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Irrigation in Minnesota

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While Minnesota rainfall was below normal in 1975 and 1976, interest in irrigation grew. An increasing number of Minnesota farmers have purchased irrigation systems during the past two years, while an even greater number have been evaluating the feasibility of similar investments. At the same time many of their farm and nonfarm neighbors have been questioning the effect of irrigation on area water supplies. This issue discusses the current status of irrigation in Minnesota. The first section reviews past development, while the latter portion discusses factors expected to be important in determining the future rate of development.

PAST DEVELOPMENT

Irrigated Acreage and Its Location

Available information indicates a few fruit and vegetable farmers in the Twin Cities area were irrigating during the early 1920's. Some Red River Valley farmers tried irrigating sugar beets and potatoes about the same time. A 1930 survey indicates 150 acres were being irrigated in the state. Approximately 1,000 acres were irrigated annually during the drought years of the mid-thirties. A 1941 survey indicates 250 farmers were irrigating a total of 1,500 acres: an average of 6 acres per farm. Irrigated acreage remained relatively constant during World War II, but increased when irrigation equipment became available again. By the early 1960's 20,000 acres were under irrigation in Minnesota. An annual Agricultural Extension Service survey indicates irrigated acreage has increased from 44,000 in 1970 to 250,000 in 1976 (table 1).

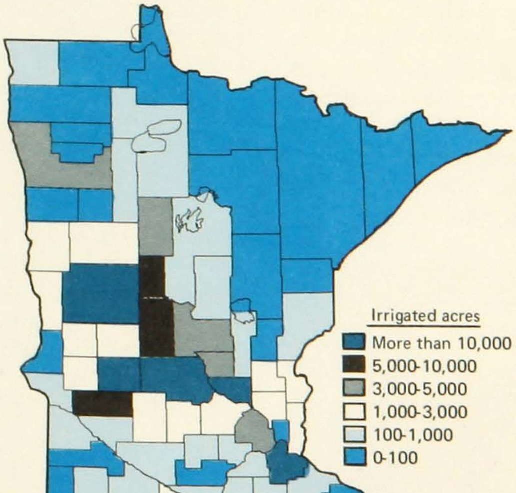
Table 1. Growth in sprinkler irrigated acreage 1970-1976

Year	Sprinkler irrigated acreage	Growth over the previous year in Acres	Percent
1970	44,000		
1971	55,000	11,000	25
1972	64,000	9,000	16
1973	86,000	22,000	34
1974	111,000	25,000	29
1975	174,000	63,000	57
1976	250,000	76,000	44

Source: Roger E. Machmeier, "Sprinkler Irrigated Acreage-Minnesota" for 1970-1976. Agricultural Extension Service, University of Minnesota.

Primarily medium-to coarse-textured glacial outwash soils are irrigated in Minnesota. They occur in limited acreages throughout the state, but mainly in central Minnesota. Table 2 lists the ten counties having the greatest acreage under

Figure 1. Sprinkler irrigated acreage in Minnesota (1975 data)



Source: Roger E. Machmeier, "Sprinkler Irrigated Acreage—Minnesota" for 1970-1976. Agricultural Extension Service, University of Minnesota.

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irrigation. The top five account for 96,764 of the 174,000 acres irrigated during 1975 (the latest year for which county totals are available). The top ten account for 123,952 of the total acres irrigated that year. Figure 1 shows the concentration of irrigation in central Minnesota, the area having the greatest acreage of glacial outwash soils.

Crops Being Irrigated

Table 3 shows the approximate crop acreages under irrigation in

Table 2. Top ten counties — sprinkler irrigated acreage — 1975

Rank	County	Acreage
1	Sherburne	28,420
2	Pope	18,765
3	Otter Tail	18,160
4	Stearns	16,618
5	Dakota	14,801
6	Swift	7,500
7	Wadena	6,221
8	Todd	5,790
9	Hubbard	4,052
10	Benton	3,625

Source: Roger E. Machmeier, "Sprinkler Irrigated Acreage-Minnesota" for 1970-1976. Agricultural Extension Service, University of Minnesota.

1975. Corn and potatoes were produced on 130,000 of the 174,000 irrigated acres that year. Extension specialists indicate an even greater proportion of the additional acreages recently converted to irrigation have been planted to corn and potatoes. It seems reasonable to expect some additional development of irrigation for a wide variety of specialty crops in the future, but the major increases are expected to result from irrigating additional acreages of corn and potatoes.

