LOW ENERGY PRECISION APPLICATION IRRIGATION FOR COTTON PRODUCTION IN THE TEXAS SOUTHERN HIGH PLAINS

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ABSTRACT

In this study the farm level economic feasibility of converting a center pivot low-pressure irrigation system to a low-energy precision application (LEPA) irrigation system for cotton production in the Southern High Plains of Texas is evaluated. The irrigation conversion is economically feasible. Therefore, the adoption of LEPA in the Southern High Plains of Texas is a viable alternative for cotton producers to assure continued profitability of agricultural operations and future firm survival.

INTRODUCTION

The Southern High Plains of Texas (SHPT) land resource area is located in the southern part of the Great Plains region of the United States. Average rainfall ranges from 10 to 20 inches per year, so supplemental irrigation in agricultural crop production is common in the area. Most of the water used for irrigation is obtained from the Ogallala formation, a major underground aquifer extending over portions of the states of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, and Texas which covers over 220,000 square miles (High Plains Associates, 1982).

Substantial increases in agricultural production have occurred in the SHPT from widespread use of irrigation since the 1940s. However, continued water withdrawals from the Ogallala have resulted in declines of the water table ranging from 50 to 200 feet (Lee, 1987; Mapp, 1988).

Rising water extraction costs associated with deeper water tables and increased energy prices have resulted in significant changes in irrigated acreage of the four major crops (corn, cotton, sorghum, and wheat) produced in the region. For example, combined irrigated acreage of those four crops declined from a high of 4.8 million acres in 1976 to 3.2 million acres in 1985, a reduction of over 33 percent. In particular, corn and sorghum (about 90 percent of which were irrigated) declined by 40 percent from 1975 to 1985 (Lansford et al., 1987). Those changes occurred because of lower profits per unit of production as compared to other irrigated areas (Mapp, 1988). Thus, efficient utilization of irrigation inputs available to producers in the SHPT has become a key component for enterprise profitability and firm survival.

In this study, the conversion of a center-pivot low-pressure sprinkler irrigation system to a low-energy precision application (LEPA) irrigation system for cotton production in the SHPT is evaluated. The conversion of a center-pivot low-pressure sprinkler irrigation system to a LEPA irrigation system is achieved by the attachment of flexible tubing which extends downward having a nozzle on the end. The primary objective of this study is to determine the farm level economic feasibility of that conversion. Although a LEPA irrigation system should decrease water use to obtain crop yields similar to those resulting from other irrigation systems, it is assumed in the economic feasibility evaluation of the conversion that producers continue to extract the same amount of water. Analysis of issues of contemporary social interest such as the implications of adopting LEPA to conserve underground water resources for use by future generations are beyond the scope of this study.

THE LOW ENERGY PRECISION APPLICATION (LEPA) IRRIGATION SYSTEM

Irrigation may be the least efficient and most expensive operation involved in the production of irrigated crops because irrigation activities are high consumers of energy (Lyle and Bordovsky, 1981). The amount of energy used in irrigation depends on the rate (gallons/minute) and depth of water extraction. Nearly two thirds of the irrigation pumps in the SHPT are powered by internal combustion engines using natural gas, whereas the remainder are powered by electric motors. Low water-application efficiency and excess energy consumption impair profitability, and thus regional competitiveness, in agricultural production. However, these conditions may be beyond the control of the agricultural producer who must rely on current technologies.

Precise control of water application to the root zone of plants with surface irrigation methods is difficult due to variability in soil intake rate, length of run, and many other factors (Lyle and Bordovsky, 1981). Developments in irrigation system technologies after World War II evolved rapidly with the introduction of lightweight and aluminum pipe. Center-pivot, side roll, and solid set high pressure irrigation systems enabled greater control over water application rates. Gains in control of water applications were possible largely at the expense of greater levels of energy used to distribute water on croplands. Additionally, water application efficiency of high pressure sprinkler irrigation systems, can be impaired by climatological conditions. For example, Clark and Finley (1975) found that spray evaporation losses from solid set high pressure sprinklers ranged from 17 percent with wind speeds of 15 mph to 30 percent with wind speeds of 20 mph. The SHPT experiences occasional wind velocities higher than those reported by Clark and Finley (1975) during the cotton growing season, and center pivot high pressure sprinkler irrigation is the most popular type of irrigation system used in the area.

