AN ECONOMIC ANALYSIS OF SUBSURFACE DRIP IRRIGATION FOR CORN

Mark E. Nelson
Extension Ag Economist, NW
Kansas State University
Colby, KS 67701

Kevin C. Dhuyvetter
Extension Ag Economist, SW
Kansas State University
Garden City, KS 67846

Subsurface drip irrigation is a highly efficient delivery system. Through more uniform irrigation application, and decreased percolation and evaporation losses, less overall water and energy is necessary compared to other irrigation delivery systems. While the annual pumping costs of a drip system are low, the initial capital investment is high, relative to other delivery systems. Because of this, drip irrigation has typically been associated with high-value crops such as fruits and vegetables. But, as parts of the Ogallala Aquifer have continued to experience varying levels of overdraft, drip irrigation has received increased attention as an alternative to present irrigation systems.

Drip irrigation research in corn production is currently being done at both the Northwest (Colby) and Southwest (Garden City) Research-Extension Centers in western Kansas. The research has largely centered on various design and production management parameters including, water use requirements, dripline spacing and dripline length. This paper first examines the economic feasibility of the various management parameters with the goal of identifying the optimum drip irrigation system design for corn, given current research. Lastly, this optimum system will be compared to a "typical" center pivot irrigation system used in western Kansas. It should be noted that the value of water resource conservation and water quality protection is not considered in this analysis.

WATER USE REQUIREMENT RESEARCH

Research studies examining the water requirements for corn using drip irrigation were conducted at both Garden City and Colby from 1989 through 1991. Yields and irrigation amounts are summarized in Tables 1 and 2.

Corn yields at both Garden City and Colby were maximized by irrigating at 100% of net irrigation needs (ET). The production research also found that water use efficiency (defined as pounds of corn produced, divided by total water used) was maximized at 75% of ET, rather than 100% of ET. Meaning that as additional water is applied over 75% of ET, the increases in yields become smaller and smaller. In fact, the research indicated that applications in excess of 100% of ET resulted in yields decreasing, costing the producer both in terms of increased pumping expense and reduced corn income.

The key, from an economic standpoint is to determine the irrigation amount that will maximize returns. This was done by analyzing the marginal returns to irrigation (calculated as the additional income generated by increased yields at each irrigation level, less the cost of pumping additional water). When marginal returns are positive, it pays to irrigate at that level, given the costs assumed.

Table 1 shows the marginal return to irrigating at 25% of net irrigation needs averaged a -$1.30 per acre for the years 1990-91 at Garden City--based on $2.25/bu. corn and a pumping cost of $2.50/ac. inch. Meaning that irrigating at 25% of ET did not produce enough of a yield increase--compared to zero irrigation, to pay for the increased pumping costs. Irrigating at 50% of ET netted a $55.50 marginal return over irrigating at 25% of ET, showing that the 35.3 average increase in corn yields easily outweighed the additional pumping costs. Positive marginal returns per acre continued for the irrigation amounts of 75% and 100% of ET ($13.63 and $10.93 respectively). Marginal returns finally turned negative at irrigation amounts of 125% of ET -$16.93, demonstrating that the most profitable irrigation level was at 100% of ET. The negative marginal return was the result of an average decrease in yields of 3.4 bushels and an average increase in pumping costs of $10.12 per acre.

Colby had similar results as evidenced by Table 2, which shows the marginal return to irrigating at 100% of ET being $23.77 for the years 1989-91. Irrigating at 125% of ET again, had negative marginal returns, -$50.67 over those same years.

The marginal returns analysis of water use requirements suggests that the economic optimum level of irrigation is at 100% of ET for both Garden City and Colby, given $2.25/bu. corn and a pumping cost of $2.50/acre inch. Energy costs would have to rise dramatically before a decreased level of irrigation would be more economical. Given the three years of data for Colby, per acre inch pumping costs would have to rise to $8.04 before the marginal returns of irrigating at 100% of ET would turn negative. At Garden City, the two years of data show that per acre inch pumping costs would have to rise to $4.62 before the marginal returns of irrigating at 100% of ET would turn negative. It should be noted, that at a pumping cost of $4.62, the marginal returns to irrigating at 75% of ET would also be negative at Garden City.