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Equipment

Sprinkler irrigation systems prevail in Minnesota. Early attempts at flood and furrow irrigation proved less satisfactory because of the difficulty of regulating water flow.

Table 3. Approximate acreage irrigated by crop — 1975

Crop	Acres
Corn	100,000
Potatoes	30,000
Truck crops	20,000
Turf & nurseries	5,000
Alfalfa	3,000
Small fruit	500
Other crops	15,500
Total	174,000

Source: Roger E. Machmeier, "Sprinkler Irrigated Acreage-Minnesota" for 1970-1976. Agricultural Extension Service, University of Minnesota.

Subsurface irrigation has been used to a limited extent, particularly in peat soils where an impervious soil layer is located within a reasonable distance of the surface. Only a small percentage of farmers has used this method. Most of the early systems were hand moved. As labor costs and field sizes increased, less labor-intensive systems became more common.

Table 4 shows the number of acres irrigated in 1975 by type of distribution system. The center pivot system accounted for more than 57 percent of the total acreage irrigated, while the traveling gun, referred to as the traveler, accounted for 21 percent. These two systems are even more dominant when considering the change in irrigated acreage in recent years. Table 5 compares the acreage irrigated by center pivot, traveling gun, and all other systems for 1973 and 1975. The change in irrigated acreage suggests that about two-thirds of the acreage irrigated for the first time in 1974 or 1975 was irrigated with the center pivot system, while approximately one-third was irrigated with the traveling gun. Some shifting of acreage formerly irrigated by another system to center pivot or traveling gun during the two years may cause these figures to understate the amount of new acreage being irrigated by other systems. Nevertheless, the figures indicate the predominance of these two systems.

Surveys on the power units being used for irrigation in Minnesota are not available. Extension specialists estimate that electric motors are currently the most popular power source. Diesel engines are second, with these two accounting for about 80 percent of the irrigation power units in the state. Liquefied petroleum gasoline (LPG), gasoline, and tractor power takeoff account for the remaining 20 percent. More emphasis has been placed on diesel power units during the last two years. Occasionally individuals deciding to irrigate made their decision too late to obtain electric service during the first year. To avoid a year's delay, these operators selected a diesel engine as the power unit. Other individuals used diesel engines because they feel diesel engines are (or soon will be) a less expensive source of power than electric motors. Often the irrigator is asked to pay part or all of the cost of constructing a powerline from the nearest source to the well. This investment, plus higher costs per kilowatt hour, has often resulted in higher relative costs for electric motors.

Table 4. Acreage irrigated by type of distribution system — 1975

Type system	Acreage	Percent of total
Hand move	5,342	3.1
Wheel move	2,873	1.6
End tow	3,228	1.8
Traveler	36,542	21.0
Boom	15,574	9.0
Gun	7,773	4.5
Center pivot	99,600	57.2
Solid set	775	0.4
Other	2,407	1.4
Total	174,114	100.0

Source: Roger E. Machmeier, "Sprinkler Irrigated Acreage-Minnesota" for 1970-1976. Agricultural Extension Service, University of Minnesota.

Profitability

Has irrigation been profitable for Minnesota farmers? A categorical yes or no cannot be given because a comprehensive study has not been completed. However, the comparison of records for some dairy farms in central Minnesota for 1973 through 1976 presented in this section provides some data. The farmers selected to keep records were on

Table 5. **Acreage irrigated by type of distribution system 1973 and 1975**

Type system	1973	1975	1973-75 Change	
			Acreage	Percent
Center pivot	41,077	99,600	58,523	66.5
Traveler	8,110	36,542	28,432	32.3
Other systems	36,969	37,972	1,003	1.2
Total	86,156	174,114	87,958	100.0

Source: Roger E. Machmeier, "Sprinkler Irrigated Acreage-Minnesota" for 1970-1976. Agricultural Extension Service, University of Minnesota.

a Tennessee Valley Authority (TVA) project. While farms were not randomly sampled, an effort was made to obtain comparability between irrigated and nonirrigated farms with respect to number of cows and available labor. Table 6 gives some annual averages for the two groups of farms. The first two lines indicate the average number of cows on farms operated by irrigators and nonirrigators. Both groups had approximately the same number of cows in 1973 and then gained slightly over the four-year period. The irrigators averaged one-and-one-half more cows per year than the nonirrigators.