Low pressure sprinkler irrigation systems were developed in an attempt to alleviate some of the water application efficiency problems as well as the high energy required to operate high pressure sprinkler systems. These low pressure irrigation systems were of the same basic design as the high pressure systems, but water pressure is decreased at least 50 percent. Water application efficiency levels of 80 and 85 percent can be attained with low pressure sprinkler irrigation systems.

More recent technological advances in irrigation systems have provided agricultural producers with a new system referred to as Low Energy Precision Application or LEPA. Although this irrigation system is still in experimental stages, it has already proved to be efficient when compared to other low pressure irrigation systems (Lyle and Bordovsky, 1983). This system can be added onto existing low pressure sprinkler systems by adding flexible tubing to the pipe drops on the low pressure system. The tubing extends down to approximately twelve to sixteen inches above the ground. Although the tubes have a nozzle on the end, LEPA nozzles spray water in a manner which confines the application to a single furrow per nozzle (details on LEPA specifications are provided by Lyle and Bordovsky, 1981; Stoecker and Lloyd, 1984). One of the two major advantages of LEPA over other low pressure irrigation systems is that evaporation losses are reduced to a minimum resulting in water application efficiency in excess of 98 percent. The other advantage of LEPA is that it requires only five to ten

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pounds of end pressure, whereas other low pressure irrigation systems require fifteen to thirty pounds.

CONVERSION OF A CENTER PIVOT LOW PRESSURE SPRINKLER TO A LOW-ENERGY PRECISION APPLICATION IRRIGATION SYSTEM

A cost analysis, summarized in the form of two partial budgets, was conducted to evaluate the conversion of a 1,389 foot long center-pivot low-pressure sprinkler irrigation system to a LEPA irrigation system for 139 acres of cotton located in the western SHPT. The budgets included electricity costs for both irrigation systems. The LEPA's system budget also included additional labor and maintenance costs associated with its operation. Costs of other variable inputs such as fertilizer, labor, insecticide, herbicide, and tillage operations were not included in those budgets because they are the same regardless of the irrigation system used. The cost of the conversion was obtained from Valley Ag-Electric, Inc. in Lamb County, Texas. Table 1 depicts an itemized list of the conversion costs.

Table 1. Itemized Conversion Costs of a 1,389 Foot Long Center Pivot Low Pressure Irrigation System to Low Energy Precision Application Irrigation System, Hockley County, Texas, 1989.

Item	Cost
278 Gooseneck pipes	$ 702.70
278 3' drops	908.82
278 Steel collars	231.11
278 PVC collars	277.95
2224 Feet LEPA hose	1,624.02
556 LEPA hose clamps	113.68
556 3/4" H.B. x 3/4" M.P.T.	203.00
139 Low flow regulators	761.26
139 Medium flow regulators	548.10
556 Stainless steel ties	73.08
278 LEPA nozzles	1,502.60
Labor to install LEPA	894.00
TOTAL CONVERSION COST	$ 7,839.94

Source: Valley Ag-Electric, Inc., Lamb County, Texas, 1989.

Irrigation costs for alternative size horsepower motors over different number of operating days per year were obtained from Lamb County Electric Cooperative, Inc. Assumptions made in deriving irrigation costs were: motors would operate for 24 hours a day at 100 percent of rated capacity and 89 percent efficiency, the price per kilowatt was $0.0465, and cotton would be irrigated 90 days per year. The annual irrigation electricity cost for operating both systems was estimated at $7,994.58 per year. Additional labor and maintenance costs associated with the operation of the LEPA system were estimated at $249.10 per year (Valley Ag-Electric Inc.)

