LIMITED IRRIGATION OF FOUR SUMMER CROPS IN WESTERN KANSAS

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SUMMARY

Research was initiated under sprinkler irrigation to evaluate limited irrigation in a no-till cropping system. Corn, grain sorghum, soybean, and sunflower were grown with 5, 10, or 15 inches of annual irrigation. The objectives were to determine the impact of limited irrigation on crop yield, soil water, water use, and profitability. Irrigations were schedule to correspond with the most critical growth stage (reproductive) of each crop which generally was from mid-July to mid-August. With higher irrigation amounts, irrigations were begun sooner and continued later in the growing season. Soil water at planting and harvest was increased with increased irrigation amounts while crop had little impact on soil water. Average grain yields of all crops increased when irrigation amounts were increased from 5 inches annually to 10 inches. Corn was the most responsive crop with a 60 bu/acre increase (53%), while all other crops responded with 21 to 27% higher yields. When irrigation amounts were increased to 15 inches, corn, sorghum, and soybean yields increased an additional 10% while sunflower yields showed a slight yield decrease (3%). Average net returns to land, irrigation equipment, and management were similar for soybean and corn and only slightly less for grain sorghum with 5 inches of irrigation. Profitability increased for all crops when irrigation was increased from 5 inches to 10 inches. At 10 inches of irrigation or more, corn was the most profitable crop. Ten inches of irrigation was sufficient to optimize net returns for grain sorghum, soybean, and sunflower while corn was the only crop where profitability was greatest with 15 inches of irrigation.

INTRODUCTION

Irrigated crop production is a mainstay of agriculture in western Kansas. However, with declining water levels in the Ogallala aquifer and increasing energy costs, optimal utilization of limited irrigation water is required. While crop rotations have been used extensively in many dryland systems, the most common crop grown under irrigation in western Kansas is corn (about 50% of the irrigated acres), often in a continuous corn system. While corn responds well to irrigation, it also requires substantial amounts of water to maximize production. Almost all of the groundwater pumped from the High Plains (Ogallala) Aquifer is used for irrigation (97% of the groundwater pumped in western Kansas in 1995 [Kansas Department of Agriculture, 1997]). In 1995, of 2.46 million acre-ft of water pumped for irrigation in western Kansas, 1.41 million acre-ft (57%) was applied to corn (Kansas Water Office, 1997). This amount of water withdrawal from the aquifer has reduced saturated thickness (in some areas up to 150 ft) and well capacities. Although crops other than corn are grown under irrigation, they have not been grown as extensively because of relatively inexpensive water and a ready market for corn to the livestock feeding industry in the area. The trend in western Kansas during the last decade has been towards increasing acreage of irrigated corn (665,000 acres in 1990 compared to 1.2 million acres in 2000) with corresponding reductions in grain sorghum (326,000 acres in 1990 compared to 71,000 acres in 2000) and winter wheat (692,000 acres in 1990 compared to 455,000 acres in 2000) [Kansas Farm Facts, 1991 and 2001]. Although corn is expected to remain the dominant irrigated grain crop (especially in areas with abundant groundwater), the need exists to develop strategies to more effectively utilize limited irrigation water for corn. While there have been increases in irrigated soybean acreage (71,000 acres in 1990 compared to 134,000 acres in 2000), there has been limited research on water use characteristics in western Kansas.

Alternative crop management practices are needed to reduce the amount of irrigation water required while striving to maintain economic returns sufficient for producer sustainability. To prepare for less water available for irrigation in the future, whether from physical constraints (lower well capacities and declining water tables) or from regulatory limitations, information on crop productivity and profitability with less irrigation water will be beneficial for agricultural sustainability.

