A STUDY TO DETERMINE THE COST OF SPRINKLER IRRIGATION IN KANSAS

by

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INTRODUCTION

The seasonal distribution of rainfall in Kansas is such that crop yields are often greatly reduced due to the lack of adequate moisture for plant use at a critical stage in the plant's growth. This fact necessitates the use of supplemental irrigation if optimum crop production is to be obtained. The sprinkler system is one method by which this supplemental water may be distributed to a crop.

Sprinkling has been used as a method of distributing irrigation water in parts of the United States since the beginning of the twentieth century. However, it was not until the development of light weight portable aluminum pipe in the early 1930's that this method began to be used to irrigate general farm crops. At this date sprinkler irrigation was not widely accepted as a method of irrigating farm crops because satisfactory couplers had not been developed. Prior to this time, this method of irrigation was confined to use on small patches of truck crops, nurseries, flower beds or small fruits. Sprinkling on these small patches was almost universally applied through permanently placed overhead perforated pipe. Later satisfactory couplers and rotating sprinklers were developed which permitted the method to be adapted to use on larger and larger acreages of general field crops.

Published data were not available from which it would be possible to determine the growth of this method of irrigation throughout Kansas. However, sales records of some of the dealers who operated throughout the state have been examined which showed that, with one exception, there had been a steady increase in their annual sales. The exception was the years 1941 through 1946 when the systems were not being manufactured because of

World War II. These sales records showed that the number of systems sold during 1951 and again in 1952 were 50 percent greater than any year previous to 1951.

PURPOSE

The purpose of the study reported in this thesis is to provide information relative to the cost of irrigating with sprinkler systems and to determine how these costs are distributed throughout the two categories of cost of ownership and cost of operation.

REVIEW OF LITERATURE

It has been noted that the number of sprinkler irrigation systems being sold in Kansas has been increasing at a rapid rate during the past two years. Costs were one factor which might significantly affect the expansion of the use of sprinkler systems as a method of distributing irrigation water. Initial capital outlay required as well as the annual costs incurred when irrigating by this method have been important items of consideration when determining whether or not to irrigate by this method.

The initial capital outlay was usually expressed on a per acre basis. Expressing it in this manner gives some basis for comparing one system to another. This capital outlay was frequently affected by such variables as: The source of irrigation water; The relative location of the source of water and the area to be irrigated; The number of lateral lines operated simultaneously; The size and shape of the area to be irrigated; The method employed in moving the pipe; The relative portability of the main and lateral lines; and the relative size of the entire system.

Rubey (11) stated regarding the initial costs:

> The original cost of installing supplemental irrigation on a well planned project in Missouri may be in the neighborhood of $50 to $100 per acre.

Becker (2) who has investigated the costs of sprinkler irrigation states:

> The original investment in irrigation equipment on the farms studied averaged $116 per acre and ranged from $30 to $504 per acre. Investment was less for large systems.

Jensen and Bevan (10) made a study of the cost of sprinkler irrigation on Idaho farms and found that the initial investment varied between the wide ranges of $28.31 to $222.22 per acre. They studied 61 systems which had an average initial investment of $82.90 per acre.

In an article in _Implement and Tractor_ (13) it is stated:

> Depending upon the amount and type of equipment installed a farmer can invest as little as $25 or as much as $100 per acre to install an efficient sprinkler irrigation system. Much depends upon such variables as: The acreage to be irrigated, the source of water (surface or well), the distance of the irrigated land from the water source, type of pumping plant, and fuel.

Code and Hamman (6) found in their investigations relative to the costs of sprinkler irrigation in Colorado that the initial capital investment for 30 systems which were studied varied from $25 to $156 per acre, and that the average investment was $79 per acre.

In bulletin No. 3, a Pacific Northwest Co. operative Extension Publication (1) it is stated:

> The cost of installing a sprinkler system varies from $75 to $100 per acre. Occasionally a large system is installed for less than $75 per acre. But equally common is the system that costs more than $100 per acre.

The per acre annual costs of irrigating with sprinkler systems have been found to be quite variable. _Country Gentleman_ (7) relates that the annual costs for one farmer who irrigated corn in Henry County, Indiana, in 1952 were $31 per acre.

Rubey (11) has found information relative to annual costs in investigations that he has conducted in Missouri. He states:

> The annual cost of keeping the installation "ready to serve" whether used or not, consists of interest, depreciation, taxes, and insurance of 7 to 10 percent annually of the original cost, or from $3.50 to $10 per acre per year.
>
> Each year that irrigation is used considerably, and this will be most years for most crops, the total annual costs for each acre, including the annual costs of the preceding paragraph, may be from $15 to $20.

Jensen and Bevan (10) found in their investigations that the annual costs of irrigating by the sprinkler method averaged $18.95 per acre when irrigating from a free water source and $18.20 per acre when irrigating from an assessed water source. They found that the average labor costs were $5.30 and $5.25 per acre per year respectively when irrigating from the previously mentioned water sources.

Regarding the annual operating costs the following is stated in an article in Implement and Tractor (13):

> In addition to the initial capital invested in the system, annual operating expenses will average about $14.50 per acre-foot of water applied with a 500 gallon per minute discharge using distillate fuel and pumping with a lift of 100 feet at a pressure of 50 pounds per square inch.

Sprinkler irrigation, not unlike other methods of irrigation, requires some amount of labor for the proper functioning of the system. However, the quantity of labor required under different methods is quite variable. It is dependent to some extent upon how fast the operator desires to accomplish the task of moving the pipe, upon the type of coupler used, the length of sections used, the method employed in moving the pipe, the crop in which the moving is being done, and upon the relative compactness of the soil upon which the operator must work.