The average production level per cow for the two groups, indicated in the second two lines, was almost identical in 1973 and 1974. However, in 1975 irrigators obtained substantially more milk per cow than nonirrigators. This suggests nonirrigators may have cut back on the ration for their cows during the drought. However, 1976 production levels are almost identical for the two groups. So the average over the four years is very similar with 1975 providing the major variation. The acreage operated by farmers in the two groups (not shown in the table) is also quite similar. During 1976 the irrigators had 224 acres of cropland compared with 232 acres for nonirrigators. The two groups of farms were quite similar in numbers of cows, production level per cow, and crop acreage. This allows comparison of the average profit or loss, and average net worth change for the two groups. The profit (net farm income) for 1973 is similar for irrigators and nonirrigators. In 1974, however, the profit is about twice as high for irrigators as nonirrigators. The difference is even more dramatic in 1975. In 1976 irrigators averaged about 170 percent of the net income of nonirrigators. Irrigators averaged about 170 percent of the income of nonirrigators over the four years 1973 through 1977. The pattern of net income also indicates that the variability of net returns from one year to the next was considerably less for the irrigators than the nonirrigators.

Table 6. **A comparison of eight irrigated and twelve nonirrigated dairy farms over four years**

Item	1973	1974	1975	1976	Average
No. of cows:					
Irrigators	39.5	41.7	42.9	43.8	42.0
Nonirrigators	39.1	40.8	41.5	40.5	40.5
Milk per cow:					
Irrigators	11,278	11,787	11,768	12,419	11,813
Nonirrigators	11,013	11,524	10,688	12,404	11,407
Profit or loss:					
Irrigators	22,152	15,588	15,570	15,884	17,298
Nonirrigators	21,301	7,396	2,461	9,469	10,157
Net worth change:					
Irrigators	17,201	7,283	9,121	8,494	45,844
Nonirrigators	15,984	3,578	-1,726	3,963	21,800

Source: Unpublished materials prepared by Paul R. Hasbargen, Agricultural Extension Service, University of Minnesota.

The effect on net worth is shown in the final lines of table 6. The change in net worth differs only $1,307 in 1973. However, during 1974 irrigators had about twice the change in net worth of nonirrigators. The difference is even greater in 1975 and in 1976. The total for the four years indicates an increase in net worth for irrigators of $45,844 compared with $21,800 for nonirrigators.

These figures neither indicate that all irrigators are making greater financial progress than nonirrigators nor that all irrigators can expect to duplicate this success. However, they do suggest that irrigation has been effective in reducing the variability of net farm income and maintaining farm income for the individuals on the record system.

FUTURE DEVELOPMENT

Additional irrigation development in Minnesota depends on the suitability of soils for irrigation, the availability of a water supply, and the profitability of irrigated crop production on areas having both.

Suitability of Soils

A recent publication listed several important characteristics in determining an area's suitability for irrigated crop production.[1]

First, the available waterholding capacity is important. The probability of drought and the need for irrigation increases as the soil waterholding capacity decreases.

A second factor is drainage. Poorly drained soils must be drained before irrigation can be considered.

Third, topography affects runoff, drainage, susceptibility of the soil to water erosion, and the general suitability of the area to irrigation.

Fourth, the size and shape of the irrigable area affects the economic feasibility of designing an irrigation system which can be operated profitably on the irrigable area.

Fifth, soil temperature is quite important in much of Minnesota. Low spring soil temperatures restrain the rate of growth of warm season crops and limit the selection of irrigable crops in much of northern Minnesota.

Sixth, current land use is also a factor. Much of the soil that would otherwise be suitable for irrigation in Minnesota is currently in forest.

[1] James B. Swan, "Potential Soils for Irrigation," published in The Potential for Irrigated Crop Production, Agricultural Experiment Station Miscellaneous Report 138-1976, University of Minnesota, pp. 8-10.

urban, recreational, or other nonagricultural uses.

Figure 2 is a map of land suitability for irrigation in Minnesota prepared on the basis of 67 geomorphic regions. These are relatively broad land areas having quite uniform soil parent materials. The map considers each of 67 geomorphic regions based on the dominant soils of that region and places each in one of three categories: geomorphic regions most suitable for irrigation; geomorphic regions moderately suitable for irrigation; or geomorphic regions least suitable for irrigation.