PROCEDURES

A field study was initiated under sprinkler irrigation at the Tribune Unit, Southwest Research-Extension Center near Tribune in the spring of 2001. The objectives were to determine the impact of limited irrigation on crop yield, soil water, water use, and profitability. All crops were grown no-till while other cultural practices (hybrid selection, fertility practices, weed control, etc.) were selected to optimize production. The experimental design was a split plot with crop being the main plot and irrigation amount as subplots. The crops evaluated were corn, grain sorghum, soybean, and sunflower grown in a 4-yr rotation (a total of 12 treatments). The crop rotation was corn-sunflower-grain sorghum-soybean (alternating grass and broadleaf crops). Irrigation amounts were 5, 10, and 15 inches annually. The irrigation amounts for a particular plot remained constant throughout the study, e.g. a plot that received 5 inches of water one year when corn was grown also received 5 inches in the other years when grain sorghum, sunflower, or soybean were grown. All treatments were replicated four times. Irrigations were scheduled to supply water at the most critical stress periods for the specific crops (generally flowering through grain fill) and limited to 1.5 inches/week. Soil water was measured at planting, during the growing season, and at harvest in one-ft increments to a depth of 8 ft. Crop water use was calculated by summing irrigation amount plus growing season precipitation plus soil water depletion (soil water at planting less soil water at harvest). Grain yields were determined by machine harvest. An economic analysis determined net returns to land, irrigation equipment, and management. Cost assumptions were based on local input costs and grain prices at harvest. Custom rates were used for all equipment operations.

RESULTS AND DISCUSSION

Precipitation during the growing season (May through September) varied greatly from year-to-year (Table 1). One year (2002) was especially dry with only 55% of normal precipitation, one year (2001) was near normal (92% of normal precipitation) and three years were wetter than normal (2003 to 2005 with 115 to 124% of normal precipitation). Hail caused severe crop damage in 2002 and moderate crop damage in 2005.

Table 1. Monthly precipitation from May through September during study period at Tribune, KS.

Year	May	June	July	August	September	Total
	- - - - - - - - -	- - - - - - - -	inches	- - - - - - - -	- - - - - - - -	- - - -
2001	3.10	1.18	4.50	1.34	0.81	10.93
2002	1.20	1.30	0.44	1.91	1.64	6.49
2003	3.07	5.39	3.99	1.74	0.58	14.77
2004	0.05	4.86	3.62	3.01	2.15	13.69
2005	2.13	4.75	0.76	4.57	1.55	13.76
Normal	2.76	2.62	3.10	2.09	1.31	11.88

Irrigations were scheduled to supply water during the reproductive growth stage for all crops. So with the lowest irrigation treatments, the initial irrigation was delayed until later in the season than with higher irrigation treatments and also the termination of irrigation was soonest with the lowest irrigation treatment. As irrigation amounts increased, the irrigations were initiated earlier in the growing season and continued later in the growing season. The average beginning and ending irrigation dates are shown in Table 2. In general, irrigations were initiated earlier for corn than the other crops because of the earlier planting date. When precipitation was sufficient within a given week, irrigations were not done thereby saving the water for later in the season.

Table 2. Average date of irrigation initiation and termination of four crops from 2001 through 2005 at Tribune, KS.

Irrigation amount	Corn	Sorghum	Soybean	Sunflower
inches	- - - - - - - - - - - - - - period of irrigation - - - - - - - - - - - - - -			
5	7/15 - 8/8	7/21 - 8/12	7/19 - 8/11	7/17 - 8/9
10	6/30 - 8/11	7/10 - 8/26	7/7 - 8/25	7/7 - 8/25
15	6/19 - 8/29	6/27 - 8/31	6/24 - 8/31	6/24 - 8/30

Soil water at planting increased with increased irrigation amounts, particularly when irrigation increased from 5 to 10 inches (Table 3). There was little difference in soil water at planting between the 10 and 15 inch irrigation treatments. Crop selection had little impact on soil water at planting.

Table 3. Soil water at planting of four crops as affected by irrigation amount from 2002 through 2005, Tribune, KS (2001 excluded because of previous irrigation history was not consistent with study treatments).

