An Economic Comparison of Subsurface Drip and Center Pivot Sprinkler Irrigation Systems

D. M. O'Brien, D. H. Rogers, F. R. Lamm, G. A. Clark

Abstract. *In the U.S. Great Plains region many irrigation systems have been converted from traditional furrow to more efficient center pivot sprinkler irrigation. Irrigators are also expressing interest in use of subsurface drip irrigation (SDI) but are concerned about the economics of its use on major field crops, such as corn. A study was conducted to analyze SDI profitability relative to center pivot sprinkler cropping systems, focusing on continuous irrigated corn production in western Kansas. Results indicated that for 65 ha fields, SDI had a distinct disadvantage in net returns of $54/ha. As field size declined, per ha investment costs for center pivots increased markedly, whereas SDI system costs adjusted proportionally. As a result SDI net returns were approximately equal to center pivot sprinkler systems for 25.9 ha fields, and greater for 13 ha fields (a $28/ha SDI advantage). These results are very sensitive to SDI life. SDI was unprofitable relative to center pivot sprinklers for SDI life of less than 10 years. Changes in corn yield and price, and dripline costs also affected the relative profitability of SDI.*

Keywords. *Microirrigation, Subsurface drip irrigation (SDI).*

Subsurface drip irrigation (SDI) systems have been in use in some areas of the United States since the early 1970s. While SDI technology has been readily adopted for use in high value and/or horticultural crops, its adoption for use in production of major field crops in the U.S. Great Plains has been very small relative to furrow flood and center pivot sprinkler irrigation systems. The purpose of this article is to investigate the potential profitability of producing field crops using SDI as compared to center pivot sprinkler systems, the predominant irrigation technology alternative in the U.S. Great Plains. The irrigated field crop used in this analysis was continuous corn, with a wheat–fallow rotation included where nonirrigated crop production was included. It is hypothesized that under some field arrangements SDI is a feasible alternative to sprinkler irrigation for major field crops in this region using current levels of technology. Although sprinkler irrigation systems have an economic advantage over SDI systems for the typical case where full-sized center pivots are used, these systems may lose important economies of scale as their relatively inflexible investment costs are concentrated onto smaller sized fields. Thus, the cost advantage for a center pivot system may diminish as field size is reduced. The SDI systems may also have lower pumping costs, because their application efficiency is higher than that of center pivot sprinklers.

Several economic analyses have compared SDI with alternative irrigation systems. Hall et al. (1988) utilized an annual budgeting approach to compare the profitability of low energy precision application (LEPA) center pivot, SDI, high pressure center pivot, and furrow irrigation systems in the Texas High Plains. LEPA systems were found to be most profitable, with a sizable return advantage over SDI systems. Bosch et al. (1992) analyzed the economic returns of SDI, fixed-location center pivot, and towable center pivot irrigation systems for Virginia crops using net present value (NPV) analysis. Investment costs for SDI were assumed to be invariant across all field sizes. On smaller fields, SDI was the most profitable system because of lower per-ha investment and lower pumping costs.

Dhuyvetter et al. (1994, 1995) used a partial budgeting approach to compare the profitability of SDI and center pivot irrigation systems for field corn production in the Kansas High Plains for a full 65 ha field. Center pivot sprinkler systems were more profitable than SDI primarily because of lower investment costs. System returns were very sensitive to such variables as system life, initial investment cost, and crop yields. Demonstrations by the California Division of Water Resources (1996) of SDI, LEPA, improved furrow, and conventional furrow irrigation methods for cotton and melon production indicated that SDI had the highest returns over the 1988-1993 period because of consistently high yields. This occurred in spite of SDI investment costs being higher than those for the other irrigation systems examined. Also, the average amount of water applied using SDI was least among the irrigation systems tested. In a case study of use of SDI with cotton in Texas, Henggeler (1997) found that

Article was submitted for publication in October 1997; reviewed and approved for publication by the Soil & Water Div. of ASAE in May 1998. Presented as ASAE Paper No. 97-2072.

This is contribution No. 98-123-J from the Kansas Agricultural Experiment Station. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of Kansas State University.