DRIPLINE SPACING RESEARCH

In general, while a narrow spacing between driplines is necessary for high yields, it results in higher overall drip system costs. On the other hand, wider dripline spacings will reduce system costs, but may cause corn yields and profits to suffer. Research studies were conducted at Garden City (1989-1991) and Colby (1990-1991), Kansas examining the effect different dripline spacings had on corn yields.

Dripline spacings of 10.0, 7.5, 5.0 and 2.5 feet were included in the Garden City study. Corn yields in Garden City increased as dripline spacings decreased from 10.0 feet to 2.5 feet (Table 3). Again, an analysis of marginal returns was used, with marginal returns calculated as the additional income generated by increased yields, less the cost of additional drip tape and connectors necessary to decrease the spacing between driplines, amortized over 10 years at nine percent interest. When marginal returns are positive, it pays to use the narrower dripline spacing, given the costs assumed.

Table 3 shows the marginal return of a 7.5 foot dripline spacing compared to a 10.0 foot spacing was $21.55 per acre for the years 1989-91 at Garden City--based on $2.25/bu. corn and a drip tape cost of $0.025/foot. Demonstrating that the benefit of increased yields was greater than the increased costs associated with the narrower spacing. In addition, the marginal return of a 5.0 foot dripline spacing compared to a 7.5 foot was $5.30. Indicating the increased income from the 9.4 bushel average increase in corn yield was greater than the $13.44 of additional driptape and connectors. The 2.5 foot dripline spacing had a negative marginal return of -$15.38 over the same years. Showing that, despite a 12.5 bushel average increase in corn yields, doubling the number of driplines (5.0 foot to 2.5 foot spacing) was not profitable.

The study in Colby included dripline spacings of 10.0, 7.5, and 5.0 feet. Yield results were very similar to the Garden City study. Based on the two year average yields, economic returns were again maximized at the 5.0 foot spacing (Table 4).

The marginal returns analysis of dripline spacing suggests that the economic optimum spacing is at five feet for both Garden City and Colby, given $2.25 per bushel corn and a driptape cost of $0.025 per foot. Driptape costs would have to rise to over $0.0367 (Garden City) and $0.0484 (Colby) per foot before a wider dripline spacing would be more feasible.

DRIPLINE LENGTH RESEARCH

Research studies examining the effect of different dripline lengths on corn yields were conducted at Garden City and Colby, Kansas in 1990 and 1991.

Dripline lengths of 330 feet (1/16 mile) and 660 feet (1/8 mile) were included in the studies at both locations. Both locations also looked at pumping the water downslope, upslope, or from both ends. No consistent differences were found in yields based on dripline length or water-flow entry point. Yields in Garden City were slightly higher at the 330 foot dripline length. However, the increase in yield was not sufficient to justify the added expense of additional submains, flushlines and required connectors (Table 5). Yields in Colby were actually higher at the 660 foot dripline length. In this case, it obviously would be more economical to utilize the longer dripline lengths because income would be higher (higher yields) and investment cost lower (fewer submains and flushlines). While it is doubtful that dripline lengths could be as long as row lengths commonly used by furrow irrigators (1/4 and 1/2 mile runs), it might be economical to have dripline lengths longer than 660 feet (1/8 mile) with proper management and slope. The results from these studies indicate the need for further research to determine optimal dripline lengths.

SUBSURFACE DRIP IRRIGATION VS. CENTER PIVOT

This section will compare the feasibility of a drip irrigation system with a low pressure center pivot system for corn using average investment and production figures. It is critical that every producer conduct their own individual analysis when considering system conversions, as yields and costs will vary significantly by producer and location.

The first step when conducting an irrigation system feasibility comparison is to identify the systems that will be compared and determine their respective investment requirements. For this analysis, a typical 160 acre field will be used and the investment requirements will be based on this crop unit size. The drip system used for the economic comparison is based on irrigating the full 160 acres at 100% of ET with 5.0 foot dripline spacings and 660 foot dripline lengths (Table 6). Table 7 is a similar investment summary for a center pivot system irrigating 126 acres.

