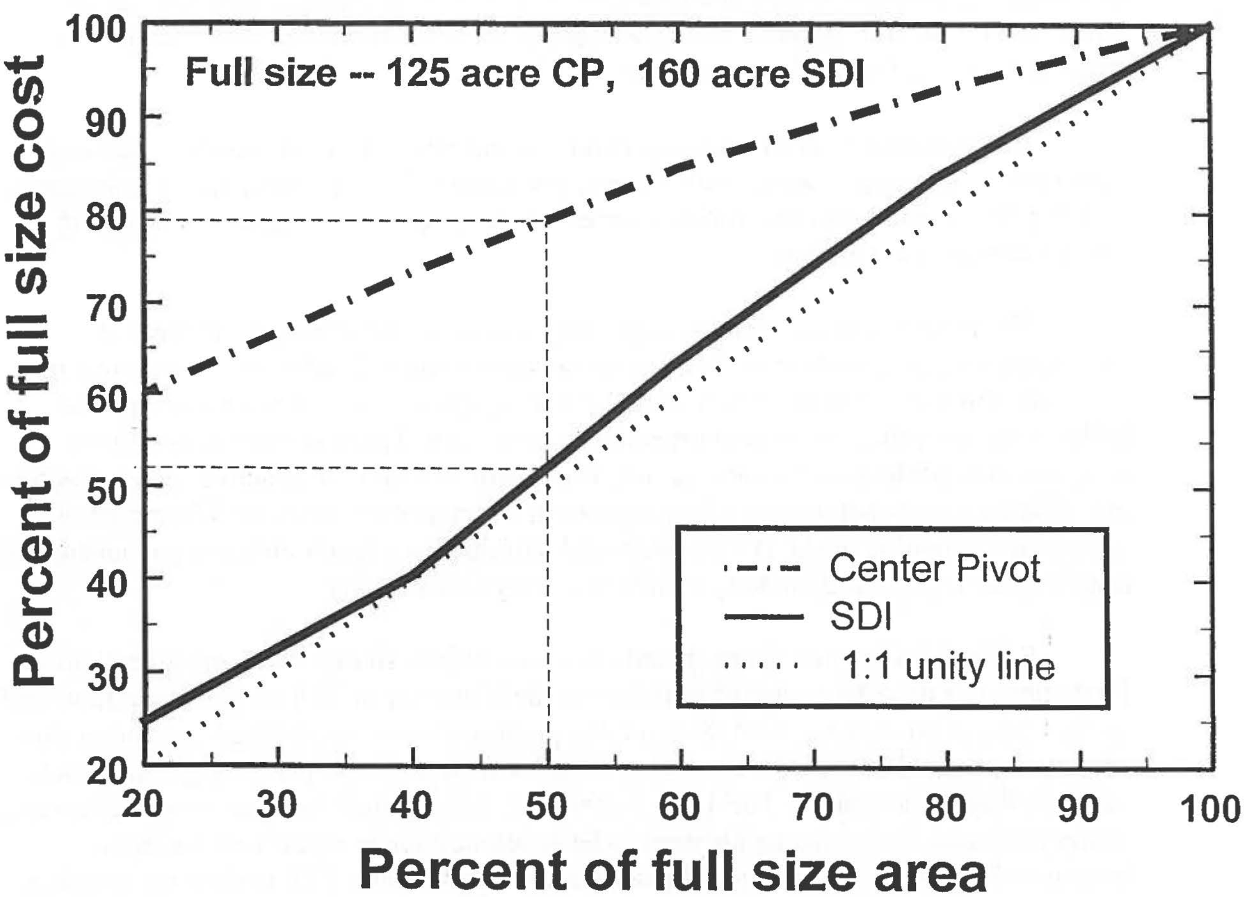

Figure 1. Investment Cost as Affected by System Size for Center Pivot and SDI Systems.

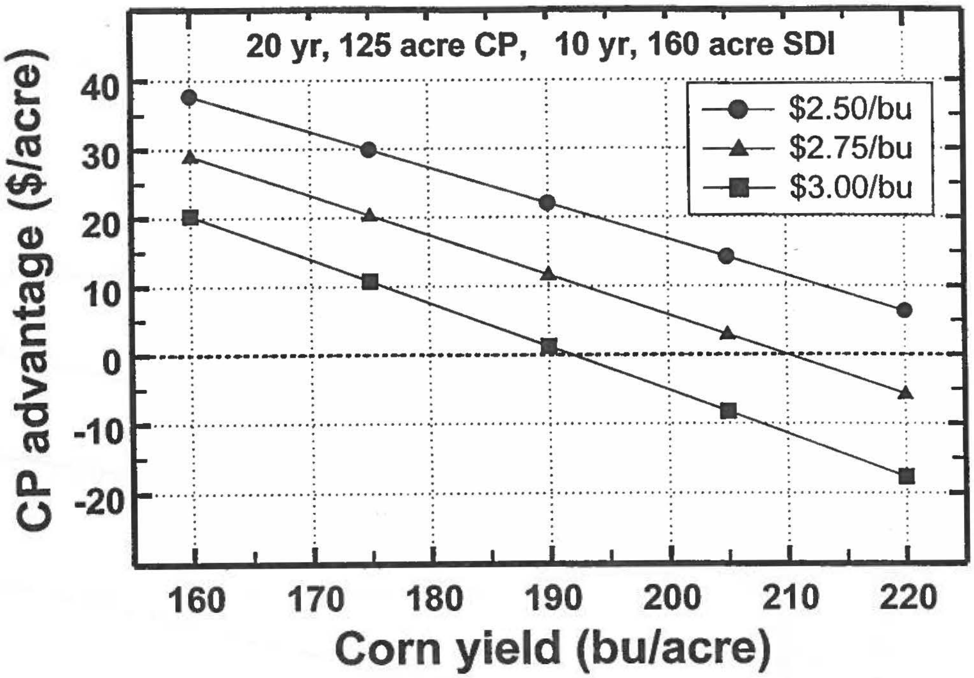

Figure 2. Net Returns Advantage of a Full Sized 125 Acre Center Pivot Cropping System over SDI as Affected by Corn Yield and Price.