Regions most suitable for irrigation are the outwash areas. Irrigation is currently concentrated on soils of low available water capacity which have developed in outwash materials in central and southern Minnesota. Soils in geomorphic regions classified as moderately suitable for irrigation have lower potential than the first group. This lesser potential may be a result of greater available waterholding capacity, poorer drainage, less favorable topography, or a nonagricultural use. Although soils in this group have higher production of nonirrigated crops than those in the most suitable category, there has been increased interest in irrigating these soils during the past two years. The regions considered least suitable for irrigation have unfavorable topography, poor drainage, soils shallow to bedrock, or low soil temperatures. A listing of regions for each of the three suitability categories is given in "The Potential for Irrigated Crop Production," Minnesota Agricultural Experiment Station Miscellaneous Report 138-1976, pp. 8-10.

Water Supply

There are two general sources of water for irrigation: surface water and groundwater. For either, irrigators are concerned with water quantity, quality, and the legal right to use. Permits to withdraw and use surface water from lakes, streams, and ponds are issued on the basis of reasonable use and ownership of land abutting the surface water source. The irrigation season usually coincides with the season of lowest lake levels and stream flows. Given the necessity of withdrawing water during the low season and the public concern for surface waters, irrigators have usually found it more expedient to obtain permits for groundwater withdrawal and use.

Permits for the withdrawal and use of groundwater from wells, pits, and sumps are issued on the basis of reasonable use. Applicants must provide information on the amounts of water to be withdrawn and the crops to be irrigated. Changes made by the 1977 Minnesota legislature require the state to be divided into area A Townships (those with adequate information for decisions on applications for well permits) and area B Townships (those with need for additional information on the availability of water and the effect of the proposed withdrawal on other users).

Applicants in area B Townships are being required to provide more information with their application for a water use permit. The additional detail includes: a summary of the anticipated well depth and subsurface geologic formation expected to be penetrated; the aquifer expected to serve as the groundwater source; anticipated groundwater quality; and the results of a properly supervised pumping test with observation in one or more wells as designated by the Department of Natural Resources. These additional requirements may seem overly cautious to some applicants. Providing the information can be both time consuming and expensive. Test pumping requires investing the capital to develop a well without knowing if the permit will be issued. However, groundwater studies have been completed for a relatively small portion of Minnesota. Supervised pumping tests encourage proper well development and provide information on the effect of pumping on other users' water supply before an investment is made to complete an irrigation system.

Surficial sand aquifers are the major source of water currently being used for irrigation in Minnesota. Wells in bedrock yield a large quantity of water and are used for irrigation in some areas of the state. A generalized map showing the surficial sand aquifers is included in "The Potential for Irrigated Crop Production," Agricultural Experiment Station Miscellaneous Report