The authors are **Daniel M. O'Brien**, Assistant Professor, Agricultural Economics, Northwest Research and Extension Center, Colby, Kans.; **Danny H. Rogers,** ***ASAE Member Engineer***, Professor, Biological and Agricultural Engineering, **Freddie R. Lamm,** ***ASAE Member Engineer***, Associate Professor and Research Agricultural Engineer, Northwest Research and Extension Center, Colby, Kans., and **Gary A. Clark,** ***ASAE Member Engineer***, Professor, Biological and Agricultural Engineering, Kansas State University, Manhattan, Kans. **Corresponding author:** Daniel M. O'Brien, Northwest Research and Extension Center, PO Box 786, Colby, KS 67701-0786; tel: (785) 462-6281; fax: (785) 462-2315; e-mail: dobrien@oznet.ksu.edu.

investment in SDI systems was profitable, largely due to increased yield. Prior to adoption of SDI, the irrigator's average cotton yield was 150% of the county average. The irrigator's average cotton yield improved to 190% of the county average after SDI adoption.

Williams et al. (1996a,b) and Delano and Williams (1997) used simulated yields within a NPV framework to compare the profitability of alternative irrigation systems in the Kansas High Plains. The irrigation systems analyzed included high pressure center pivot, low pressure center pivot, low drift nozzle center pivot, low energy precision application center pivot (LEPA), furrow, and surge furrow irrigation. In a comparison of these irrigation systems with SDI, surge furrow and conventional furrow irrigation systems had the highest net returns, followed by low drift nozzle and LEPA center pivot systems. Net returns for corn with SDI were greater than returns with high pressure center pivots, but marginally less than returns with low pressure center pivots, low drift nozzle, and LEPA center pivot systems. The net returns and relative profitability ranking of SDI among the alternative irrigation systems considered were very sensitive to the yield response received from irrigation and crop prices. As in Dhuyvetter et al. (1994, 1995), only a full 65 ha field was analyzed for these irrigation systems.

This study differed from most previous studies by analyzing how alternative field size and shape scenarios affect the profitability of SDI systems relative to center pivot systems. Although Bosch et al. (1992) did examine SDI system economics across alternative field sizes, he assumed a constant per ha adjustment of SDI investment costs. In this study, the alternative field size and shape scenarios were based on separate SDI system designs and costs. This study also accounted for decoupled USDA farm program payments as instituted in the 1996 Federal Agricultural Improvement and Reform (FAIR) Act. Under past farm programs, target price deficiency payments were reduced as corn prices increased up to the target price level. But under the 1996 FAIR Act, production flexibility contract (PFC) payments do not vary in response to corn price changes. Therefore, corn price variation has a more direct effect on net revenue estimates than in past analyses, which assumed the previous farm bill price support framework.

Procedures

This analysis assumed a field in western Kansas with an existing surface irrigation system, which is to be converted to either a center pivot or a SDI cropping system. The existing well or water supply is located midway between the ends at the edge of the field and is fully depreciated but not in need of replacement. Projections of annual pre-tax net returns were calculated using investment cost estimates for alternative irrigation systems and estimated crop budgets for irrigated corn and summer fallow wheat in western Kansas. The main objective was to analyze the profitability of center pivot and SDI irrigation and cropping systems for various field sizes. Sensitivity analysis was performed to determine the effect on net returns of changes in corn yields and prices, irrigation system life span, and SDI dripline costs.

Profitability Analysis

A partial budgeting approach was used to compare irrigation and cropping system profitability. Unlike a whole-farm budget, a partial budget does not indicate whether the entire operation is profitable, but only if one enterprise has a net return advantage over another. Consequently, partial budgeting may not recognize all costs that affect the farm operation. For example, during the startup period, management of newly installed SDI systems may take more time than that required for management of the more familiar center pivot systems. Time not devoted to other farm enterprises could affect their production efficiency and profitability. This SDI cost factor is not accounted for in the partial budget analysis. Management of SDI systems is not necessarily more difficult than that of other irrigation systems but it does require a different set of procedures.

The economic analysis also was carried out on a pre-tax basis, without consideration of the impact of the tax deductable depreciation of capital investments in irrigation equipment upon annual cropping system profitability. Because the economic analysis did not account for tax depreciation these results actually under represent the relative profitability of both SDI and center pivot irrigation systems. This results in a conservative analysis because taxable deductions for a SDI system would be greater than for center pivots because of SDI's larger capital investment.

Field Investment Costs and Design Considerations

Six field sizes were considered, the largest being a 65 ha field on which a standard sized (50.6 ha) center pivot could be installed. The center pivot size was reduced in 10 ha increments down to 10 ha. The corresponding square SDI field was assumed to be fully irrigated; whereas, the center pivot field was assumed to have a combination of irrigated area under the irrigated circle and nonirrigated area in the corners of the square. The exception was in the last comparison, which assumed a typically shaped 32.4 ha field (a 65 ha field split into two equal rectangular parts) on which a standard-sized center pivot would irrigate a semicircle of 25.9 ha, leaving 6.5 ha in dryland wheat-fallow rotation in the nonirrigated portions.