Irrigation amount	Corn	Sorghum	Soybean	Sunflower
inches	- - - - - - - inches of water in 8 ft profile - - - - - -			
5	5.65	6.26	4.83	6.93
10	9.35	9.36	8.84	10.51
15	9.46	10.34	9.59	10.34

Profile soil water at harvest responded similarly to that at planting in that there was considerably more soil water with 10 rather than 5 inches of irrigation but little further increase with 15 inches of irrigation (Table 4). In general, soil water at harvest was 1 to 2 inches less than at planting. Crop selection had little impact on soil water at harvest.

Table 4. Soil water at harvest of four crops as affected by irrigation amount from 2001 through 2005, Tribune, KS.

Irrigation amount	Corn	Sorghum	Soybean	Sunflower
inches	- - - - - - - inches of water in 8 ft profile - - - - - -			
5	4.76	3.71	3.74	4.63
10	8.18	7.81	8.36	8.45
15	8.50	8.64	8.79	9.79

Crop water use increased with increased irrigation amounts (Table 5). Crop water use was greater with grain sorghum at the lowest irrigation amount but with corn at the highest irrigation amount. Sunflower used the least amount of water.

Table 5. Crop water use by four crops as affected by irrigation amount from 2001 through 2005, Tribune, KS.

Irrigation amount	Corn	Sorghum	Soybean	Sunflower
inches	- - - - - - - inches of water - - - - - -			
5	17.95	19.26	17.43	16.92
10	22.48	22.34	21.44	20.71
15	26.38	25.81	25.15	22.89

Average grain yields of all crops increased when irrigation amounts were increased from 5 inches annually to 10 inches (Table 6). Corn was the most responsive crop with a 60 bu/acre increase (53%), while all other crops responded with 21 to 27% higher yields. When irrigation amounts were increased to 15 inches, corn, sorghum, and soybean yields increased an additional 10% while sunflower yields showed a slight yield decrease (3%). Grain yields varied greatly during the study period (values in parenthesis in the table). The low yields were caused by hail damage in 2002 and 2005. The highest yields for most crops were in 2004 except grain sorghum which had the highest yields in 2001.

Table 6. Average grain yield of four crops from 2001 through 2005 as affected by irrigation amount, Tribune, KS. Values in parenthesis are range in grain yields.

Irrigation amount	Corn	Sorghum	Soybean	Sunflower
inches	- - - - - - - - - - - -	bu/acre	- - - - - - - - - -	lb/acre
5	114 (14-204)	93 (13-134)	30 (12-49)	1550 (70-2530)
10	174 (73-245)	114 (57-149)	38 (23-52)	1880 (230-2700)
15	191 (93-260)	125 (80-172)	42 (28-51)	1820 (270-2780)

With 5 inches of irrigation, average net returns were similar for soybean and corn (Table 7) and only slightly less for grain sorghum. Profitability increased for all crops when irrigation was increased to 10 inches. At 10 inches of irrigation or more, corn was the most profitable crop. Corn was also the only crop where profitability was greatest with the highest irrigation level. All other crops were more profitable with 10 inches of water. In this study, sunflower was the least profitable crop at all irrigation levels.

Table 7. Average net return to land, irrigation equipment, and management for four crops as affected by irrigation amount from 2001 through 2005, Tribune, KS.

Irrigation amount	Corn	Sorghum	Soybean	Sunflower
inches	- - - - - - - - - - annual net return, $/acre - - - - - - - -			
5	27	12	31	-12
10	130	28	56	-3
15	146	27	52	-26

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REFERENCES:

Kansas Department of Agriculture. 1997. Kansas reported water use summary, calendar year 1995. State of Kansas, Topeka, KS.

Kansas Farm Facts. 1991 and 2001. Kansas Agricultural Statistics. Kansas Dept. of Agriculture and U.S. Dept. of Agriculture, Topeka, KS.

Kansas Water Office. 1997. 1995 Kansas irrigation water use. State of Kansas, Topeka, KS.