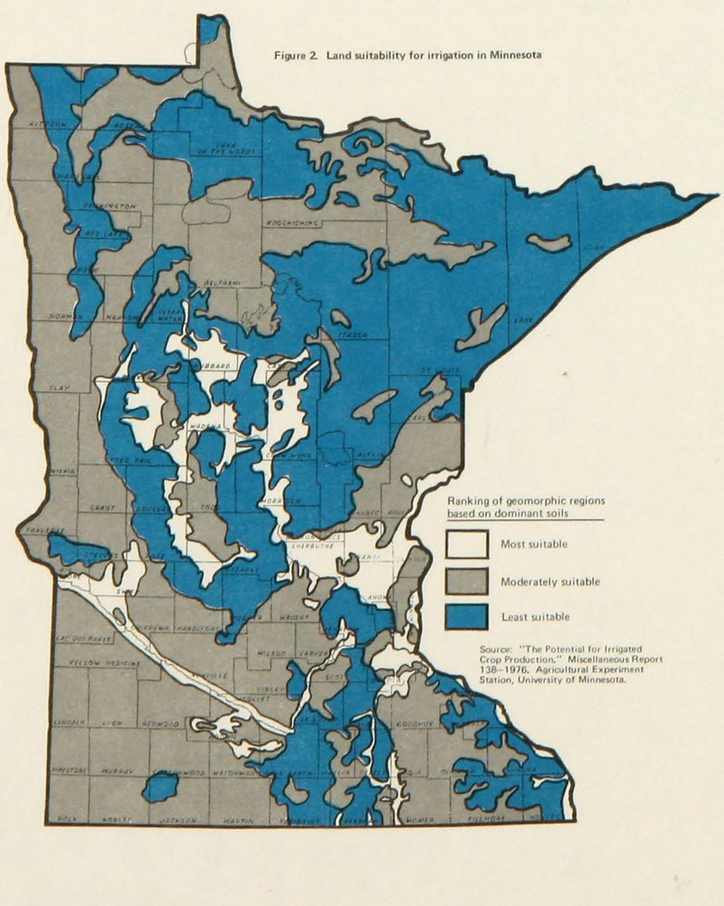

Figure 2. Land suitability for irrigation in Minnesota

Table 7. Initial investment, average annual ownership and average annual operating costs for alternative systems irrigating from a well with 100 feet of lift

Water situation	900 Gallons per minute				600 Gallons per minute			
Type Fuel	Diesel		Electricity		Diesel		Electricity	
Distribution system	Center pivot	2 Traveling guns	Center pivot	2 Traveling guns	Center pivot	1 Traveling gun	Center pivot	1 Traveling gun
Initial investment								
Well development	$11,970	$11,970	$11,970	$11,970	$11,970	$11,970	$11,970	$11,970
Pump and power unit	15,581	16,327	9,774	15,001	13,664	14,017	7,931	9,610
Distribution system	31,374	33,707	31,374	33,707	30,518	16,131	30,518	16,131
Total	$58,925	$62,004	$53,118	$60,678	$56,152	$42,118	$50,419	$37,711
Annual ownership costs								
Capital recovery	7,147	8,212	6,217	7,729	6,789	5,404	5,927	4,671
Insurance	411	431	356	420	386	238	332	197
Total	$7,558	$8,643	$6,573	$8,149	$7,175	$5,642	$6,259	$4,868
Percent of initial investment	12.8	13.9	12.4	13.4	12.8	13.4	12.4	12.9
Annual operating costs								
Energy	3,173	5,294	3,184	5,311	3,288	3,175	3,298	3,185
Pump & motor lube & repairs	1,278	1,788	188	245	1,146	1,287	167	197
Distribution system opr. costs	471	2,888	488	2,888	458	1,195	475	1,195
Labor	507	1,500	507	1,500	507	800	507	800
Total	5,429	11,470	4,367	9,944	5,399	6,457	4,447	5,377
Annual costs per acre irrigated								
Ownership costs	58	58	50	54	55	71	48	64
Operating costs	42	76	34	66	42	81	34	67
Total	100	134	84	120	97	152	82	131

138-1976, University of Minnesota. This report lists eight groundwater studies covering 2.2 million acres in central Minnesota that are completed and underway. Another map in Miscellaneous Report 138 indicates the portion of those areas studied which has potential well yields in excess of 600 gallons per minute. A third map outlines the area (generally the southeastern portion of the state) where bedrock can yield large quantities of groundwater. Although no estimates are available, a quantity sufficent for irrigation is likely in much of the area.

Irrigation water quality is classified according to its total salts content, the percentage of total salts that are sodium salts, and the concentration of boron. Usually the higher the total salts content the poorer the irrigation water quality. However, the quality must be considered with the soils and crops being irrigated.

Water quality in Minnesota is generally acceptable for irrigation although potential problems exist along the state's western border. A more complete discussion of water quality and its potential effect is given in "The Quality of Minnesota Waters for Irrigation," Agricultural Experiment Station Technical Bulletin 239, University of Minnesota.

Irrigation System Costs

Like other farm machinery and equipment, the price of irrigation systems has increased in recent years. Energy costs to operate the systems have also been increasing. Table 7 includes estimates of the initial investment required, the annual overhead costs, and operating costs for some alternative irrigation systems. The estimates are based on well-development costs, equipment prices, and fuel and labor costs prevalent in the irrigated areas of Minnesota during the summer of 1977.

The specific conditions associated with well development, the purchase of the equipment, and the financing of the venture significantly affect irrigation system costs. Some of the more important factors affecting irrigation system costs are the feet of lift, the pumping rate in gallons per minute that can be maintained, the type and price of fuel, the size and type of distribution system, the amount of water pumped annually, and the cost of financing the system. Estimates are included for eight typical situations with 100 feet of lift. Pumping rates of 600 and 900 gallons per minute are analyzed for each of two types of energy (diesel and electrical) and the two most common distribution systems being installed in Minnesota, center pivot and traveling gun. The figures in table 7 assume the center pivot system is designed to irrigate 130 acres out of a quarter section of land. The gun system operating with 900 gallons per minute is assumed to include two traveling guns and irrigates 150 of the 160 acres in a quarter section. However, the 600 gallon per minute system is assumed to have only one traveling gun and to irrigate 80 acres.