Investment costs and field shapes and sizes used to compare the profitability of these two irrigated cropping systems are shown in table 1 and figure 1, respectively. Irrigation system investment costs were estimated using 1996 information from private industry and Kansas State

Table 1. Investment costs for various sizes of center pivot and SDI systems*

Field Scenario	Center Pivot Irrigated Area	Center Pivot Dryland Corners	SDI Irrigated Area	Center Pivot Total Cost ($/Field†)	Center Pivot Cost/ha ($/ha)	SDI Total Cost ($/Field‡)	SDI Cost/ha ($/ha)
O	50.6	14.2	64.8	40,782	806	86,210	1,331
A	40.5	10.9	51.4	37,948	938	72,258	1,406
B	30.4	8.1	38.5	34,527	1,138	54,388	1,415
C	20.2	5.7	25.9	29,909	1,478	34,836	1,345
D	10.1	2.8	13.0	24,459	2,417	21,251	1,641
E§	25.9	6.5	32.4	34,050	1,315	45,606	1,408

* Areas in hectares.
† Includes underground pipe and electrical service and generator.
‡ 1.5 m dripline spacing.
§ Typical 65 ha field split into two equal rectangular parts, resulting in a 25.9 ha semicircle for the center pivot.

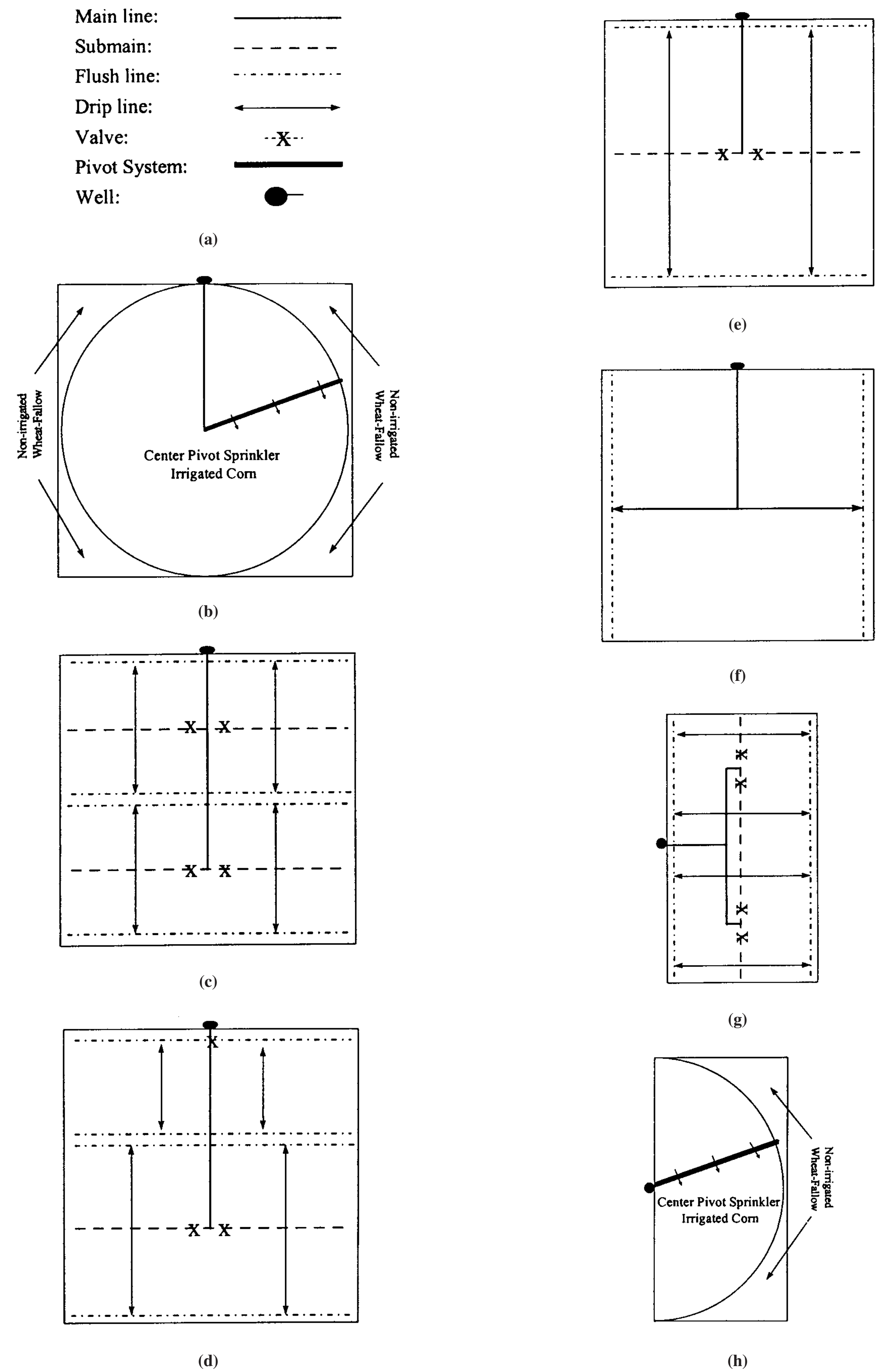

Figure 1–Designs for SDI and center pivot sprinkler irrigation systems.

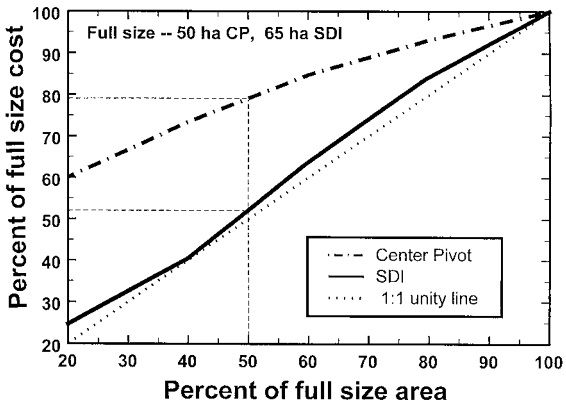

Figure 2–Investment cost as affected by system size for SDI and center pivot sprinkler irrigation systems.

University. Average system lives were projected to be 20 years for the center pivot and 10 years for the SDI system, with no salvage value assumed at the end of their projected lives. Per irrigated ha investment costs for center pivots increase markedly as field size declines in comparison to the more stable SDI per irrigated ha investment costs (fig. 2). As field size decreased by 50%, the SDI system cost also decreased by approximately 50%. In comparison, as field size decreased by 50%, the center pivot system cost was approximately 80% of that the full-sized system.

