IRRIGATED CROP PRODUCTION ECONOMICS AND LAND LEASE ARRANGEMENTS

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INTRODUCTION

Irrigated crop producers in the U.S. Central Plains have come under pressure in recent years as groundwater levels have declined and energy prices have risen. With the limitations on the amount of water available to irrigate, and the additional cost of pumping that water, many producers are trying to determine if they should change their irrigation practices, or perhaps stop irrigating altogether. Making decisions such as these involves many variables and is therefore often complex. However, there are some economic principles that can guide producers in making complicated decisions regarding irrigated crop production decisions.

DECLINING WATER

The issues of declining water and rising energy costs undoubtedly are related in terms of decisions facing irrigators. Certainly, both irrigators with maximum irrigation capacity, and those with diminished irrigation capacity face the issue of rising energy costs. However, the impact of rising energy costs may be more acute with limited irrigation capacity as lower capacity wells require more energy to apply an inch of water than higher capacity wells. In addition, the options producers with limited irrigation capacity have in terms of cropping options may be limited as well. For example, low capacity irrigation wells may not be able to supply sufficient water during critical stages of crop production for certain crops. Consequently, high water use crop may not be an option for some producers.

To address the issue of limited well capacity, two studies were started at the K-State Southwest Research Center in Tribune, KS. The first study is a limited-irrigation study that compares four crops (corn, grain sorghum, soybean, and sunflower) at three irrigation levels (5, 10, and 15 inches). Average yields from 2001-2005 are shown in table 1. Corn, which increased in yield from 114 bu/a with 5 inches of irrigation to 173 bu/a and 191 bu/a with 10 and 15 inches of irrigation, respectively, had the highest response to water. The other three crops experienced yield increases from 21% to 28% (compared to corn at 52%) as irrigation increased from 5 to 10 inches. On a percentage basis, all crops except sunflower had similar yield increases as irrigation was increased from 10 to 15 inches. Sunflower actually had a small reduction in yield.

Table 1. Average Yield at Three Irrigation Levels in Tribune, KS (2001-05).

Crop	5 in	10 in	15 in
Corn (bu/a)	114	173	191
Grain sorghum (bu/a)	93	114	125
Soybean (bu/a)	30	39	42
Sunflower (lbs/a)	1,547	1,872	1,821

Table 2 shows the corresponding returns for each crop at each irrigation level. The values in the table represent returns to land, irrigation equipment, and management based on average production practices, costs, and prices during the study. At five inches of water, soybean had the highest average return at $35/a. Corn, grain sorghum, and sunflower followed next at $31/a, $16/a, and $-9/a, respectively. At 10 and 15 inches of irrigation, returns for corn more than double soybean, the next most profitable crop.

Table 2. Average Returns ($/a) at Three Irrigation Levels in Tribune, KS (2001-05).

Crop	5 in	10 in	15 in
Corn	31	134	151
Grain sorghum	16	31	31
Soybean	35	61	57
Sunflower	-9	0	-23

The second study initiated at the Southwest Research Center in Tribune in 2003 is a limited-irrigation crop rotation study. In this study, four rotations involving four different crops were limited to 10 inches of irrigation per rotation. The rotations include continuous corn, corn-wheat, corn-wheat-grain sorghum, and corn-wheat-grain sorghum-soybean. Since corn has a higher response to water than wheat, in all the rotations that included wheat, the wheat crop was limited to 5 inches of irrigation water, while the corn crop in that rotation received 15 inches. Continuous corn, and other crops in the rotation with corn and wheat received 10 inches of irrigation.

Average yields from the limited-irrigation rotation study are shown in table 3. Continuous corn averaged 170 bu/a, while corn (with 5 more inches of water) in the other rotations averaged between 211 and 213 bu/a. Wheat yields averaged from 32 to 34 bu/a across all rotations. These yields were lower than expected, but were largely due to late spring freezes in 2004 and 2005 and stripe rust in 2005. Yields for grain sorghum (125 to 128 bu/a) and soybean (45 bu/a) were similar to yields observed in the limited-irrigation study. Table 4 shows the average returns for each rotation. Continuous corn had the highest average return to land, irrigation equipment, and management at $111/a. The other three rotations earned returns in the range of $66 to $73/a.

Table 3. Average Yields in Limited Irrigation Rotations in Tribune, KS (2003-05).

Crop	Rotation*			
	Corn-Corn	Corn-Wheat	Corn-Wheat-Sorghum	Corn-Wheat-Sorghum-Soybean
Corn	170	213	211	213
Wheat	--	33	32	34
Grain Sorghum	--	--	125	129
Soybean	--	--	--	45

* Each rotation is limited to average total of 10 inches of irrigation. In the rotations containing wheat, the wheat crop receives 5 inches of irrigation, while the corn crop receives 15 inches, for an average of 10 inches across the rotation.

Table 4. Average Returns ($/a) in Limited Irrigation Rotations in Tribune, KS (2003-05).