Table 7 has four sections. The first section lists the initial investment or the new cost of the system indicated by the column heading. The second and third list the annual ownership and operating costs of the system, respectively. The ownership and operating costs are presented per acre in the fourth section.

The initial investment is presented for the three major components of the irrigation system. Well development includes the cost of drilling three test holes, drilling the well, casing, gravel packing the well, test pumping, purchasing, and fitting the screen. The initial cost of the

Table 8: Expected yields, costs, and returns per acre for nonirrigated and irrigated corn on sandy soils in Minnesota

Area	Yield in bushels per acre	Operating costs per acre	Irrigation costs per acre	Total costs shown[1]	Returns above costs shown for three alternative corn prices[2]		
					1.75	2.25	2.75
	---dollars---						
North Central Zone							
Nonirrigated	30	47	—	47	5.50	20.50	35.50
Irrigated	110	102	100	202	−9.50	45.50	100.50
Central Zone							
Nonirrigated	40	50	—	50	20.00	40.00	60.00
Irrigated	130	108	100	208	19.50	84.50	149.50
South Central Zone							
Nonirrigated	50	58	—	58	29.50	54.50	79.50
Irrigated	160	117	100	217	63.00	143.00	223.00

[1] Machinery ownership (capital recovery, insurance and housing) costs and land costs have not been included.

[2] The return can be interpreted as a return to the ownership costs on machinery and equipment, a return for the use of land, and a return to management.

pump and the power unit is included in the second category. With diesel engines this category also includes the cost of the right angle drive and fuel tanks. The cost of a generator is included for the diesel engine-center pivot system to provide power for the electric drive sprinkler system. The cost of the necessary starter and controls is included in this category for units powered by electric motors. However, the cost of building an electrical line to bring power to the well site has not been included because the amount of investment is highly variable. Power companies frequently require paying part or all of the construction cost of the line from the edge of the irrigator's property to the well site. This may add a significant amount to the initial investment in an irrigation system powered by an electric motor.

The distribution system includes the cost of the pipe, any hose required, and the sprinkler system itself. The initial investment in the center pivot systems includes 1,000 feet of underground plastic (PVC) pipe and the cost of the center pivot system. Traveling gun systems operating with 900 gallons per minute include 4,700 feet of above-ground aluminum pipe, two 660-foot hoses, and two traveling guns. Traveling guns operating under 600 gallons per minute include 3,000 feet of above-ground aluminum pipe, 660 feet of hose, and one traveling gun.

Estimates of the initial investment for systems pumping 900 gallons per minute range from $53,118 to $62,004. The initial investment in systems pumping 600 gallons per minute is somewhat less because the cost of the pump and the power unit is lower. The initial investment in the traveling gun systems on the 600 gallon per minute well is somewhat less than those for 900 gallons per minute because only one traveling gun is included in each case. It is also assumed that only 80 acres are irrigated with each of these two systems. Dividing total investment by the number of acres irrigated indicates that initial investment costs for these systems are $400 to $450 per acre. The exceptions ($471 and $526 per acre) are the traveling gun systems on the 600 gallon per minute well. However, these systems could be extended under most conditions to irrigate more than 80 acres, again, bringing them in line with investment costs in the range of $400 to $450 per acre irrigated.

Some annual costs associated with an irrigation system remain relatively constant regardless of the acre inches of water applied during the year. Capital recovery (which includes depreciation and interest), and insurance against storm and vandalism are normally considered fixed costs. Estimates of these ownership costs are presented in the second section of table 7.

Capital recovery was computed using a 9 percent interest rate and a $0 salvage value. The length of life assumed was 12 years for diesel engines and 15 years for pumps, right angle drive, aluminum pipe, and sprinkler systems. A 20-year life was assumed for fuel tanks and underground pipe. Wells, electric motors and controls were depreciated over 25 years. An insurance premium is included to cover the engine and fuel tank (or motor and controls), above-ground pipe, and the sprinkler system.

One method of placing the ownership costs in perspective is to relate them to the initial investment of the respective systems. The total annual ownership costs range from 12.4 to 13.9 percent of the initial investment in the irrigation systems.