The SDI system field designs should be considered to provide a general but non-specific guideline of system layout and the required components (table 2). The water source was assumed to be of adequate quality to require no special treatment. Although the specific fitting needs to connect the SDI system to the pumping plant are site specific, the components before entry into the mainline would include an automated screen filter with pressure gauges and a control valve. Each zone is equipped with a control valve and pressure gauges at the inlet and distal end. The driplines are connected at the distal end into a normally closed flushline. The flushline is elbowed to the surface and is equipped with a removable endcap and airvent.

The SDI mainlines were conservatively sized with friction losses kept to approximately 20% of an initial well head pressure which was estimated to be 140 kPa. All water lines are assumed at zero slope. However, in Kansas most SDI systems would be installed on fields being converted from surface irrigation. These fields would be uniformly sloped with the well typically located at the upper end. Positive pressure head changes would be the most likely actual field scenario, making the mainline sizes for the example fields the largest size required. Submains were sized for 10% (less than 7 kPa) pressure drop across the submain. Dripline spacing was 1.5 m and dripline lengths were limited to manufacturer's recommendations.

Dripline investment is the largest cost item for each SDI field size and design scenario. Dripline's proportion of total cost ranges from 46% to 49% for all field size scenarios except for the smallest field size (13 ha scenario D) for which it is 39%. Installation costs (trenching, labor, and tractor) are the second largest cost item, ranging from 18% to 23% across all scenarios. The total cost of main line, submain, and flushline pipe is the third largest cost item, ranging from 12% to 16% of total SDI system cost across these scenarios.