In an article in Implement and Tractor (14) it is stated:

> .....According to data developed in irrigation studies by the University of Nebraska, the man-hour requirements for sprinkler irrigation vary from a low of .85 man-hours per acre per irrigation in the tri-county area to a high of 1.25 man-hours per acre per irrigation in the North Platte area.

Jensen and Bevan (10) found that the total labor requirement for sprinkler irrigation varied between .3 and 1.8 man-hours per acre per irrigation on the 61 systems studied. The average labor requirement for all systems was .9 man-hours per acre per irrigation.

Code and Hammon (6), investigators working in Colorado have developed a general rule for computing the labor requirement for moving pipe. They state:

> Labor cost can be roughly computed on the basis of 1 man-hour required to move 1/4 mile of pipe. Many report that the item amounts to from 1/2 to 3/4 man-hours per acre.

METHOD AND PROCEDURE

Limitations of the Study

In every study or investigation certain limits must be placed upon what is to be included in the investigation. This study was designed to be limited to the determination of the costs on those systems which were being used as the only method of irrigation water distribution by each operator. This limitation was placed upon the study in order to eliminate the tendency for farmers and others to report data relative to their systems on a comparative rather than a factual basis. Throughout the investigation this limitation proved to be helpful in defining the boundaries of the study.

The study was further limited to the investigation of systems that were designed for use on general agricultural crops that are grown in Kansas. Such crops as nursery stock, flowers, and other specialized crops were not considered to be general agricultural crops in the state.

Location of Systems

A survey was conducted in October, 1952, as a preliminary step in this study, in an effort to determine the number and the area distribution of the sprinkler systems that were being used in the state. This survey was conducted through correspondence with the County Agricultural Extension Agents. Eighty-one of the 105 agents replied to this correspondence and reported that there were a total of 173 systems in their counties. The numerical distribution of these systems is shown in Table 1. No data were obtained from the remaining 24 counties relative to the number of sprinkler systems that were located in those counties.

Source of Data

The data that were used in this study were obtained by personal farm visits or by correspondence with those who were associated with the particular system being studied. The operational data given by farmers were often only an estimate; in other cases actual records supplied the information, in still others, information was supplied by the dealer who sold the system. The acreage of each crop that was to be irrigated with each system was supplied by the owner and/or operator.

In November, 1952, personal visits were made with farmers in Riley, Clay, Ottawa, Saline, Dickinson, and Geary counties and data were obtained relative to their systems. During December, 1952, personal visits were made to farms

Table 1. Sprinkler systems in Kansas.

County	No. systems in use	No. systems in study	County	No. systems in use	No. systems in study	County	No. systems in use	No. systems in study
Allen	0		Greeley	1		Osborne	3	
Anderson	0		Greenwood*			Ottawa	2	2
Atchison	0		Hamilton	1		Pawnee	2	
Barber	0		Harper	0		Phillips	0	
Barton	3		Harvey	1	1	Pottawatomie	2	
Bourbon	2		Haskell	1		Pratt	0	
Brown*			Hodgeman	2		Rawlins	5	
Butler	1		Jackson*			Reno	5	
Chase*			Jefferson	1		Republic	1	
Chautauqua*			Jewell	1		Rice	0	
Cherokee*			Johnson	0		Riley	7	4
Cheyenne	5	2	Kearney	1		Rooks*		
Clark	2		Kingman	0		Rush	2	1
Clay	5	1	Kiowa*			Russell	0	
Cloud*			Labette	1		Saline	11	2
Coffey*			Lane*			Scott	1	
Comanche	0		Leavenworth*			Sedgwick	4	
Cowley*			Lincoln	0		Seward	1	
Crawford	0		Linn*			Shawnee	1	
Decatur	10	3	Logan*			Sheridan	2	1
Dickinson	2	1	Lyon	0		Sherman	3	3
Doniphan*			McPherson	0		Smith	1	
Douglas	1		Marion	2	1	Stafford	1	
Edwards*			Marshall	4		Stanton	4	
Elk	0		Meade*			Stevens	1	
Ellis	4		Miami*			Sumner	1	
Ellsworth*			Mitchell*			Thomas	3	3
Finney	6	1	Montgomery	0		Trego	0	
Ford	6	3	Morris	0		Wabaunsee*		
Franklin	0		Morton	1		Wallace	1	1
Geary	4	1	Nemaha	1		Washington	2	
Gove	1		Neosho	0		Wichita	7	2
Graham	3		Ness	6		Wilson*		
Grant	6	1	Norton	1	1	Woodson	0	
Gray	6	2	Osage*			Wyandotte	5	

*Counties not reported.

located in Graham, Sheridan, Thomas, Sherman, Cheyenne, Rawlins, Decatur, and Norton counties and information was secured about their sprinkler systems. Again in March, 1953, personal visits were made to farms located in Barton, Rush, Ness, Wichita, Finney, Grant, Gray and Ford counties to secure information relative to the costs associated with their systems.

A total of 50 personal visits were made to farms in the 22 counties listed above and information acceptable for use in this study was obtained from 31 of the farms visited.

In addition to the personal farm visits that were made to secure data, 50 information forms requesting data about their systems were mailed to farmers. (See appendix for copy of forms which were mailed). These forms were mailed to those users of sprinkler systems in counties in which only one or two systems were reported in use. Therefore, a high percentage of acceptable reports was not expected to be secured by this manner. It was anticipated that many of these users would report that they were using their systems in the production of specialized crops such as nursery stock or flower beds. Of the thirty forms that were returned, 24 reported that they were using their systems in the production of specialized crops. The other 6 reports were satisfactory for use in the study.

A total of 37 reports acceptable for use in the study were received from the two sources. These are listed by quantities and counties in Table 1.