The operating costs of an irrigation system include energy, lubrication, repairs, and labor. The annual operating cost estimates are presented in the third section of table 7 and assume 12 inches per acre of effective water applied annually. Although the amount of water applied per acre is constant, the total amount of water pumped and the hours the system is operated are greater for traveling guns than for center pivots because 20 additional acres are irrigated. Wells producing 600 gallons per minute must be pumped 1.5 hours to provide the amount of water a 900 gallon per minute well will produce in one hour.

Fuel requirements were estimated using average consumption per horsepower hour and the size of engine or motor. Fuel costs were based on 44¢ per gallon for diesel and an average of 4¢ per kilowatt hour. Lubrication and repair cost estimates were based on engineering standards. Labor requirements of .065 hours per acre per irrigation for center pivot systems and .2 hours per acre per irrigation for traveling gun systems were used to estimate labor costs. The analysis assumes 1.25 acre inches are applied per irrigation with center pivot systems, requiring 12 irrigations per year. Traveling guns are assumed to apply ten irrigations of 1.6 inches each. Labor is valued at $5 per hour. Operating costs for the distribution systems include a charge of 4¢ per kilowatt hour for the electricity required to drive the center pivot systems, operating costs for gasoline engines on the traveling guns, the operating cost of a 60 horsepower tractor to move the traveling guns from one lane to another, and repairs on the distribution system.

Table 7 indicates the systems using electric motors have lower operating costs than systems using diesel engines, given the energy prices and assumptions noted earlier. For instance, the center pivot system with a 900 gallon per minute well and 100 feet of lift using an electric motor has annual operating costs of $4,367, while the same system using a diesel engine has annual operating costs of $5,429.

The annual ownership costs and annual operating costs to apply 12 inches of effective water are expressed on a per acre basis in the final section of table 7. The estimates range from $82 to $152 per acre. Notice that the cost per acre is somewhat higher for traveling guns than center pivot systems used on the same well size and fuel type.

Crops requiring less than 12 inches of effective water will have somewhat lower costs than those listed in table 7. However, applying less water affects only the operating cost. The ownership cost remains the same providing the length of system life is assumed to remain the same. For instance, the system using the diesel engine and a center pivot with 900 gallons per minute but applying only 8 inches of effective water per acre (a gross application of 10 inches) would have operating costs of $28 per acre instead of $42. Ownership and operating cost would be $28 plus $58 or a total of $86 per acre.

These costs include the ownership and operating costs of the irrigation system, but not additional crop production costs such as seed, fertilizer, pesticides, and harvesting. These additional costs are estimated for corn production in the following section.

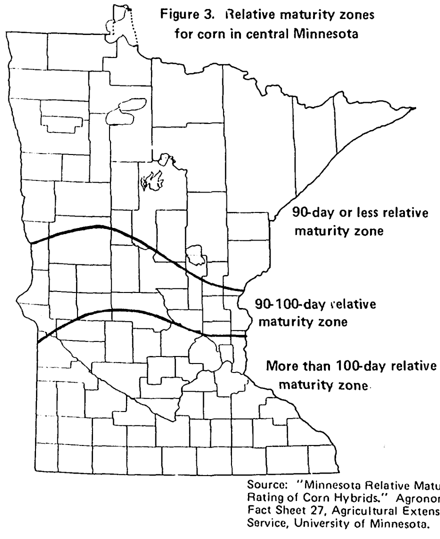

Figure 3. Relative maturity zones for corn in central Minnesota

Source: "Minnesota Relative Maturity Rating of Corn Hybrids." Agronomy Fact Sheet 27, Agricultural Extension Service, University of Minnesota.

Profitability of Irrigated Corn Production

Although farmers irrigate a variety of crops in Minnesota, the discussion of relative profit potential for alternative crops is beyond the scope of this issue. This discussion is confined to a comparison of costs and returns per acre for nonirrigated and irrigated corn produced on coarse-textured soils. As noted earlier, the most common crop irrigated is field corn. It is the crop most new irrigators produce when they are learning to manage an irrigation system. It is also a crop that is easily marketed in any area of the state. For these reasons the profitability of irrigating corn is a good index of the economic incentive to expand irrigation.