Table 2. Subsurface drip irrigation system capital requirements for alternative field sizes

		Subsurface Drip Irrigation System Scenarios					
Item	$/Unit	Base (O)	A	B	C	D	E
Number of SDI hectares		64.8 ha	51.4 ha	38.5 ha	25.9 ha	13.0 ha	32.4 ha
203 mm main line pipe	$4.27/m	$6,006	$2,293	$1,763	$1,086	$761	
152 mm lateral/submain pipe	$2.46/m	1,020	3,528	3,051	1,253	439	$3,465
102 mm flushlines	$1.97/m	7,104	5,645	3,661	2,004	1,416	3,168
Dripline	$0.0984/m	41,976	33,193	24,829	16,733	8,354	20,909
Dripline connectors	$2.46/m	3,168	2,820	1,829	1,002	708	1,584
203mm × 203mm × 203mm × 203mm cross	$200/cross	400					
203mm × 203mm × 152mm × 152mm cross	$200/cross		200				
203mm × 203mm × 203mm tee	$340/tee						
203mm × 152mm reducing coupling	$25/coupling	100	25		25	25	
203mm × 203mm × 152mm tee	$340/tee			340			
203mm pressure control valve	$440/valve	1760				440	
152mm × 152mm × 152mm tee	$145/tee		145	145	145		435
152mm endcaps	$45/cap		180	270	90	45	180
152mm valves	$375/valve		1,500	1,125			
152mm elbows	$95/elbow			95			190
152mm × 102mm reducing couplings	$20/cplg	80					
102mm elbows	$30/elbow	360	480	300	240	120	480
102mm valves	$375/valve						1,500
102mm × 51mm reducing bushing	$18/bushing	216	288	180	144	72	288
51mm plugs	$6/plug	72	96	60	48	24	96
Air vents	$25/vent	350	350	350	350	150	350
PVC glue	250	250	200	200	200	250	
Trenching	$2.23/m	10,322	9,196	6,455	3,975	2,400	5,834
Filter	4,500	4,500	4,500	4,500	4,500	2,200	
Pressure gauges	$20/gauge	360	360	280	280	140	360
Producer labor (installation)	$8/labor h	7,200	6,376	4,360	2,384	1,240	3,792
Tractor use (installation)	$7/tractor h	966	833	595	378	217	525
Total costs		$86,210	$72,258	$54,388	$34,837	$21,251	$45,606
System costs/Irrigated hectare		$1,331/ha	$1,406/ha	$1,415/ha	$1,345/ha	$1,641/ha	$1,408/ha

Crop Income and Expenses

The center pivot cropping system included irrigated corn with dryland wheat fallow on the nonirrigated corners (table 3). In this analysis the entire SDI cropping system area was in irrigated corn. Irrigation well capacity was assumed adequate for corn production in all scenarios. SDI systems were assumed to have slightly lower expenses for irrigation fuel and repair because of lower pumping requirements (table 4). Center pivot-irrigated corn was assumed to require 457 mm of applied water; whereas, SDI-irrigated corn was assumed to require 406 mm (an 11% reduction in applied irrigation amount for SDI). Large differences existed in irrigation equipment depreciation and interest costs between alternative irrigation systems for the baseline 65 ha comparison, with per ha SDI irrigation equipment expenses being much higher than those for center pivot systems (table 4). Per ha variable expenses for crop production were assumed to be unchanged across alternative field size scenarios. For SDI systems, per ha depreciation and interest costs for irrigation equipment also did not vary appreciably as field size declined across the alternative scenarios. This was in contrast to center pivot sprinkler systems, where marked increases occurred in per ha depreciation and interest costs for irrigation equipment as field size declined (table 1). Because land costs and management expenses over and above base labor expenses were not accounted for in these partial budgets, net revenue projections represent per ha net returns to land and management.

Results and Discussion

Comparison of Economic Returns

Projected income for center pivot cropping systems were less than for SDI across all the field-size scenarios (table 5). This was due to the production of irrigated corn

Table 3. Crop revenue assumptions for SDI and center pivot systems

Income	Corn-SDI	Corn-Pivot	Wheat
Crop yield (Mg/ha)	11.93	11.93	2.69
Crop price ($/Mg)	$98.42	$98.42	$134.11
PFC payment ($/ha)*	$86.49	$86.49	$24.71

* PFC: USDA production flexibility contract payments.