Early in the course of the study it was found that uniformity among farmers was entirely lacking in their estimates of the amount of water that was being applied to comparable areas of a given crop. Therefore, it was decided to use the estimated consumptive use data that had been computed by Hanson and Meyers (9) for the calculation of the normal optimum total quantity of water that would be required for each irrigation unit. These data have been calculated to give the estimated normal net irrigation requirement by counties for the various field crops that are grown in Kansas. It was deemed that the use of these data would more nearly give results to the study that could be interpreted as an average over a period of years.

The rate at which water was being discharged by each system was determined in one of four ways. For those systems which were using streams as a water source the rate of discharge was estimated by using the discharge pressure, the pump R.P.M. and the operating characteristic curve for the pump. For those systems which were pumping from wells a more reliable estimate of the rate of discharge was obtained. For the majority of those systems which were using wells as water sources the rate of discharge was based upon tests that were made by the driller or by the Division of Water Resources, Kansas State Board of Agriculture. These rates and the total quantities of water required by the crops (which was calculated in the manner stated above) which the system was serving were used to determine the total annual hours of operation. The total annual hours thus obtained were used as the basis for the remaining calculations.

Summary of Data

The following is a summary of the information that was received from the owners and/or operators of the 37 systems which were studied.

	Number of Systems
1. Source of water being utilized:	
Well	27
Stream	10
2. Type of pump being used:	
Centrifugal	11
Turbine	26
3. Estimated output of pump:	
200 GPM - 500 GPM	13
500 GPM - 800 GPM	17
1000 GPM - 1600 GPM	7
4. Fuel used or source of energy:	
Electricity	3
Gasoline	13
L-P Gas	10
Diesel Fuel	4
Natural Gas	7
5. Method employed in moving pipe:	
Hand move	30
Wheel move	4
Tractor move	3

6. Length of main line sections - 20 ft. and 30 ft.

7. Lateral lines:
   Length of sections - 20 ft., 30 ft., and 40 ft.
   Diameter of pipe used - 3 in., 4 in., and 5 in.
   Spacing on main lines - 20 ft., 40 ft., 60 ft.

8. Operating Pressure:

At pump discharge	35-80 p.s.i.
At last sprinkler on line (Est.)	30-70 p.s.i.

9. Acres of crops irrigated:

Crop	Acreage	
	All farms	Av. per farm
All crops	3803	103.7
Alfalfa	1246	33.6
Corn	348	9.4
Sorghum	545	14.7
Wheat	1120	30.3
Tame pasture	544	14.7

10. Average estimated time (man-hours) required to move 1/4 mile of 4" lateral 60 feet to new location by various methods in different crops:

Crop	Labor required (Man hours) Tractor move	Wheel move	Hand move
Alfalfa	1/3 - 1/2	1/3 - 1/2	3/8 - 3/4
Corn	Not satisfactory	3/8 - 5/8*	1 - 1 1/2**
Sorghum	Not satisfactory	3/8 - 5/8	1 - 1 1/2
Wheat	1/3 - 1/2	1/3 - 1/2	3/8 - 3/4
Tame pasture	1/3 - 1/2	1/3 - 1/2	3/8 - 3/4

*When corn is small
**When corn is tall.

11. Percentage of total costs invested in sprinkler system and in Power Plant Pump and well:

Source of water	Percentage invested in sprinkler system	Percentage of cost invested Power Plant and well
Stream	Ave. 65	Ave. 35
Well	Ave. 40	Ave. 60

RESULTS OF STUDY

Source of Water

Since it was known that a direct relationship exists between the energy required for irrigation and the total vertical distance that the water is being lifted, it logically would follow that the cost of irrigating from a stream would conceivably be lower than the cost when irrigating from a well, merely due to the difference in vertical lift. The source of irrigation water was determined in order to be able to evaluate its effect upon annual irrigation costs.

Of the 37 systems that were studied, 27 or 73 percent were irrigating from wells which had a static lift of from 18 to 180 feet. The remaining ten or 27 percent were irrigating from streams. The static lift from the streams varied from 15 feet to 35 feet. The owners of the latter systems stated that to their knowledge, the streams being used had continued to flow (although at times only small amounts) since 1930. This would indicate that the streams would be reasonably reliable sources of limited supplies of irrigation water.

None of the systems studied, and only one of the farmers contacted was using a lake or a farm pond as a source of irrigation water. The farmer who was attempting to irrigate from a farm pond was enthusiastic about his set-up. However, the information which he supplied was not deemed adequate for this study. Considerable interest was expressed by many of the farmers contacted in this study concerning the possibilities of irrigating from a farm pond with a sprinkler system.

It was found that only a small percentage of those farmers contacted possessed Water Rights for their irrigation needs. The importance of securing these water rights was emphasized to all of those who were contacted.

The ten systems that were irrigating from streams are listed in Table 2, giving the county and stream used as a source of water.

Pressures Used

The pressures being used on the systems studied were in all cases given as the pressure in pounds per square inch at the pump discharge. These pressures were useful in calculating the power required by the system but cannot be used as an indication of sprinkler discharge pressures, due to the fact that there may be considerable pressure loss between the pump discharge and the farthermost sprinkler because of friction in the main and lateral lines.

Table 2. Location of system and stream supplying water.

System No.	Location by County	Name of Stream
2	Ottawa	Solomon River
3	Ottawa	Solomon River
4	Saline	Gypsum Creek
11	Dickinson	Chapman Creek
24	Marion	Cottonwood River
25	Norton	Prairie Dog Creek
27	Harvey	Little Arkansas River
29	Wichita	Beaver Creek
30	Wichita	Beaver Creek
32	Grant	North Fork Cimarron

The 37 systems studied were using pressures at the pump discharge which varied between 35 and 80 p.s.i. However, only one system was using a pressure greater than 60 p.s.i. Eleven of the operators reported that they were maintaining a pressure of 40 p.s.i. at the pump discharge.