The irrigation system costs used were based on a dealer survey in 1992. Annual ownership costs were calculated by amortizing the system cost over its estimated useful life (10 years for the drip system and 15 years for the center pivot system) at 9 percent interest. A zero salvage value for both systems was assumed. While a subsurface drip system would have a low salvage value, a center pivot system may potentially have a relatively high salvage value at the end of 15 years. But because of 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 this analysis.

The second step in an irrigation system feasibility comparison is to decide upon three key production parameters; the crop acreage breakdown, crop yields and the amount of irrigation applied. These figures are intertwined and will vary by well size (gpm), irrigation system, field size, farm and location. The drip system in this comparison is assumed to irrigate 160 acres versus 126 for the center pivot. The remaining 34 acres (center pivot corners) are assumed to be in a wheat-fallow rotation with 17 acres planted to wheat each year. Well size is assumed adequate to support either system at full capacity thus irrigated corn yields are equal at 175 bushels. The amount of irrigation necessary for optimal yields is an elusive figure, varying by year, location and system. For this analysis, 18.5 acre inches of irrigation is assumed for the subsurface drip system, which is the 1990-91 average irrigation level for Colby and Garden City at 100% of ET. While it is generally assumed that center pivot systems are not as efficient as drip systems, and as a result require higher levels of irrigation for equal yields, how much additional irrigation is difficult to ascertain. This analysis first compares the feasibility of a drip system versus a center pivot system requiring an additional 10% of applied irrigation (Table 8). It also compares the two systems when the additional irrigation needed by the center pivot system is at levels of 5%, 15%, 20%, 25% and 35% greater than the drip system's 18.5 acre inches (Table 9).

The analysis in Table 8 shows that over a 160 acre field, the center pivot system has a $16.70 per acre return advantage over the subsurface drip irrigation system. While the drip system irrigates more acres and can generate greater returns to management and investment--$22,177 versus $17,433, it cannot overcome the greater annual ownership costs, given the assumptions used. Annual ownership costs were calculated as the cost of the system ($81,217 versus 42,226) amortized over the expected life (10 versus 15 years) at 9% interest. It should be noted, that if system life is equal (15 years) the return advantage for the center pivot decreases to $0.58 per acre.

Additional economic comparisons were made varying both annual crop prices and corn yields. These analyses were conducted to study the potential income advantage the drip system had over the center pivot system due to more irrigated acres (160 vs 126), given the sample field used. These comparisons found that overall returns per acre could be equated between the two systems with relatively small changes in annual corn yields or crop prices. For example, a 7.5 bushel increase in drip system corn yields compared to those of the center pivot (182.5 vs 175) would equate annual per acre returns, holding all other variables constant. In addition, a $0.50 increase in both corn and wheat prices ($2.75 and $3.75) was enough to equate annual per acre returns between the drip and center pivot irrigation systems.

Table 9 demonstrates that irrigation efficiencies of center pivot systems relative to drip systems have little impact on drip system feasibility compared to center pivots. Even when the center pivot system requires 35% more applied irrigation, it is still a better investment, given the assumptions used.

The economic comparison (Table 8) illustrates that, given the field size and investment values used in this feasibility comparison, a center pivot system is more economical than a drip system. But one advantage of the drip system is a more efficient use of water, hence lower pumping costs. A question that may be asked is, "could increased energy costs cause the drip system to be more economical than a center pivot?" The answer is, "not likely." Because of the higher investment value of a drip system, energy costs have little impact on feasibility. In fact, as long as the center pivot application efficiency remains within 15% of the drip system, energy costs have little or no impact. If the center pivot system requires larger amounts of applied irrigation, 20% or more, then energy costs will have an impact. But energy costs would have to rise significantly before the drip system would be more economical.

Another question that could be asked is, "if the overall investment values of drip and center pivot systems were closer, would drip systems be more feasible?" The answer is "yes." In the current comparison, the investment difference is $38,991 ($81,217 - $42,226). Using the analysis in Table 8, if the investment value of the drip system were lowered to $64,070, the feasibility of the two systems would be equal.