Table 4. Crop enterprise expenses for SDI and center pivot systems for scenario O (65 ha)

	Cropping System Enterprises		
Cost Items	Corn - SDI	Corn - Pivot	Wheat
Variable Costs			
Labor	$52.26	$52.26	$26.69
Seed	83.03	83.03	24.71
Herbicide	81.84	81.84	36.62
Insecticide	102.72	102.72	0.00
Fertilizer	114.16	114.16	37.56
Fuel & oil - crop	25.82	25.82	17.17
Fuel & oil - pumping	107.14	120.54	
Crop machinery repairs	57.33	57.33	26.98
Irrigation repairs and maintenance	11.86	13.34	
Crop insurance	16.68	16.68	12.08
Drying	46.95	46.95	0.00
Consulting	16.06	16.06	0.00
Miscellaneous	17.30	17.30	12.36
Interest on 1/2 variable costs	36.64	37.41	9.71
Total variable costs per hectare	$769.79	$785.44	$203.88
Fixed Costs			
Depreciation	$37.91	$37.91	$30.52
Interest on machinery	39.36	39.36	31.70
Irrigation equipment depreciation	150.78	57.97	
Interest on irrigation equipment	72.75	46.48	
Insurance	5.09	3.78	1.19
Total fixed costs per hectare	$305.89	$185.50	$63.41
Total costs per hectare	$1,075.68	$970.94	$267.29*

*Wheat-fallow rotation costs are on a per seeded wheat hectare basis, excluding fallow area.

Table 5. Center pivot (CP) and SDI economic returns comparison across field size scenarios

	Base Scenario O		Scenario A		Scenario B		Scenario C		Scenario D		Scenario E	
	64.8 ha		51.4 ha		38.5 ha		25.9 ha		13.0 ha		32.4 ha	
Item	Pivot	SDI	Pivot	SDI	Pivot	SDI	Pivot	SDI	Pivot	SDI	Pivot	SDI
Cropping System												
Irrigated area	50.6 ha	64.8 ha	40.5 ha	51.4 ha	30.4 ha	38.5 ha	20.2 ha	25.9 ha	10.1 ha	13.0 ha	25.9 ha	32.4 ha
Non-irrigated area	14.2 ha	0 ha	10.9 ha	0 ha	8.1 ha	0 ha	5.7 ha	0 ha	2.9 ha	0 ha	6.5 ha	0 ha
A. Crop Income												
Irrigated corn	$63,788	$81,689	$51,056	$64,797	$38,323	$48,535	$25,465	$32,651	$12,732	$16,388	$32,651	$40,845
Dryland wheat	$2,737	---	$2,101	---	$1,561	---	$1,099	---	$559	---	$1,253	---
Total income	$66,525	$81,689	$53,157	$64,797	$39,885	$48,535	$26,563	$32,651	$13,291	$16,388	$33,903	$40,845
B. Crop Costs												
Variable costs	$41,189	$49,882	$32,920	$39,567	$24,702	$29,637	$16,446	$19,937	$8,228	$10,007	$21,005	$24,941
Fixed costs	$9,836	$19,822	$8,404	$16,307	$6,928	$12,266	$5,319	$7,976	$3,634	$4,590	$6,360	$10,293
Land, Mgmt. costs	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total costs	$51,025	$69,704	$41,324	$55,874	$31,630	$41,903	$21,765	$27,914	$11,862	$14,598	$27,365	$35,234
C. Net Returns to Land, Management	$15,500	$11,985	$11,833	$8,923	$8,255	$6,632	$4,798	$4,737	$1,429	$1,790	$6,538	$5,611
Return difference:												
Total (SDI – pivot)	– $3,515		– $2,910		– $1,623		– $61		+ $361		– $927	
Per ha (SDI – pivot)	– $54.24/ha		– $56.61/ha		– $42.16/ha		– $2.36/ha		+ $27.77/ha		– $28.61/ha	

with its higher income over all the field area for SDI. For center pivot cropping systems only part of the field area was used for irrigated corn production, with the remainder in production of non-irrigated wheat in a wheat-fallow rotation (table 1).

The per hectare income advantage of SDI was essentially stable across the field size scenarios, with minor differences occurring only from rounding of center pivot sizes to a nominal size within the square portion of the field. However, differences existed in net returns to land and management (income minus all non-land and management expenses) for the two systems across the field-size scenarios.

Center pivot systems had a projected net return advantage of $42 to $57 per ha for larger size fields (38.5 and 65 ha) primarily because of the lower per hectare investment costs for the larger center pivot sprinkler systems compared to SDI. Returns for the two systems were essentially equal for the 26 ha scenario, but favor SDI (a $28 per ha advantage for SDI) for smaller sized fields (13 ha). This was mainly due to large increases in per hectare investment costs for center pivot sprinklers for the smaller sized field. On scenario E, the half-circle center pivot cropping system with 25.9 ha of irrigated corn plus 6.5 ha of dryland wheat-fallow had a net returns advantage ($29 per ha) over the SDI system.