Rate of Pumping

The rates of pumping varied between 200 G.P.M. and 1600 G.P.M. for the 37 systems studied. Five of the systems were pumping at rates of 400 G.P.M. or less while there were also five systems pumping at rates greater than 850 G.P.M. One of those pumping from streams was pumping more than 850 G.P.M. and two were pumping less than 400 G.P.M.

The pumping rates for those pumping from streams was determined by using the discharge pressures at the pump, the R.P.M. of the pump and the characteristic curves for each pump. These rates for those systems which were using wells as a source of water were based upon the operator's estimate. The operator's estimate was based upon tests which were made by the driller or tests which were made by the Division of Water Resources of the Kansas State Board of Agriculture.

Acres of Crops and Estimated Normal Net Irrigation Requirement

The total acres that were planned to be irrigated by the 37 systems was 3803. The estimated normal net irrigation requirement for the total acreage distributed as shown by Table 3 is 42,458 acre-inches.

It was not possible to secure yield data on crops grown as had been originally planned because many of the systems were in use only a portion of the crop-growing season.

Each farm planned to irrigate an average of 103.7 acres, and would supply an average of 11.1 acre inches of irrigation water per year to the acreage under normal conditions if the crop acreages were distributed as they were found to be in the study.

The volume of water required by the various crops was computed on the basis of the estimated normal net irrigation requirement of the crops. The estimated normal net irrigation requirement of crops has been computed by Hanson and Myers (9). Their estimates are based upon the consumptive use of water by crops for Kansas crops and conditions.

It is noted in Table 3 that alfalfa requires 50.5 percent of the total

Table 3. Distribution of crop areas and quantity of water required.

Crop	Acreage devoted to each crop	Acre-Inches of water required for acreage	Percent of total acreage	Percent of total water applied
Alfalfa	1246	21,576	32.8	50.5
Corn	348	3,202	9.15	7.55
Sorghum (Grain)	545	4,754	14.3	11.2
Wheat	1120	6,685	29.4	15.7
Tame Pasture	544	6,235	14.3	14.65

water applied, yet it occupies only 32.8 percent of the total acreage; while the acreage of wheat irrigated occupied 29.4 percent of the total acreage but used only 15.7 percent of the total water which was applied to the entire acreage.

The percentage distribution of the areas of crops being irrigated as shown by Table 3 bears out the statement made by a high percentage of the farmers contacted that they were using their sprinkler irrigation systems in an effort to stabilize their livestock enterprise. Nearly all of the farmers reported that their corn acreage was for silage and that a high proportion of the wheat acreage was being irrigated for its value as livestock pasture rather than for a grain crop.

In Table 3 it is noted that corn occupies less than ten percent of the total acreage irrigated. The reason for this low acreage of corn is because of the difficulties encountered when moving the lateral lines in tall growing corn. This would indicate that sprinkler systems are not generally suited to use on tall growing row crops such as corn or silage sorghums.

Total Annual Use

The systems varied widely in respect to the total hours of annual use. This range varied from a low of 240 hours per year to a high of 1640 hours per year. The average for all the systems studied was 790 hours per year. Eleven of the systems were used at least 1000 hours per year while only eight were used less than 500 hours per year.

The total hours of annual use was determined by dividing the acre-inches per year required by all the crops which the unit was serving by the acre-inches per hour output from the pump.

Initial Investment

The initial investment consisted of the capital invested in the well, pump, power unit, main and lateral lines. The cost of drilling and casing the wells varied from $11 to $14 per foot. The variation within this price range was dependent upon how far the driller had to move and upon the depth drilled. The deeper wells were drilled cheaper on a per-foot cost basis than the shallower wells. The pump and power units were usually purchased as a unit. In many cases (this was particularly true for those units utilizing centrifugal pumps) separate costs were not given for the pump and power unit. The pump and power unit costs were dependent upon the total dynamic head and the rate of pumping. An example of this cost was a system which used a deep well turbine pump to pump 1600 G.P.M. against a total dynamic head of 230 feet of water. This system had $13,500 invested in the pump and power unit. This may be compared to the cost of a pump and power unit which utilized a centrifugal pump and power unit to pump from a stream. This pump and power unit was pumping 1000 G.P.M. against a total dynamic head of 150 feet of water. This pump and power-unit cost $1575. The cost of pipe including couplers and sprinklers was dependent upon the size of pipe and the length of section. The longer lengths of sections were cheaper on a per-foot basis because fewer couplers were required. Examples of this cost was a 40 foot length of four inch aluminum lateral pipe with sprinkler and coupler which cost 85 cents per foot and a 30 foot length of five inch aluminum main line with couplers which cost $1.02 per foot.

This study also showed that the distribution of the initial investment into the investment which was due to the sprinkler system and that which was due to the remaining factors of power plant pump and well differed greatly for those systems which were irrigating from streams and those which were irrigating from wells. For systems that were irrigating from streams it was found that approximately 65 percent of the investment was for the sprinkler system while for those systems which were irrigating from wells it was found that the investment in sprinkler systems was equal to only about 40 percent of the total investment.

The study made very apparent the significant role that the source of irrigation water played in determining the capital investment that was required in order to begin irrigation farming. This fact was better emphasized by placing the information in Table 4.

It was noted that while the average acreage irrigated from wells was approximately 1.5 times the average acreage irrigated from streams, the average total investment when irrigating from wells was nearly 2.8 times the average investment when irrigating from streams. The relationship of these investments was better illustrated when comparisons were made on a per-acre basis. The capital investment for the ten systems which were irrigating from streams averaged $46.10 per acre with a range of $34.00 to $88.00 per acre, as compared to the average capital investment for the 27 systems which were irrigating from wells of $85.50 per acre with a range of $52.00 to $176.00 per acre.

Table 4. Investments when irrigating from well and stream.