Table 1. Marginal Returns To Various Irrigation Levels In Corn ($/ac.), Garden City, KS[1]

Year	Irrigation % of ET	Irrigation Inches	Yield bu./ac.	Added Irr.(in)	Added Cost[2]	Added Bu.	Added Income[3]	Marginal Return
1990[4]	0.00	0	134.3					
	0.25	1.8	140.3	1.8	$ 4.50	6.0	$ 12.00	$ 7.50
	0.50	6.8	159.3	5.0	$12.50	19.0	$ 38.00	$25.50
	0.75	13.4	162.5	6.6	$16.50	3.2	$ 6.40	($10.10)
	1.00	19.3	176.3	5.9	$14.75	13.8	$ 27.60	$12.85
	1.25	23.8	174.3	4.5	$11.25	-2.0	($ 4.00)	($15.25)
1991	0.00	0	131.8					
	0.25	1.8	129.0	1.8	$ 4.50	-2.8	($ 5.60)	($10.10)
	0.50	8.8	180.5	7.0	$17.50	51.5	$103.00	$85.50
	0.75	15.7	207.8	6.9	$17.25	27.3	$ 54.60	$37.35
	1.00	20.1	217.8	4.4	$11.00	10.0	$ 20.00	$ 9.00
	1.25	23.7	213.0	3.6	$ 9.00	-4.8	($ 9.60)	($18.60)
90-91	0.00	0.0	133.1					
Avg.	0.25	1.8	134.7	1.8	$ 4.50	1.6	$ 3.20	($ 1.30)
	0.50	7.8	169.9	6.0	$15.00	35.3	$ 70.50	$55.50
	0.75	14.6	185.2	6.8	$16.88	15.3	$ 30.50	$13.63
	1.00	19.7	197.1	5.2	$12.88	11.9	$ 23.80	$10.93
	1.25	23.8	193.7	4.0	$10.12	-3.4	($ 6.80)	($16.93)

1 Yield and irrigation data from:
"Water Requirement for Corn with Drip Irrigation", T. Weis, et.al., SWREC, Garden City, KS, KSU Report of Progress 657.
2 Added cost is calculated as added irrigation inches x $2.50/inch.
3 Added income is calculated as added bushels x $2.25/bushel less $0.25/bushel harvest cost.
4 Plots received hail in 1990.

Table 2. Marginal Returns To Various Irrigation Levels In Corn ($/ac.), Colby, KS[1]

Year	Irrigation % of ET	Irrigation Inches	Yield bu./ac.	Added Irr. (in)	Added Cost[2]	Added Bu.	Added Income[3]	Marginal Return
1989[4]	0.00	0.00	126.0					
	0.25	1.95	141.0	2.0	$ 4.88	15.0	$ 30.00	$ 25.13
	0.50	6.85	158.7	4.9	$12.25	17.7	$ 35.40	$ 23.15
	0.75	10.15	174.9	3.3	$ 8.25	16.2	$ 32.40	$ 24.15
	1.00	15.50	180.6	5.4	$13.38	5.7	$ 11.40	($ 1.98)
	1.25	19.70	166.8	4.2	$10.50	-13.8	($ 27.60)	($ 38.10)
1990	0.00	0.00	96.2					
	0.25	3.42	125.1	3.4	$ 8.55	28.9	$ 57.80	$ 49.25
	0.50	7.80	166.8	4.4	$10.95	41.7	$ 83.40	$ 72.45
	0.75	13.52	192.6	5.7	$14.30	25.8	$ 51.60	$ 37.30
	1.00	17.95	221.4	4.4	$11.08	28.8	$ 57.60	$ 46.53
	1.25	22.80	195.9	4.9	$12.13	-25.5	($ 51.00)	($ 63.13)
1991	0.00	0.00	69.1					
	0.25	3.30	107.7	3.3	$ 8.25	38.6	$ 77.20	$ 68.95
	0.50	7.25	173.2	4.0	$ 9.88	65.5	$131.00	$121.12
	0.75	13.65	227.9	6.4	$16.00	54.7	$109.40	$ 93.40
	1.00	16.75	234.7	3.1	$ 7.75	6.8	$ 13.60	$ 5.85
	1.25	21.35	237.6	4.6	$11.50	2.9	$ 5.80	($ 5.70)
89-91 Avg.	0.00	0.00	111.1					
	0.25	2.89	133.1	2.9	$ 7.23	22.0	$ 43.90	$ 36.68
	0.50	7.30	162.8	4.4	$11.03	29.7	$ 59.40	$ 48.37
	0.75	12.44	183.8	5.1	$12.85	21.0	$ 42.00	$ 29.15
	1.00	16.73	201.0	4.3	$10.73	17.3	$ 34.50	$ 23.77
	1.25	21.28	181.4	4.6	$11.38	-19.6	($ 39.30)	($ 50.67)

