Drip Irrigation for Corn Production
The Research Approach in Western Kansas

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INTRODUCTION

The Ogallala or High Plains Aquifer is one of the largest freshwater sources of groundwater in the world, covering parts of six states in the Great Plains. Many areas of irrigated crop production are experiencing overdraft of the aquifer due, in part, to irrigation. In western Kansas, irrigation uses nearly 95% of the total water use. Irrigation, though occupying a small percentage of the land area, has a significant effect on total crop production and stabilization of the economy. The number one agricultural industry in the state, the red meat industry, depends on a large local supply of irrigated feedgrains. The impact of drastic irrigated acreage reductions could have a severe impact on that industry and thus the entire state. Everyone agrees additional efforts are needed to develop new and better water management techniques to conserve non-renewable resources such as the Ogallala aquifer. We can not afford to wait until there is little water resource left to conserve.

The Kansas Agricultural Experiment Station (KAES) recognizes that water-resource constraints and changing economics may dictate a move towards advanced-irrigation technologies such as drip irrigation. In recognition of the fact, the KAES began in 1988 to devote a significant amount of time and resources to the evaluation of subsurface drip irrigation for row crops in western Kansas. Over $250,000 of financial resources available to the KAES has been devoted to this effort for the first three years of the effort, not including faculty and staff time. The research thrust is multidisciplinary, including agricultural engineers, agronomists, and agricultural economists. The drip irrigation systems at Colby and Garden City, Kansas are designed expressly for research and cover nearly 25 acres, consisting of over 225 separate field plots.

Efforts currently underway are evaluating the water requirement of drip irrigated corn, the frequency of drip irrigation events, determining the uniformity of irrigation on long dripline laterals, evaluating spoon-feeding of nitrogen to the crop through the driplines, determining water redistribution and percolation under drip irrigation, determining the optimum spacing of the driplines, determining the optimum plant population for drip irrigated corn and determining the overall economics of the practice. This report summarizes the current research in progress.

IRRIGATION REQUIREMENTS

The average net irrigation requirement for corn in western Kansas is 15-16 inches. However, the annual requirement varies with annual variations in climatic conditions. Many of the irrigators in the area will apply 15-18 inches with center-pivot sprinklers and 18-24 inches with furrow irrigation. Drip irrigation offers the promise of being able to reduce the amount of applied water to the net requirement because of its nearly 100% application efficiency. Studies were initiated at both Colby and Garden City, Kansas to determine the irrigation requirement of corn grown with subsurface drip irrigation. Six irrigation treatments were made ranging from no irrigation to heavy irrigation (125 % ET). Yields tended to plateau at both sites at an irrigation level that met 75% of ET (Figure 1). Increasing the irrigation amount above 100% of ET actually decreased yields in most years (Figure 2). This decrease in yields probably reflects the lack of adequate aeration caused by the high frequency of irrigation for the heavy irrigation treatment. In the three-year study at Colby, an approximately 25% reduction in irrigation from the normal amount resulted in the highest amount of grain produced per unit of water use. Based on these data, it does appear significant water savings are possible without a sacrifice in yields.

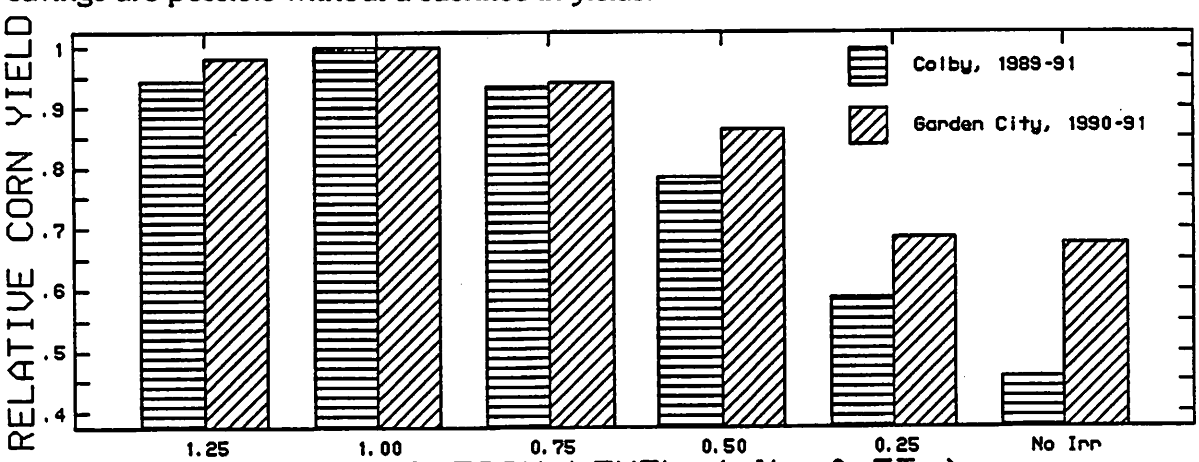

Figure 1. Relative corn yields in relation to irrigation level for drip-irrigated corn at Colby and Garden City, Kansas.