Source of water	Average Acreage Irrigated	Range of acreage Irrigated	Average total Invest.	Range of total ave. Invest.	Ave. Invest. per acre	Range of Invest. per acre
Streams	73.8	30 - 240	$3406.80	$1800-$8800	$46.10	$34-$888
Wells	111.5	20 - 341	$9540.00*	$1900-$25000*	$85.50*	$52-$176

*These figures include cost of well.

Analysis of Costs

<u>Cost of Ownership</u>. For the purpose of analysis in this study these costs were considered to be those annual costs that are independent of the hours of annual use. They include such items as depreciation, interest on investment, and taxes. Cost of housing was omitted in this study because it was found that the systems were not being housed. Insurance costs were not included because it was found that the farmers were assuming the risk themselves.

In this study it was found that the total annual cost of ownership represented an average of 49.9 percent of the total annual costs. The range in this percentage for the individual systems was from 22.1 percent to 75.5 percent. For eight of the systems the ratio of the annual cost of ownership to the total annual costs was less than 40 percent greater for ten of the systems. The wide range in this ratio was influenced by the depth of well, the location of the area irrigated in relation to the location of the water source, and the total hours of annual use. It was noted that this ratio was greatest for those systems which were pumping from deep wells operating relatively few hours each year and the well was not centrally located. For those who were irrigating from streams this ratio was greatest for those who were using greater lengths of main line and operating only a relatively few hours annually. Diversification of crops irrigated was one method by which many of the farmers secured greater hours of annual use from their systems.

The individual items of cost of ownership were analyzed separately so that the distribution of these costs into the various categories could be better understood.

Depreciation. The length of depreciation period which was expected to be realized by the owners of the system was expressed as merely an estimate by the owners, due to their lack of adequate experience with the systems. The majority of the owners expressed belief that the systems should last 15 years under normal useage. Some felt that with good care the systems would last 20 years. There was some question in the minds of a few of the operators as to whether various parts of the system should be depreciated at different rates. Again due to lack of experience as to the life of the various parts of the system they were depreciating the entire system at the same rate.

The depreciation period used in this study was 15 years for the entire system including the well, pump, power unit, and sprinkler system. On this basis it was found that the percentage of annual costs due to depreciation ranged from a low of 10.4 percent to a high of 51.2 percent. Those operators whose depreciation costs represented a small percentage of total annual costs were utilizing a small investment to irrigate a great number of hours annually. This was accomplished by growing a diversity of crops which did not require peak quantities of water at the same time. Those systems whose depreciation costs represented a high percentage of the total annual cost were using a large investment to irrigate only a comparatively few hours annually. An example of this was a system which had an investment of $11.500 being used to irrigate only wheat. This particular system was operated only 240 hours annually, hence its depreciation costs represented a high percentage of the total annual costs. For all the systems studied it was found that depreciation cost averaged 34 percent of the total annual costs.

Interest on Investment. Those farmers who were contacted during the survey reported interest rates varying from five to six and one-half percent. For the study an interest rate of six percent was used. Since this charge could be considered to be an annual charge only on the basis of the undepreciated balance of the investment, interest was calculated at the rate of six percent on one-half of the initial investment. This gave an average charge of 3 percent of the first cost throughout the life of the system.

This cost item was also calculated on the basis of the percentage of the total annual costs. It was found that interest amounted to an average of 15.13 percent of the total annual cost and ranged from a low of 6.74 percent to a high of 23.1 percent. This wide variation was found to be influenced most by the total hours of annual use of the system. The relationship was inverse, however. This ratio of annual interest charges to total annual costs was ten percent or less for ten of the systems studied and 20 percent or greater for six of the 37 systems studied.

Taxes. It was found that this item was very difficult to evaluate. Many of those contacted reported that their systems weren't assessed, hence no taxes were paid. However, those who had some knowledge of the taxes on their systems reported that the taxes varied between one and one-half percent and two percent of the assessed valuation. From the few estimates that were secured, it was found that the assessed valuation approximated 20 percent of the undepreciated balance. For this study an average annual charge for taxes of one and one-half percent of 20 percent of the undepreciated balance was used.

On this basis charges for taxes represented an average of .77 percent of the total annual costs and the range for all the individual systems studied was from .35 to 1.15 percent.

Cost of Operation. The cost of operation was considered to include those costs that were incurred due to the operation of the system and included such items as fuel or energy, lubrication, repairs and maintenance and labor. It was found that the total costs of operation represented an average of 50.1 percent of the total annual costs. The range of this ratio for individual farmers was from 24.4 percent to 78 percent with ten systems having this ratio less than 40 percent and nine systems with this ratio greater than 60 percent. This ratio was found to be directly proportional to the total hours of annual use of the systems.

Fuel or Energy. One of the four engine fuels, gasoline, L-P gas, diesel fuel or natural gas were being used by most of the systems studied. However, three were using electricity as a source of energy. The distribution of the systems in relation to the type of fuel used or energy source is given in Table 5.

For the 37 systems studied fuel or energy costs represented an average of 25.1 percent of the total annual costs. For those systems which were pumping from streams the fuel or energy costs represented 29.7 percent of the total annual costs. This higher fuel cost can be attributed to the fact that the majority of those who were pumping from streams were using gasoline for fuel. It can readily be seen from Table 5 that gasoline is a more expensive fuel than natural gas.

Table 5. Distribution and unit cost of fuels or energy.

Fuel or source of power	Number of systems	Ratio: Annual Fuel or Power Costs / Total Annual Costs	Cost of fuel or power per unit
Electricity	3	34.4%	$200 annually + 2¢/kwh
Gasoline	13	29.6%	16.6¢ - 16.9¢/gallon
L-P Gas	10	25.7%	9¢ - 11¢/gallon
Diesel fuel	4	25.2%	14¢ - 15.8¢/gallon
Natural gas	7	13.0%	19¢ - 22¢ / M

Since only three of the systems observed were using electricity as a power source and only four were using diesel, it can readily be understood that statistically the ratio of the annual fuel or power cost to the total annual cost for these two items did not give a reliable average for use in comparison to the other fuels used.