1 Yield and irrigation data from:
"Water Requirement of Corn under Drip Irrigation", F.R. Lamm, NWREC, Colby, KS, KSU Report of Progress 660.

2 Added cost is calculated as added irrigation inches x $2.50/inch.

3 Added income is calculated as added bushels x $2.25/bushel less $0.25/bushel harvest cost.

4 Plots received hail in 1989.

Table 3. Marginal Returns To Various Dripline Spacing Levels In Corn($/ac.), Garden City, KS[1]

Year	Dripline Spacing(ft)	Driplines per qtr.	Driptape ft./acre	Yield bu./ac.	Added Driptape	Added Cost[2]	Added Bu.	Added Income[3]	Marginal Return
1989	10.0	264	4,356	192.9					
	7.5	352	5,808	201.4	1,452	$ 6.72	8.5	$17.00	$10.28
	5.0	528	8,712	204.6	2,904	$13.44	3.2	$ 6.40	($ 7.04)
	2.5	1,056	17,424	217.4	8,712	$40.31	12.8	$25.60	($14.71)
1990[4]	10.0	264	4,356	180.5					
	7.5	352	5,808	186.0	1,452	$ 6.72	5.5	$11.00	$ 4.28
	5.0	528	8,712	193.7	2,904	$13.44	7.7	$15.40	$ 1.96
	2.5	1,056	17,424	215.0	8,712	$40.31	21.3	$42.60	$ 2.29
1991	10.0	264	4,356	208.8					
	7.5	352	5,808	237.2	1,452	$ 6.72	28.4	$56.80	$50.08
	5.0	528	8,712	254.4	2,904	$13.44	17.2	$34.40	$20.96
	2.5	1,056	17,424	257.7	8,712	$40.31	3.3	$ 6.60	($33.71)
90-91	10.0	264	4,356	194.1					
Avg.	7.5	352	5,808	208.2	1,452	$ 6.72	14.1	$28.27	$21.55
	5.0	528	8,712	217.6	2,904	$13.44	9.4	$18.73	$ 5.30
	2.5	1,056	17,424	230.0	8,712	$40.31	12.5	$24.93	($15.38)

1 Yield and irrigation data from: "Drip-Line Spacing and Plant Population for Corn", W. Spurgeon, et.al., SWREC, Garden City, KS, KSU Report of Progress 657.

2 Added cost is calculated as added driptape (ft/ac) @ $.025/ft. + additional ends (8 ends/dripline/160 ac) @ $1.55/end ($.75/connector & supply line + $.80 labor) ammortized over 10 years @ 9%.

3 Added income is calculated as added bushels x $2.25/bushel less $0.25/bushel harvest cost.

4 Plots received hail in 1990.

Table 4. Marginal Returns To Various Dripline Spacing Levels In Corn ($/ac.), Colby, KS[1]

Year	Dripline Spacing(ft)	Driplines per qtr.	Driptape ft./acre	Yield bu./ac.	Added Driptape	Added Cost[1]	Added Bu.	Added Income[2]	Marginal Return
1990	10.0	264	4,356	217					
	7.5	352	5,808	225	1,452	$ 6.72	8.0	$16.00	$ 9.28
	5.0	528	8,712	224	2,904	$13.44	-1.0	($ 2.00)	($15.44)
1991	10.0	264	4,356	171					
	7.5	352	5,808	183	1,452	$ 6.72	12.0	$24.00	$17.28
	5.0	528	8,712	208	2,904	$13.44	25.0	$50.00	$36.56
90-91	10.0	264	4,356	194					
Avg.	7.5	352	5,808	204	1,452	$ 6.72	10.0	$20.00	$13.28
	5.0	528	8,712	216	2,904	$13.44	12.0	$24.00	$10.56

[1] Yield and irrigation data from:
"Optimum Spacing of Driplines for Drip-Irrigated Corn", F.R. Lamm, NWREC, Colby, KS, KSU Report of Progress 660.