Sensitivity to Changes in Key Factors

A series of sensitivity analyses was done to determine how these results would be affected by changes in key economic factors such as corn yield and price, irrigation system life, and SDI dripline costs.

Increases in crop revenue brought about by higher corn yields and/or prices caused net returns for SDI to improve relative to those for center pivot cropping systems (fig. 3). For 65 ha scenario O, center pivot cropping systems are projected to be more profitable than SDI for all but the highest combinations of corn yield (greater than 11.9 Mg/ha) and price ($108.26/Mg or greater). With an average corn price of $118.11/Mg in scenario O, SDI had a net returns advantage for yields of 12.9 and 13.8 Mg/ha. However, as corn price declined to $108.26/Mg, SDI only had a net returns advantage for corn yields of approximately 13.2 Mg/ha or more. With an even lower corn price of $98.42/Mg, center pivot systems had a net returns advantage over SDI across the range of yields considered.

As field and irrigation system size decline from the 65 ha in scenario O to 26 ha in scenario C, the relative profitability of SDI improves for various corn yield and price combinations. For an average corn price of $118.11/Mg, SDI had equal or greater net returns than center pivot systems across the range of yields considered in scenario C. However, for a lower corn price of $108.26/Mg, SDI only had a net returns advantage for corn yields greater than 11.9 Mg/ha. For the lower corn price of $98.42/Mg, center pivot systems had a net returns advantage over SDI for all except the highest corn yields considered (greater than 13.4 Mg/ha).

In general, combinations of corn prices and yields associated with lower corn enterprise gross revenue favored center pivot cropping systems. But as average corn prices and yields increased, SDI became economically competitive. These sensitivity results support other findings regarding the relative net returns advantage of center pivot sprinkler systems on larger fields (38 ha or more), and of SDI on smaller fields (26 ha or less).

Changes in the life span of SDI from 5 to 10 to 15 years had a dramatic effect on the relative net returns of SDI and center pivot systems for all field size scenarios (fig. 4). Changes in SDI life from 5 to 15 years increased projected net returns by $176 to $220/ha across the field size scenarios considered. In comparison, changes in center pivot system life span from 15 to 25 years had a relatively small impact on SDI versus center pivot net returns. A center pivot life of 20 years was assumed in these sensitivity analyses.

Net returns of SDI with a 10-year life were markedly lower than for center pivot systems for the 65 ha, 51 ha, and 38 ha field scenarios, as well as for the 32 ha half circle center pivot scenario E. However, SDI with a 10-year life had nearly equal returns with center pivot sprinkler systems in the 26 ha field scenario C, and a net returns advantage for the 13 ha scenario D. Across all field size scenarios, SDI with a 5 year life span had lower net returns than pivot sprinkler irrigation systems. Conversely, SDI with a 15 year life had net returns advantages over center pivots for field sizes smaller than 38 ha, and only a small net returns disadvantage for the larger field size scenarios.

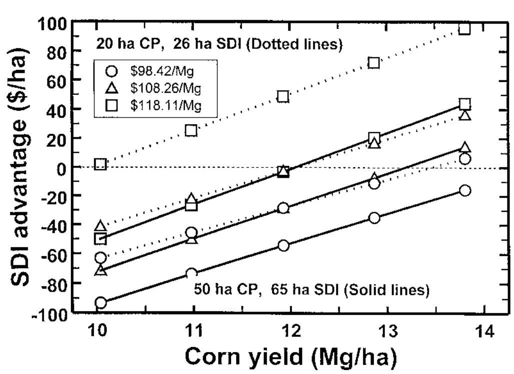

Figure 3–Net returns advantage of SDI over selected center pivot sprinkler irrigation systems as affected by corn yield and price.

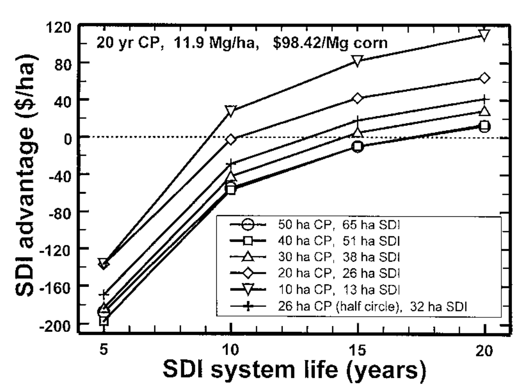

Figure 4–Net returns advantage of SDI over center pivot sprinkler irrigation as affected by system size and SDI life.