The prices used for the calculations in Table 5 were current in the locality at the time the information was obtained.

Lubrication. The percentage of total annual costs that were attributable to lubrication was found to be 1.39 percent. Eighty cents per gallon was used as the unit cost for engine oil for all of the systems. The farmers estimate of the quantity used annually was used for the calculations. This estimate was quite variable, however, it was not felt that the estimates were any more variable than the actual quantities used. Some operators changed oil every 60 hours while others changed it at 100 hours or in some cases annually. For all the systems studied the percentage of total costs that were incurred due to lubrication ranged between one percent and two percent.

Repairs and Maintenance. Since many of the systems had been in use one year or less, the farmers stated that their estimate of the repairs and maintenance costs could not be exact. However, those farmers interviewed were very cooperative and gave what was considered by the writer to be reasonable estimates of this cost.

Due to the wear caused by sand particles in the irrigation water it was estimated that one-fifth of the sprinkler heads would have to be replaced each year. This was considered to be an item of repair and maintenance rather than one of depreciation. It was estimated that this amount would be adequate to cover maintenance and repair costs for the sprinkler lines unless the system was subjected to careless handling. The owners' estimates of the repair and maintenance on the power plant and pump ranged from one to five percent of the original investment. The lower percentage estimates were associated with the larger more expensive systems while the high percentage estimates were for those with lower total investments.

Calculated upon the basis of each farmer's estimate it was found that the percentage of the total annual costs that were due to repair and maintenance costs averaged 8.51 percent for the 37 systems studied.

Labor. The estimates and/or actual data obtained for this item were extremely variable. Farmers reported that the rate at which pipe was moved was dependent upon a number of factors, the most important of which are the following: size of pipe moved, type of coupler used, method of moving pipe (whether mechanical or hand move) crop in which the pipe was moved, relative compactness of the soil when the pipe was being moved, quantity of labor available for moving pipe, and the rate at which those doing the moving desired to work. The rate at which they reported moving the pipe was from one-third to three-fourths man hours required to move one-fourth mile of four inch lateral.

From observations that were made by the writer it was noted that there is no significant difference in the time required to move pipe by the three methods of wheel move, hand move and tractor move. The difference lies in the amount of physical energy expended by the worker. Those farmers contacted verified this conclusion.

The cost per man hour for labor, used in this study was $1.25 per hour. The number of man hours required was based upon the farmer's estimate of his rate of moving the pipe. Calculated upon this basis the percentage of the total annual operating costs that was charged to labor was found to be an average of 15.1 percent.

For the entire acreage included in this study it was found that the labor requirements averaged 1.97 man-hours per acre per season. At a price of $1.25 per man-hour this was equivalent to an annual cost of $2.46 per acre per year for labor.

<u>Total Annual Costs</u>. The total annual costs were found to average $15.84 per acre for the 37 systems that were studied. It was noted that there was a difference in the average annual per-acre costs between farms of those farmers who were irrigating from streams and those who were irrigating from

wells. For those ten systems which were using streams or sources of water the average annual cost was $14.27 per acre while for those 27 systems which were irrigating from wells this cost was $16.57 per acre. This saving can be accounted for by the saving in depreciation due to the lower initial investment of the systems which were irrigating from streams as compared to the investment for those systems which were irrigating from wells.

The range on these total annual costs was from $5.65 to $24.95 per acre. This lower cost was obtained by utilizing a stream as a water source, irrigating 240 acres of crops that was composed of 40 acres of alfalfa and 200 acres of wheat, and using natural gas as a fuel. The total investment in the system was $8800.00 and it was operated 1345 hours annually. The higher cost of $24.95 was obtained by a system which had an initial investment of $4500. A well was used as a source of irrigation water to irrigate 35 acres of crops composed of 15 acres of alfalfa and 20 acres of corn. This system was being operated 430 hours annually and was using gasoline as fuel.

SUMMARY

The 37 systems that were studied were analyzed on the basis of the farmers' estimates or records of their costs. These estimates, while not exact gave results which were comparable to the costs which were found by other workers in other areas.

Because much of the data used were estimated, any inferences or conclusions drawn from this study cannot be exact. However, it was felt that the results were reliable estimates. Based upon the material presented in this thesis the following conclusions and observations were made:

1. The ratio of cost of ownership to cost of operation were very nearly 1:1 (49.9:50.1).

2. Depreciation accounted for 34 percent of the total annual costs or 68.1 percent of the total annual ownership costs. Since depreciation accounts for such a large percentage of the total annual ownership costs, it should be considered very carefully if it is desired to reduce annual costs.

3. Interest on investment was responsible for 15.13 percent of the total annual costs.

4. The percentage of annual costs due to taxes was .77 percent.

5. The cost for fuel or energy represented 49.2 percent of the total operation costs, or 25.1 percent of the total annual costs. The cheapest fuel was natural gas which, unfortunately, isn't readily available for all farmers who are irrigating.

6. Cost of lubrication represented only 1.39 percent of the total annual costs.

8. The costs that were incurred due to labor were 15.1 percent of the total annual costs.

9. Since the combined costs of fuel or energy and labor account for 40.2 percent of the total annual costs, these two items should be scrutinized very closely when designing and/or using a sprinkler irrigation system so that total annual costs may be kept to a minimum.

10. The average total annual costs were $14.27 per acre for those farmers who were irrigating from streams and $16.57 per acre for those farmers who were using wells as a source of water supply.

11. The initial investment required to begin irrigation farming averaged $46.10 per acre for those who were irrigating from streams and $85.50 per acre for those who were irrigating from wells.

12. The sprinkler system accounted for about 65 percent of the initial costs for those systems which were utilizing streams as a source of water and about 40 percent of the initial costs for those systems which were using wells as a source of water.