The major difference between LEPA and other irrigation systems is that LEPA reduces water evaporation, resulting in increased water application efficiency (in most cases above 98 percent) and increased cotton lint yields. A 1984 evaluation of the center-pivot low-pressure irrigation system used in this study by the Hockley County Soil Conservation Service, showed that the actual water application efficiency of the system was 77.46 percent. That is, 77.46 percent of the water applied through the irrigation system was actually delivered to the ground. Local farm records show that average cotton yield for the 1984, 1985, 1987, and 1988 crop years was 1.36 bales (680 lbs.) of lint per acre.

During the crop years of 1986, 1987, and 1988 the Hockley County Soil Conservation Service conducted tests indicating an average increase of 21.84 percent in cotton lint yields by using LEPA. Similar increases due to LEPA have been documented for soybeans by Lyle and Bordovsky, 1983. Thus, using 21.84 percent as an estimate of the expected cotton yield increases obtained by LEPA, the expected lint yields in this study would be 1.657 bales (828.5 lbs.) per acre.

Assuming a price of $0.60/lb. for cotton lint, the increase in cotton lint yield would provide an additional $89.10 per acre for an increase in annual total gross revenue to land, overhead, risk, and management of $12,391.13 over that obtained with the low pressure sprinkler irrigation system. Adjusting this value for the additional LEPA labor and maintenance costs of $249.10, results in a total gross return increase of $12,142.03 (Table 2).

Table 2. Partial Budget Comparing the Low Pressure Sprinkler (LPS) to the Low Energy Precision Application (LEPA) System, Hockley County, Texas, 1989.

System	Yield (lbs./A.)	Operating Cost (OC)	Total Gross Revenue(TGR)	TGR - OC	Change in TGR - OC
LPS	680.0	$7,994.58	$56,740.56[a]	$48,745.98	
LEPA	828.5	$8,243.68[b]	$69,131.69	$60,888.01	$12,142.03

[a] Assumes a $0.60/lb. cotton lint price. Obtained as the product of number of acres in the circle (139.07), cotton lint yield (680), and per pound cotton lint price ($0.60).

[b] Includes the additional labor and maintenance cost of $249.10.

Agricultural producers must consider lint price variability in their decision to convert low-pressure sprinkler systems to LEPA. Thus, alternative cotton lint price scenarios may be used to evaluate the additional annual gross revenue generated by the adoption of LEPA. Furthermore, because the conversion of the center pivot from low pressure sprinkler to LEPA is an investment, the economic feasibility of the investment must be evaluated through time.

Table 3 depicts the increases in total gross revenues across alternative cotton price scenarios ranging from $0.35/lb. to $0.75/lb. Once the expected increases in cotton yields associated with the conversion from low pressure sprinkler to LEPA is considered, it can be seen that nominal total gross return annual increases range from $6,979.06 to $15,239.82, depend-

Table 3. Increases in Total Gross Returns Across Alternative Cotton Price Scenarios Due to LEPA's Increased Water Application Efficiency in Cotton Production, Hockley County, Texas.

(1) Cotton Price ($/lb.)	(2) Nominal Annual Increase ($)	(3) Present Value of Increases ($)	(4) Cost of LEPA ($)	(5) Net Present Value of Investment (3)-(4)	(6) Benefit Cost Ratio (3)/(4)
0.35	6,979.06	50,576.49	7,839.94	42,736.55	6.45
0.37	7,392.10	53,569.73	7,839.94	45,729.79	6.83
0.39	7,805.14	56,562.97	7,839.94	48,723.03	7.21
0.41	8,218.18	59,556.21	7,839.94	51,716.27	7.60
0.43	8,631.21	62,549.45	7,839.94	54,709.51	7.98
0.45	9,044.25	65,542.69	7,839.94	57,702.75	8.36
0.47	9,457.29	68,535.93	7,839.94	60,695.99	8.74
0.49	9,870.33	71,529.16	7,839.94	63,689.22	9.12
0.51	10,283.37	74,522.40	7,839.94	66,682.46	9.51
0.53	10,696.40	77,515.64	7,839.94	69,675.70	9.89
0.55	11,109.44	80,508.88	7,839.94	72,668.94	10.27
0.57	11,522.48	83,502.12	7,839.94	75,662.18	10.65
0.59	11,935.52	86,495.36	7,839.94	78,655.42	11.03
0.61	12,348.56	89,488.60	7,839.94	81,648.66	11.41
0.63	12,761.59	92,481.84	7,839.94	84,641.90	11.80
0.65	13,174.63	95,475.08	7,839.94	87,635.14	12.18
0.67	13,587.67	98,468.32	7,839.94	90,628.38	12.56
0.69	14,000.71	101,461.50	7,839.94	93,621.62	12.94
0.71	14,413.75	104,454.70	7,839.94	96,614.86	13.32
0.73	14,826.78	107,448.00	7,839.94	99,608.10	13.71
0.75	15,239.82	110,441.20	7,839.94	102,601.30	14.09