Crop	Rotation*			
	Corn-Corn	Corn-Wheat	Corn-Wheat-Sorghum	Corn-Wheat-Sorghum-Soybean
Corn	118	185	204	208
Wheat	--	-23	-27	-22
Grain Sorghum	--	--	39	45
Soybean	--	--	--	88
Rotation	118	81	72	80

* Each rotation is limited to average total of 10 inches of irrigation. In the rotations containing wheat, the wheat crop receives 5 inches of irrigation, while the corn crop receives 15 inches, for an average of 10 inches across the rotation.

When water levels decline and energy prices increase, one of the first questions many producers ask is whether they should continue growing irrigated corn.

According to the two studies from Tribune, the answer to that question appears to be “Yes”. This is still the case with assumed irrigation pumping costs being 72% higher in 2005 than 2004. However, every producer needs to run his own numbers as everyone’s situation may be different. For example, because of differences in well depths, or inefficient pumping or delivery systems, one producer’s pumping cost per acre-inch may be significantly higher than another’s. Likewise, one producer’s yield response to irrigation may vary from his neighbor’s. Therefore, it is critically important that producers understand the relationship between irrigation water and yield and other yield increasing inputs (i.e. fertilizer). Only then can accurate economic comparisons of crops be conducted.

ENERGY COSTS

Arguably the biggest concern of crop producers in the Central Plains region is the issue of high energy prices. This issue, of course, affects all crop growers, but impacts irrigators to a greater extent. Consequently, all irrigators are asking questions that perhaps only producers with limited irrigation well capacities were asking in the past. In addition to considering other crop options, producers are also considering planting high input crops, but cutting back on inputs such as seed, fertilizer, and irrigation water. Historically, such practices have not always maximized profits. Following is a discussion of the economic principles governing optimal use of fertilizer and irrigation water.

The economic principle guiding the use of yield increasing inputs such as fertilizer and irrigation water is the marginal cost equal marginal revenue (MC = MR) principle. In other words profit will be maximized at the point where the cost of an additional unit of an input (MC) equals the revenue associated from the use of the additional unit of that input (MR). In crop production, this principle would dictate that fertilizer and irrigation water should continue to be added as long as the benefit (yield increase * crop price) is greater than the cost of adding another pound of fertilizer or acre-inch of irrigation water.

The greatest difficulty in determining the input level where MR just covers MC is knowing the relationship between crop yield and that input. These yield response functions to fertilizer and irrigation water are necessary to calculate the economic optimum amount of those inputs to apply. Fortunately, research has been conducted in Kansas to develop yield response functions for the major crops in Kansas. This research has been used to generate adjustments to the KSU nitrogen recommendations to reflect current high nitrogen (N) prices (Kastens, et al). It has also been incorporated into a spreadsheet that is designed to help producers determine which crop is most profitable for their operation. In addition, *KSU-Crop Budgets 2006.xls* will help producers determine the economic optimum amount of nitrogen fertilizer and irrigation water to apply given their yield goals, expected fertilizer and irrigation costs, and forecasted crop prices. The *KSU-Crop Budgets 2006.xls* spreadsheet and paper describing how the

KSU nitrogen fertilizer recommendations were modified to reflect price are available on www.AgManager.info.

Table 5 shows the economic optimum N fertilizer and irrigation rates for irrigated wheat, corn, grain sorghum, soybean, and sunflower at historical nitrogen ($0.21/lb) and irrigation pumping costs ($3.10/in). Using corn as an example, a producer with a yield goal of 225 bu/a, 20 lbs of soil test N, and 2.0% organic matter would apply 278 lbs/a of N as an economic optimum. If that same producer expected 18 inches of annual rainfall, the economic optimum amount of irrigation water to apply would be 17.1 inches.

Table 5. Economic Optimum Nitrogen Fertilizer and Irrigation Rates Based on Historical Energy Prices.

	Wheat	Corn	Sorghum	Soybean	Sunflower
Yield Goal	75	225	125	65	2,800
Soil Test N, lbs/a	20	20	20	20	20
Organic matter, %	2.0	2.0	2.0	2.0	2.0
N price, $/lb	0.21	0.21	0.21	0.21	0.21
Irrigation pumping cost, $/in	3.10	3.10	3.10	3.10	3.10
Econ. optimum N, lb/a	112	278	114	0	125
Econ. optimum irrigation, inches	12.6	17.1	12.8	16.6	15.0
Yield at econ. optimum	71.1	221.0	119.5	58.5	2,706

Table 6 shows the economic optimum N fertilizer and irrigation rates for the same crops in table 5, but with an N price of $0.40/lb and irrigation pumping costs of $6.50/in. When N and irrigation costs increase, the optimal rates of each decrease significantly. Economic optimum N rates drop from 278 lbs/a to 225 lbs/a as price increases from $0.21/lb to $0.40/lb. Likewise, economic optimum irrigation rates drop from 17.1 inches to 14.2 inches as pumping costs increase from $3.10/in to $6.50/in.

Clearly, the historically high energy prices have an impact on crop production decisions. Both optimal fertilizer N and irrigation rates decline as energy prices rise above historical averages. However, the magnitude of the decline will depend on each producer’s situation, so it is again important that every producer run his own numbers to determine the economic optimum N and irrigation rates for a given farm.