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REFERENCES

(1) Agri. Exp. Sta. and Agri. Ext. Ser. Coop. Oregon State College, The State College of Washington and Univ. of Idaho. Sprinkler Irrigation. Pacific Northwest Bul. No. 3, Nov. 1951, p. 13.

(2) Becker, M. H.
Sprinkler Irrigation Costs and Practices. Agri. Exp. Sta. and U.S.D.A. cooperating. Oregon State College, Bul. 532. March, 1953. p. 21.

(3) Bittinger, M. W. and Frevert, R. K.
Labor Requirements for Sprinkler Irrigation of Corn. Agri. Eng. 33 (5):270-272. May, 1952.

(4) Blaney, Harry F.
Irrigation Requirements of Crops. Agri. Engg. 32 (12):665-668. Dec. 1951.

(5) Christiansen, J. E.
Irrigation by Sprinkling. Calif. Agri. Exp. Sta. Bul. 670. Oct. 1948.

(6) Code, W. E., and Hamman, A. J.
When to use Sprinkler Irrigation in Colorado. Colo. A. and M. College of Agri. Exp. Sta. and Agri. Ext. Ser. Coop. Bul. 405-A. June, 1950. p. 19.

(7) Corn Irrigation Pays Big Profit. Country Gentleman. Vol. CXXII No. 6. June 1953. p. 64.

(8) Gray, Alfred S. and Reid, Crawford.
Sprinkler Irrigation Handbook, Third Edition. Rainbird Sprinkler Mnfg. Corporation, Glendora, Calif. 1952.

(9) Hanson, R. E. and Meyers, Walter E.
Irrigation Requirements Estimates for Kansas. Kansas State College Engr. Exp. Sta. Bul. 69. June, 1953.

(10) Jensen, Max C. and Bevan, Ronald C.
Cost of Sprinkler Irrigation of Idaho Farms. Univ. of Idaho Agri. Exp. Sta. Bul. 287, Moscow, Idaho. Oct. 1951, p. 3, 10, 13.

(11) Rubey, Harry.
Supplemental Irrigation for Missouri and Regions of Similar Rainfall. Univ. of Mo. Engr. Exp. Sta. Bul. 33. Third Revised Edition 1953. p. 52.

(12) Sprinkler Irrigation, Bureau of Reclamation. United States Dept. of the Interior. U. S. Govt. Printing Office. 1949.

(13) What you should know about selling sprinkler irrigation systems. Implement and Tractor, March 28, 1953. Vol. 68, No. 7. p. 44, 92.

(14) What you should know about selling sprinkler irrigation systems. Implement and Tractor. Vol. 68, No. 11, May 23, 1953. p. 154.

(15) Whitaker, R. W. and Lytle, W. F. Supplemental Irrigation of Pasture. Agri. Engg. 32(3):163-165. March, 1951.

APPENDIX

APPENDIX

SPRINKLER IRRIGATION SYSTEM INFORMATION

Of the following questions, answer those that apply to your system.

Water Supply:

A. Well

Total lift _____ ft. Static water level _____ft. (depth to water)

Drawdown _____ ft.

B. Lake, stream, or farm pond. (Underline applicable one.)

Total lift _____ ft. Estimated flow of stream _____ gallons or cubic feet per minute, or total storage of lake or farm pond _____ acre-feet.

Pump:

Make __________ Serial No. __________ Model __________ Type, Centrifugal or turbine. Diameter Inlet _____ inches Discharge _____ inches. Date installed __________ Designed R.P.M. _______Estimated yield in _______ gallons per minute at _____ R.P.M. Operating Pressure at pump discharge _____P.S.I.

Power Unit:

A. If internal Combustion Engine:

Make __________ Model __________ Rated H.P. _____ Fuel used _______ Cost per gal. ______ Fuel consumption ________ gal/hr. Oil used _______ quarts per 10 hr. Oil changed every _____ hrs. Capacity of crankcase _______ qts.

B. If power unit is an Electric Motor.

Rated H.P. of Motor __________. Name of Power Company from whom power is purchased.

____ ________________________________

Name Address

SPRINKLER DISTRIBUTION SYSTEM

I. General Questions.

Laterals are moved by: (carrying) (tractor move)(wheel move) or other. Laterals are left set in 1 location _____ hrs. There (is) (is not) significant amount of run-off after this length of time. Laterals are set in an (East-west) (North-South) (other) direction.

II. Main Line.

Type of Main Line (Aluminum or __________) Portable or permanent?
other

Name of Manufacturer ____

Name of Coupler ____

Length & diameter of main line _____ ft. of _____ inches diameter

Length of Main Line sections 10, 20, 30, 40 ft.

III. Lateral Lines.

Type of Laterals. (Aluminum or ________ other) Portable or permanent?

Spacing of Laterals on Main Line ________ ft.

Length & diameters of each Lateral ______ ft. of 3" diameter ____ ft. of 4" diam. _____ ft. _____ diameter of other.

Length of Lateral sections 10, 20, 30, 40 ft.

No. of laterals in complete system _____.

No. of laterals operated simultaneously _____. Lateral setting time ____ hrs.

IV. Sprinklers

Type of Sprinklers ____________. Nozzle size _____. Spacing on laterals __ft.

No. of Sprinklers ________________ Size of Sprinkler Risers _____ diam. & _____ length.

Operating pressure at sprinkler _____ P.S.I.

CROPS IRRIGATED 1952

Total Acres Irrigated 1952 _______ Acres.