[2] Added cost is calculated as added driptape (ft/ac) @ $.025/ft. + additional ends (8 ends/dripline/160 ac) @ $1.55/end ($.75/connector & supply line + $.80 labor) amortized over 10 years @ 9%.

[3] Added income is calculated as added bushels x $2.25/bushel less $0.25/bushel harvest cost.

Table 5. Marginal Returns To Various Dripline Lengths In Corn ($/ac.), Garden City and Colby, KS[1]

Location/Year	Dripline Length(ft)	Number of submains	Yield bu/ac	Added Cost[1]	Added Bushels	Added Income[2]	Marginal Return
Garden City[4]							
1990	660	4	187.2				
	330	8	196.0	$26.00	8.8	$17.60	($ 8.40)
1991	660	4	218.2				
	330	8	222.5	$26.00	4.3	$ 8.50	($17.50)
90-91 Avg.	660	4	202.7				
	330	8	209.2	$26.00	6.5	$13.05	($12.95)
Colby							
1990	660	4	231.2				
	330	8	219.3	$26.00	-11.9	($23.80)	($49.80)
1991	660	4	208.5				
	330	8	200.0	$26.00	-8.6	($17.10)	($43.10)
90-91 Avg.	660	4	219.9				
	330	8	209.6	$26.00	-10.2	($20.45)	($46.45)

1 Yield and irrigation data from:
"Drip-Line Length Study", W. Spurgeon, et.al., SWREC, Garden City, KS, KSU Report of Progress 657. "Dripline Length Study", F.R. Lamm, NWREC, Colby, KS, KSU Report of Progress 660.
2 Added cost is the added investment necessary to shorten dripline length ammortized over 10 years @ 9% (see Table 6).
3 Added income is calculated as added bushels x $2.25/bushel less $0.25/bushel harvest cost.
4 Plots received hail in 1990.

Table 6. Capital Requirements: Drip Irrigation System (160 ac.)

Item	----- Items by Foot ----- Feet	Price/ft.	Subtot	Single Items	Total	Your Farm Total
8" Mainline Pipe	1980	$1.25	$ 2,475		$ 2,475	________
8" Submain Pipe	2640	$1.25	$ 3,300		$ 3,300	________
6" Submain Pipe	1360	$0.65	$ 884		$ 884	________
4" Submain Pipe	1280	$0.65	$ 832		$ 832	________
4" Flushline Pipe	10560	$0.65	$ 6,864		$ 6,864	________
Driptape	1399200	$0.025	$34,980		$34,980	________
Driptape connectors (sply tbg & slv lock)				$3,168	$ 3,168	________
2- 8" PIP Crosses				$ 140	$ 140	________
4- 8" PVC Butterfly gate valves				$1,600	$ 1,600	________
4- 8-6" PVC reducers				$ 60	$ 60	________
4- 6-4" PVC reducers				$ 40	$ 40	________
12- 4" PVC elbows				$ 84	$ 84	________
12- 4" PVC removable endcaps				$ 66	$ 66	________
PVC glue & solvent				$ 200	$ 200	________
Filter- 900 Gpm, automated sand media				$8,525	$ 8,525	________
26- Pressure Gages (0 - 30 Psi)				$ 416	$ 416	________
Trenching	15180	$0.60	$9,108		$ 9,108	________
Producer Labor (995.4 hrs @ $8/hr)				$7,963	$ 7,963	________
Producer Provided Tractors (62 hrs)				$ 512	$ 512	________
Total					$81,217	________
Per Irrigated Acre System Costs					$507.61	________

**All charges based on producer installation

Table 7. Capital Requirements: Center Pivot Irrigation System (126 ac.)