The difference in expected yield per acre between irrigated and nonirrigated production is one of the important factors in determining the profitability of crop production. Column 1, table 8 shows estimates of expected corn yields on sandy soils. Central Minnesota was divided into three areas from north to south based on relative maturity zones for corn (figure 3). The division between the northern and central portion is approximately a line connecting Perham and Wadena. The boundary between the central and southern portion is approximately the northern boundary of Swift County. The figures in table 8 indicate a difference between nonirrigated and irrigated corn yields ranging from 80 bushels per acre in north central Minnesota to 110 bushels in south central Minnesota.

The cost of inputs used in producing corn are listed in columns 2 and 3 of table 8. Operating costs per acre include the cost of fuel, lubrication, repairs for machinery operation, seed, fertilizer, herbicides, insecticides, labor for the machine operation at $3 per hour and interest on the operating capital. Irrigation costs have been included for the diesel-center pivot system on the 900-gallon per minute well listed in table 7. It is assumed an effective application of 12 inches (15 inches gross) is applied. Ownership costs of $58 plus operating costs of $42 or a total of $100 per acre have been included. Total costs shown are the sum of operating costs per acre and irrigation costs per acre.

Return above costs shown is obtained by multiplying the price of corn listed by the bushels per acre and subtracting total costs shown. Notice that a charge has not been deducted for machinery ownership costs, the use of land (rental charge or interest and taxes on owned land, and management). The return over costs shown can be interpreted as a return to the ownership costs on the machinery and equipment, a return for the use of land and return to management. As the price of corn increases so does the incentive to irrigate.

Energy Costs

Some irrigators have been concerned about the effect of increasing energy prices on irrigation profitability. Obviously, any increase in cost will reduce the operator's net return if everything else remains the same. However, the energy cost represents a relatively small portion of total irrigation cost in Minnesota compared with many other parts of the country. For instance, the center pivot system with a diesel engine and a 900-gallon per minute well has annual energy costs of $3,173 or $24.41 per acre irrigated based on a diesel price of 44¢ per gallon. A 25 percent increase in the price of diesel fuel, to 55¢ per gallon, would increase annual energy costs to $3,966 or $30.51 per acre. The impact of a price increase of this magnitude on other inputs used in production may well exceed the increased fuel cost to pump irrigation water. The impact on other inputs affects producers on nonirrigated land in much the same manner.

Other Factors

Individuals evaluating potential irrigation investments must consider the suitability of soils, the availability of an adequate quantity and quality of water, and the longrun profitability of the investment. The effect on variability of net returns, the ability to insure a feed supply for livestock, and the availability of labor and management time are also frequently considered. Reducing the variability of net returns may contribute to profitability of the business through more efficient credit management. Insuring a feed supply may enable a producer to intensify and raise the efficiency of the livestock enterprise. In some cases the competition between irrigation and other requirements for labor and management effort results in reduced profitability.

Don't overlook its effect on the after-tax net cash income of the business. The availability of financing and the ability of the individual to use the investment credit and rapid depreciation greatly enhances the profitability of the investment. Examples of projected net cash flows for alternative systems and methods of financing are available in other publications.[2]

Conclusions

Minnesota has experienced a rapid rate of irrigation development during the 1970's. Most of the irrigated acreage is on central Minnesota's sandy soils. Surficial aquifers are the primary water supply. Approximately 75 percent of the irrigated acreage was planted to either corn or potatoes in 1975, with a range of field and specialty crops produced on the rest. Diesel engines and electric motors are used to power approximately 80 percent of the irrigation pumps. Water is distributed through center pivot and traveling gun sprinkler systems.

The information required to predict future development is only partially available. Soils data indicate additional acreage highly suitable for irrigation exists in Minnesota. However, groundwater studies have been completed on only a small part of those areas considered highly suitable. Groundwater studies of the surficial aquifers underway and planned for the next 10 years should provide much of the needed information. As identification of areas having suitable water supplies continues, increasing investment and operating costs are reducing the economic incentive for further development. As energy costs increase, this incentive declines. While it is reasonable to expect continued expansion of irrigated acreage in Minnesota, more normal rainfall, lower crop prices, and increased production costs can be expected to slow past rates of expansion.

[2] For instance see Vernon R. Eidman and Fred J. Benson, "Analyzing the Profitability of Owning and Leasing Irrigation Systems on Sandy Soils in West Central Minnesota," Minnesota Agricultural Extension Service Farm Management Series FM 608, St. Paul, February 1976.

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