Table 6. Economic Optimum Nitrogen Fertilizer and Irrigation Rates Based on Current Energy Prices.

	Wheat	Corn	Sorghum	Soybean	Sunflower
Yield Goal	75	225	125	65	2,800
Soil Test N, lbs/a	20	20	20	20	20
Organic matter, %	2.0	2.0	2.0	2.0	2.0
N price, $/lb	0.40	0.40	0.40	0.40	0.40
Irrigation pumping cost, $/in	6.50	6.50	6.50	6.50	6.50
Econ. optimum N, lb/a	67	225	67	0	83
Econ. optimum irrigation, inches	7.6	14.2	8.3	15.2	10.6
Yield at econ. optimum	59	209	103	59	2,420

LAND LEASE ARRANGEMENTS

Current energy prices also have the possibility of impacting crop land lease arrangements. How much a crop lease agreement will be affected will depend on the type of agreement, the terms of the agreement, and the magnitude of the cost increase. While crop share leases are most common in Kansas, other types of rental arrangements have been increasing in use in recent years. The most popular type of these leases include cash rental arrangements, and “net share” leases, which are basically crop share arrangements in which the tenant provides all crop inputs, but would receive a higher percentage of the crop than they would in a typical crop share arrangement.

Equitable crop share arrangements should follow five principles: 1) Yield increasing inputs (i.e. fertilizer and irrigation water) should be shared, 2) lease terms should be reviewed and technology changes, 3) crop returns should be shared in the same percentage as resources contributed, 4) tenants should be compensated for any unused long-term investments at lease termination, and 5) effective tenant-landlord communications. In terms of managing rising input costs, principles 1 and 3 are particularly relevant. If a crop share lease is equitable (i.e. returns are shared in the same proportion as resources contributed), then sharing the yield increasing input guarantees that it will be applied at the economic optimum. In addition, sharing the yield increasing input guarantees that the lease will remain equitable regardless of the price of that input.

An example is provided in table 7. In this table, the base crop share lease is for 125 acres of center-pivot-irrigated corn, in which the tenant owns the irrigation motor and pivot, and the landlord owns the well, pump and gearhead. In this example, crop inputs that are shared include fertilizer, herbicides, insecticides, and irrigation pumping costs. When N fertilizer and irrigation pumping costs are at levels typical during the last 5 to 10 years, the equitable landlord/tenant crop share split is 23.8%/76.2%. If N fertilizer and irrigation costs increase to current levels ($0.40/lb and $6.50/in, respectively), the equitable crop share split does not change.

In another scenario, identical to the base scenario except that irrigation pumping costs are not shared, the landlord/tenant crop share split would be 20.1%/79.9%. At current prices, the equitable crop share split would be 17.1%/82.9%. This clearly demonstrates that if yield increasing input costs increase significantly, and they are not shared equitably, the lease may become inequitable if crop returns are not adjusted accordingly. Precisely how a crop share lease should or should not be adjusted will of course depend on the specifics of each lease.

Table 7. Effect of High Energy Prices on Equitable Crop Share Percentages.

Lease Scenario	Equitable Share % (L/T)
Base crop share	23.8/76.2
Crop share with high energy costs	23.8/76.2
Crop share not sharing irrigation costs	20.1/79.9
Crop share not sharing irrigation with high energy costs	17.1/82.9

Cash rents would also be affected if input costs increased. A equitable cash rent equivalent to base crop share arrangement described above would be $67.14/a. At current costs the equitable cash rent would fall to $29.15/a. The decline in cash rent is the result of a reduction in profitability from the higher energy costs. This suggests that tenants who are cash renting may need to renegotiate the lease with their landlord. Of course, approaching the landlord to help "share the pain" will have to be weighed against the prospect of potentially losing the land. Also, if tenants are looking for a long-term agreement, then long-term input prices should be used to determine an equitable cash rent.

SUMMARY

Diminishing groundwater levels and rising energy costs have had a negative impact on irrigated crop production. Producers have many decisions to make regarding crop selection and crop input use. Research has been conducted to evaluate crop response to irrigation levels and alternative limited-irrigation rotations. Results indicate that corn has a higher response to irrigation to produce higher yields and therefore higher returns in most situations. Higher energy costs may impact optimal application rates for nitrogen fertilizer and irrigation. Depending on the crop, yield goal, and soil test nitrogen, economic optimum fertilizer rates may decline by 10 to 30%. When irrigation pumping costs are considered simultaneously, economic optimum fertilizer and irrigation rates may fall even more. Crop share lease arrangement that share fertilizer and irrigation pumping costs will not be impacted by the higher energy costs. Crop share leases that do not share fertilizer and irrigation pumping costs may need to be evaluated to determine whether any changes need to be made to the lease. Likewise, cash rents may need to be evaluated to determine whether any adjustments need to be made. With any of these issues, producers need to evaluate their situations individually, as what may be optimal for one situation may not be optimal for another.

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