Item	----- Items by Foot -----		Subtot	Single Items	Total	Your Farm Total
	Ft.	Price/ft.				
Pivot System				$34,000	$34,000	______
Undergrnd Pipe	1320	$2.30	$3,036		$ 3,036	______
Electrical Wiring	1320	$2.00	$2,640		$ 2,640	______
Connectors				$ 350	$ 350	______
12 KVA Generator				$ 2,200	$ 2,200	______
Total					$42,226	______
Per Irrigated Acre System Costs					$335.13	______

** All charges on an installed basis.

Table 8. Subsurface Drip Irrigation Feasibility Comparison

	Drip		Pivot
NET INVESTMENT	$81,217		$42,226
Interest rate on investment	9.0%		9.0%
Years for payback	10		15
IRRIGATION MANAGEMENT			
Annual repairs[1]	$500		$500
Pumping cost/inch of water[2]	$1.97		$2.13
Inches of water pumped/acre[3]	18.50		20.35
Pumping energy cost/acre	$36.37		$43.28
ACREAGE BREAKDOWN			
Irrigated corn acres	160		126
Dryland wheat acres			17
Dryland fallow acres			17
TOTAL ACRES	160		160
RETURNS ANALYSIS[4]			
Crop Income:			
Irrigated acres	$63,000		$49,613
Dryland acres	0		1,934
TOTAL INCOME	$63,000		$51,546
Crop Expenses:			
Irrigated acres	$39,407		$32,053
Dryland acres	0		767
Total property taxes[5]	$ 1,416		$ 1,293
TOTAL EXPENSES	$40,823		$34,113
Returns to Management and Total Investment	$22,177		$17,433
Annual Cost of Irrigation Equipment (P & I)[6]	$12,655		$ 5,239
Returns to Management, Land and Mach. Investment	$ 9,522		$12,195
DIFFERENCE		$2,672	
Returns to Mgt, Land and Mach. Investment/Acre	$59.51		$76.22
DIFFERENCE/ACRE		$16.70	

1 Because little is known concerning annual repair costs, they are assumed equal for this analysis.
2 Based on 225 feet of lift, a price for natural gas of $3.00/mcf, pump efficiency at 80% of NPPPC, and 25 PSI for drip and 35 PSI for the center pivot system.

3 Assuming the center pivot will require 10% more water applied.
4 Acres x income and expenses from Table 10.

5 1% the value of land (irrigated = $885/ac and dryland = $472/ac).

6 Annual payment based on the net investment value amortized over the number of years for payback at nine percent interest.

Table 9. Drip Irrigation Feasibility Table With Varying Center Pivot Irrigation Efficiencies Relative To The Drip System[1]

	Total		Per Acre Returns		
	Drip	Pivot	Drip	Pivot	Difference
Crop Income:	$63,000	$51,546			
Annual Cost of System	$12,655	$ 5,239			
Crop Expenses[2]:	$40,823		$59.51		
5% > irrig.		$33,854		$77.83	$18.32
10% > irrig.		$34,113		$76.22	$16.70
15% > irrig.		$34,372		$74.60	$15.09
20% > irrig.		$34,631		$72.98	$13.47
25% > irrig.		$34,890		$71.36	$11.85
35% > irrig.		$35,408		$68.12	$ 8.61

[1] Based on data from Table 8.

[2] Crop expenses of the center pivot system vary based on the added irrigation relative to the drip system (18.5 acre inches).

Table 10. Per Acre Crop Income And Assorted Expenses[1]

	Irrigated Corn	Dryland Wheat
Crop yield	175	35
Crop price/bushel	$2.25	$3.25
Crop sales/acre	$393.75	$113.75
Labor cost @ $8.00/hour	$20.00	$ 9.60
Seed	32.00	3.12
Herbicide	26.25	9.40
Insecticide	49.04	0.00
Fertilizer	33.35	3.60
Crop fuel and oil	8.05	5.55
Machinery repairs	21.50	11.90
Crop consulting	6.00	0.00
Total crop expenses/acre[2]		$ 45.11
drip corn	$246.29	
pivot corn	$254.39	

[1] The listed crop expenses are from MF-585, "Center-Pivot-Irrigated Corn", and MF-257, "Summer Fallow Wheat in Western Kansas", Kansas State University.

[2] Total crop expenses include all expenses listed, plus irrigation pumping costs, and interest on 1/2 of variable costs at 9 percent.