These results indicate that the life of SDI must be at least 10 years for it to be economically competitive with center pivot sprinkler systems. At Kansas State University research centers SDI has been in use for up to nine years without any appreciable deterioration. As of this time, several commercial SDI systems in the southwestern United States have been in use for nearly 20 years. Evidence suggests that if properly designed and managed, SDI can function effectively for long periods of time.

Dripline prices had a major impact on the total cost of SDI, with decreasing prices improving its economic competitiveness with center pivot sprinkler systems (fig. 5). However, the net returns ranking of SDI versus center pivot systems were generally not affected in these three field size scenarios. Only in the case of the 26 ha field scenario C did dripline price variation cause a change in the net return advantage of either center pivot or SDI. In this scenario, SDI only had a net returns advantage for dripline prices below $0.10/m. For the 13 ha scenario D, SDI was more profitable for all except the highest dripline prices considered ($0.125/m or greater).

Advantages and Limitations of SDI

The preceding analysis has indicated some of the advantages and limitations of SDI. Among SDI's advantages are the ability to fully irrigate a field as compared to center pivot systems which by design necessitate some nonirrigated crop land. Increased water application efficiency is another advantage of SDI. A 10% water application efficiency advantage was included for SDI in this analysis. However, some SDI users in the western U.S. corn belt are reporting greater water savings for irrigated corn production. Lamm et al. (1995) indicates that a 25% reduction in net irrigation requirements is possible due to lower water losses from drainage, soil evaporation, and runoff. However, water pumping costs are not a major factor affecting the economic comparisons (Dhuyvetter et al., 1995).

Disadvantages of SDI include the cost of learning to manage a new irrigation technology. Management of SDI would include both the actual operation of the system during the irrigation season, as well as management practices to minimize damage to underground driplines from burrowing rodents. Repair of subsurface dripline can be time consuming and frustrating in comparison to repairing other types of irrigation systems.

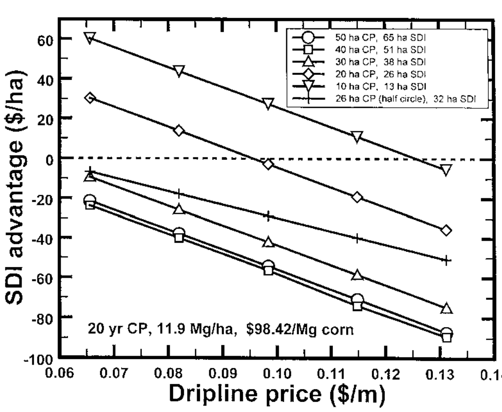

Figure 5–Net returns advantage of SDI over center pivot sprinkler irrigation as affected by system size and SDI dripline price.

Conclusions

Several factors influence the relative profitability of SDI and center pivot cropping systems. According to the assumptions used in this analysis, center pivot cropping systems have higher estimated net returns than SDI on 65 ha fields. As field size decreases, net returns of center pivot cropping systems eventually fall below those of SDI systems. This occurs primarily because per ha investment costs for SDI remain relatively stable as field size declines; whereas, per hectare investment costs increase markedly for center pivot sprinkler irrigation systems.

Net returns of SDI are very sensitive to system longevity or life span. If SDI only lasts five years, it is noncompetitive in a net returns sense with center pivot cropping systems across all commonly considered field-size scenarios. If SDI has a 15-year life it is economically competitive with center pivots on fields of less than full size (i.e., less than 65 ha), and even approaches economic competitiveness on full sized fields.

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

Any decrease in the base dripline prices results in improved net returns for SDI relative to center pivot cropping systems. However, the selection of the most profitable irrigation and cropping system was only affected on 26 ha fields. For larger field size scenarios, center pivot systems maintained a clear net returns advantage across the range of dripline prices considered. For the smaller 13 ha field scenario, SDI maintained a net returns advantage for all except the highest dripline price considered.

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

Future SDI research should focus on several areas. First, more information is needed on the longevity of SDI and on the costs of renovation. Second, further investigation is needed of the potential water use efficiencies and uniform application benefits for SDI relative to center pivots. Third, an analysis is needed of how increased production risk and lower projected income for non-irrigated crop production influence a producer's selection among irrigation systems. From a financial management perspective, more understanding is need of the potential land valuation and taxation impacts from converting existing surface irrigation systems that are fully irrigated to center pivot sprinkler systems that are partially irrigated. Finally, ongoing efforts are needed in the design and development of efficient, low cost, SDI and center pivot irrigation and cropping systems.

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