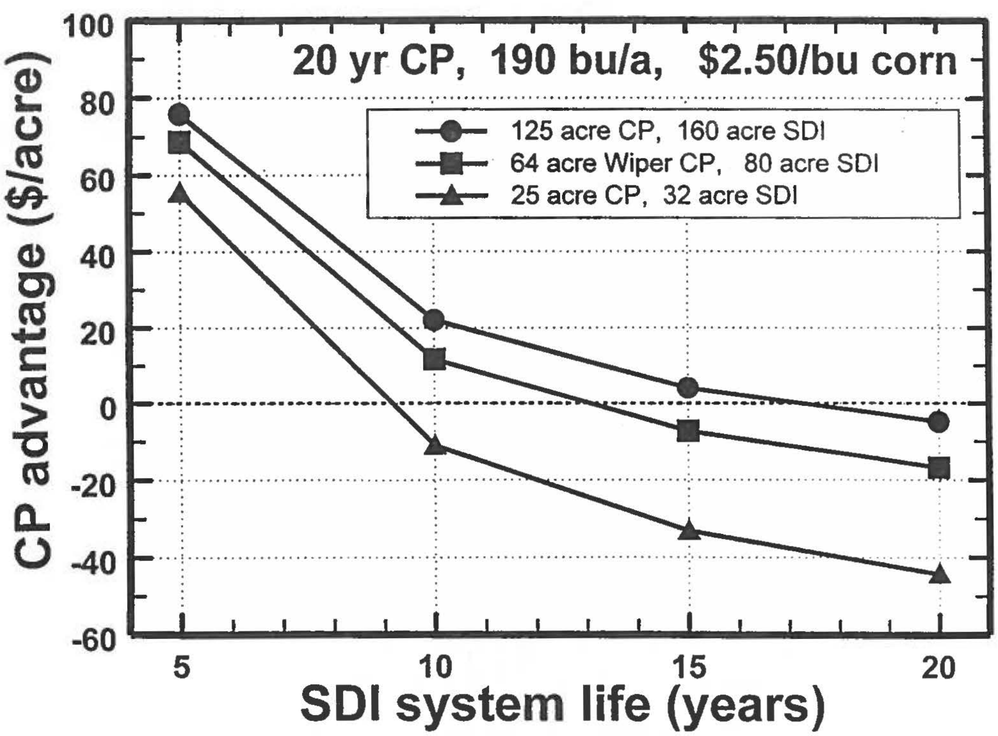

Figure 3. Net Returns Advantage of a Center Pivot Cropping System over SDI as Affected by System Size and SDI System Life.

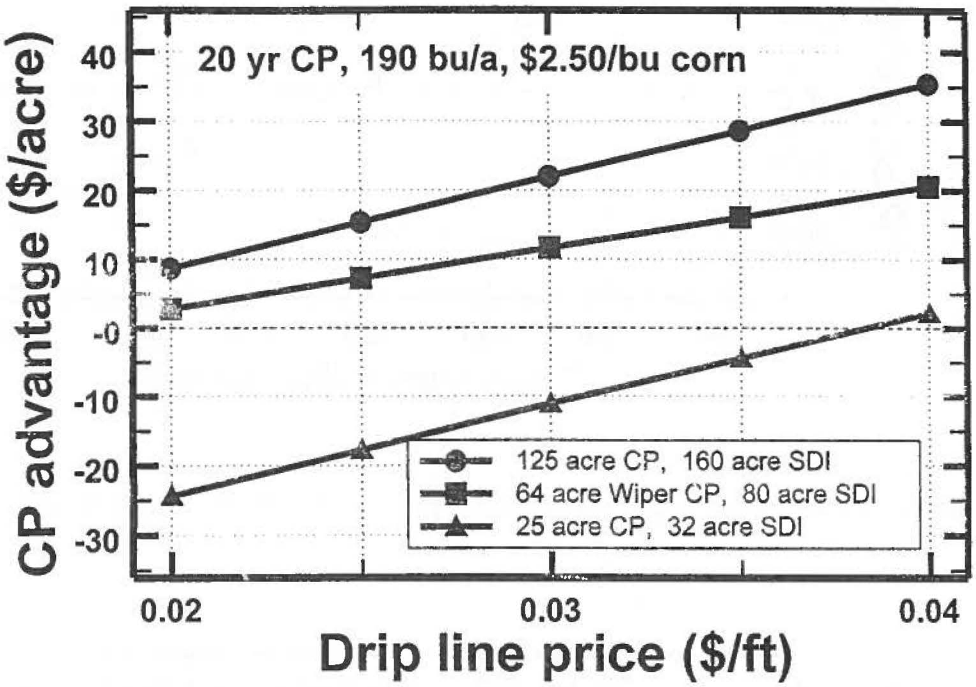

Figure 4. Net Returns Advantage of a Center Pivot Cropping System over SDI as Affected by System Size and SDI Dripline Price.