Crop	Acres	No. of Times Irri.	Acre-In. of Water Applied for Season	Yield (Known or Est) Tons-Bu-#Beef or #Milk per Acre	Yield of Comparable Area of Non-Irri. Crop. Est.	Pipe Moving Data: Req'd to move 1 Lateral to New Location: Time (Min or Hrs	Pipe Moving Data: Req'd to move 1 Lateral to New Location: No. of Men	Pipe Moving Data: Req'd to move 1 Lateral to New Location: Man-hrs Total	Pipe Moving Data: Cost per man hour
Corn (Grain)									
Corn (Silage)									
Sorghum (Grain)									
Sorghum (Silage)									
Soy beans									
Alfalfa (Hay)									
Alfalfa (Seed)									
Tame Pasture									
Other Crops									

COST DATA FOR 1952

Equipment	Pumping Plant Assy. (Pump, Power Unit & Drive)	Well	Distribution System	
			Main Line (Includes Couplers & Valves)	Laterals (Includes Sprinklers Risers & Couplers)
Year Purchased				
Estimated Life in Years				
Fixed Costs: Initial Cost				
Int. on Inv. (Rate)				
Taxes (Rate)				
Operating Costs: Hours used annually				
Fuel used annually & total cost (Gals. or KWH)				
Oil (Gals) used annually & total cost				
Repairs (Annual Cost Est.)				
Man-hours Labor & cost per man-hr. for Mtse. & Rep.				

This space is left for any remarks or questions that you would care to make about your system, or sprinkler irrigation in general.

Project 203
Form S - 1

Sprinkler Irrigation Distribution Data
FIELD LAYOUT

Plant No. ____________
Date ________________
Sketch by ____________

Operator ______________________________
Owner ________________________________ Legal Description ______________________________
Address ______________________________

Orientation

Scale: 1/2" = ______ft.

Note: On this sheet sketch and dimension setup. Show:
1. Type, acreage, and field boundaries of crops sprinkled in 1952.
2. Location of pump and well, stream, lake or pond.
3. Lateral and main line positions, spacing, and sizes.
4. Indicate direction and percent of slope.

---x---x---x---
portable laterals
---o---o---o---
portable main
---1---1---1---
permanent lateral
---11---11---11
permanent main

A STUDY TO DETERMINE THE COST OF SPRINKLER IRRIGATION IN KANSAS

by

RUSSELL L. HERPICH

B. S., Kansas State College
of Agriculture and Applied Science, 1950

AN ABSTRACT OF A THESIS

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In recent years there has been an increased interest in Kansas in the use of the sprinkler system as a method of distributing irrigation water. As with most any method of irrigation the initial investment required and the annual costs incurred when irrigating with a sprinkler system are quite large. It was for the purpose of determining these initial costs and annual operating costs that this study was conducted.

The study was limited to those systems which were being used as the only method of irrigation on general agricultural crops that are grown in Kansas. Systems which were being used to irrigate nursery stock, truck crops or orchard crops were not considered in this study.

The numerical and area distribution of the systems in use throughout Kansas was determined through correspondence with the County Agricultural Extension Agents. Reports were secured from approximately 80 percent of the counties. Data were secured, relative to the systems studied, by the survey method. Thirty-one of the 37 acceptable information reports were secured by making personal visits to the farms. Information was secured about the remaining 6 systems included in the study by correspondence with the owners and/or operators.

The data that were obtained were based either on the farmers' estimates or his records. Some of these data regarding initial investments in the systems were secured from the dealer who sold the system. Farmers' estimates of the actual quantities of water that were used for various crops were so erratic that it was decided to use the estimated normal net irrigation requirements for various crops in the counties of Kansas, which had been calculated by Hanson and Meyers (9), as a basis for computing the quantities of water required of each unit and by each area of crop.

In the study it was found that 10 of the 37 systems of 27 percent of all those studied were irrigating from streams and 27 or 73 percent were pumping from wells. The vertical lift for those pumping from streams varied from 15 to 35 feet while for those pumping from wells this lift ranged from 18 to 180 feet.

The pressures being used by the systems ranged from 35 p.s.i. to 60 p.s.i. at the pump discharge.

The rate of pumping varied from 200 g.p.m. to 1600 g.p.m. All except 3 of those pumping from streams were pumping between 400 g.p.m. to 850 g.p.m.

The total area of crops that were being irrigated was 3803 acres. Computed on the basis mentioned above these crops would require 42,458 acre-inches of water annually. The crops grown and the percentage of the total area occupied by each crop was alfalfa 1246 acres, 32.8%; corn 348 acres, 9.15%; sorghum (grain) 545 acres, 14.3%; wheat 1120 acres, 29.4%; tame pasture 544 acres, 14.3%.

In a great percentage of cases the farmers remarked that they were irrigating in order to stabilize their livestock enterprise. They stated that nearly the entire acreage of corn was for silage and that the main intent when irrigating wheat was for its value as pasture rather than as a grain crop. The acreage distribution of the crops irrigated substantiated the farmers' statements.

The average total hours that the systems operated when supplying the water required by the crops, as previously calculated, were 790 hours. Eleven of the systems were required to operate more than 1000 hours while eight operated 500 hours or less annually. The capital investment for those systems operating from streams averaged $46.10 per acre while the investment for those who were irrigating from wells averaged $85.50 per acre.

Cost of ownership included the items of depreciation, interest on investment, and taxes. These items represented an average total of 49.9% of the total annual costs. Depreciation was responsible for 34% of the total annual costs; interest on investment accounted for 15.13% of the total annual costs and taxes were responsible for an average of .77% of the total annual costs.

Cost of operation included the costs attributable to fuel or energy, lubrication, repairs and maintenance and labor. The average percentage of the total annual costs that were due to each factor was fuel or energy 25.1%; lubrication 1.39%; repairs and maintenance 8.51%; and labor 15.1%.

The total annual costs averaged $14.27 per acre for those systems that were pumping from streams, as compared to an annual cost of $16.57 for those systems which were using wells as a source of water. For all the systems that were studied the total annual costs averaged $15.84 per acre.