ing on the cotton price level. If the life span of the conversion of the irrigation system is ten years, and an 8 percent discount rate is used, the associated present value of the increases of gross returns from the conversion ranges from $50,576.49 to $110,441.20 over this ten year period. Taking into consideration the LEPA conversion cost the associated net present value of returns associated with the irrigation system conversion would range from $42,736.55 to $102,601.30.

Another indicator of the economic feasibility of the conversion of the irrigation system is given by the benefit-cost ratio which ranges from 6.45 to 14.09 (Table 3). For example, for a $0.45/lb. cotton price the benefit cost ratio is 8.36. This implies that benefits are 8.36 times the cost, or that for every $1.00 of investment, benefits would equal $8.36. Furthermore, careful examination of the information in Table 3 reveals, that the pay-back period of the investment would be less than one year for all cotton price scenarios with the exception of the $0.35/lb. and $0.37/lb., in which it would be a little longer than one year. In other words, the conversion of the center pivot low pressure sprinkler to LEPA system would pay for itself in less than one year in most of the cotton price scenarios analyzed. Considering that cotton prices in the SHPT during the last fifteen years have varied from $0.46/lb. in 1975 to $0.69 in 1980 (Texas Department of Agriculture), the economic feasibility of the irrigation system conversion is established.

CONCLUSION

The primary objective of this study was to determine the farm-level economic feasibility of converting a 1,389 foot long center pivot low pressure sprinkler irrigation system to a LEPA irrigation system for cotton production in the SHPT. Because of increased water application efficiency obtained with LEPA, the conversion would be economically feasible. Some drawbacks are associated with the use of LEPA, such as increased concern for row spacing, increased maintenance costs, and increased labor requirements. Nevertheless, LEPA is a viable option to farmers in the SHPT because the benefits from its use outweigh the costs.

Few LEPA systems are currently in use in the SHPT. Widespread adoption of LEPA in the SHPT would improve agricultural water use efficiency.

REFERENCES

Clark, R. N., and W. W. Finley. 1975. Sprinkler Evaporation Losses in the Southern Plains. Amer. Soc. Agric. Eng. Paper No. 75-2573, St. Joseph, Missouri.

High Plains Associates. 1982. Six-State High Plains-Ogallala Aquifer Regional Resource Study. A Report to The U. S. Department of Commerce and The High Plains Study Council, Austin, Texas, March.

Lansford, V. D., W. L. Harmon, and J. T. Musick. 1987. The Texas High Plains: Adjustments to Changing Economic and Resource Conditions, 1970-1985. Texas Agricultural Experiment Station Miscellaneous Publication No. MP-1637, College Station, Texas.

Lee, J. G. 1987. Risk Implications of the Transition to Dryland Agricultural Production on the Texas High Plains. Unpublished Ph. D. Dissertation, Department of Agricultural Economics, Texas A&M University, College Station, Texas.

Lyle, W. M., and J. P. Bordovsky. 1981. Low Energy Precision Application (LEPA) Irrigation System. Transactions, 24(5): 1241-1245.

Lyle, W. M., and J. P. Bordovsky. 1983. LEPA Irrigation System Evaluation. Transactions, 26(3): 776-781.

Mapp, H. P.. 1988. Irrigated Agriculture in the High Plains: A Future of Decline? Annual meeting of the Western Agricultural Economics Association, Honolulu, Hawaii, July 10-12.