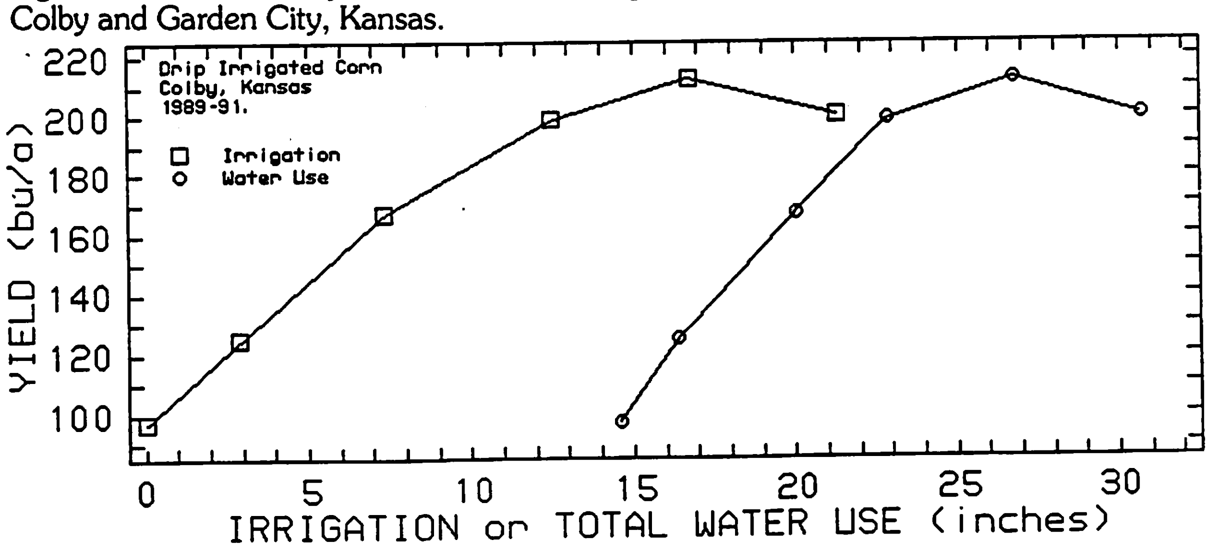

Figure 2. Drip-irrigated corn yields in relation to irrigation or total water use, KSU Northwest Research Extension Center, 1989-91.

SPACING OF DRIPLINES

Much of the adoption time frame for the drip irrigation technology will be driven by economics. Increasing the spacing of dripline laterals would be one of the most significant factors in reducing the high overall investment costs of drip irrigation.

Two studies have been conducted to determine the optimum dripline spacing for irrigated corn. The study at Garden City, Kansas has evaluated four dripline spacings, 30-, 60-, 90- and 120-inches with corn planted perpendicular to the dripline lateral. Plant population ranging from 20,000 to 38,000 plants/acre was an additional variable in this study. At the Colby field installation three dripline spacings were examined, 60-, 90- and 120-inches with corn planted parallel to the driplines. The spacing treatments in this study were evaluated both at full irrigation and at reduced irrigation (Irrigation reduced in relation to number of driplines in the treatment with the 60-inch spacing considered standard).

Averaged over all the years, corn yields were reduced in both studies 10 to 11% for the 120-inch spacing as compared to the standard 60-inch spacing when full irrigation was practiced (Table 1). This increased to 31% when irrigation was reduced by 50% for the 120-inch spacing. Annual results varied with climatic conditions with the wider spacings performing acceptably in some years and in some years not. The results, when incorporated into an economic model, showed an advantage for the wider spacings in some years. However, the 60-inch spacing was best when averaged over all years for both studies. However, more study is warranted because reducing the investment cost by 33 to 50% by using the wider spacings would make drip irrigation comparable in cost to sprinkler irrigation.

Table 1. Corn yields obtained with various dripline spacing treatments under full and reduced irrigation at Garden City and Colby, Kansas, 1989-91.

Spacing Trt.	Irrigation Trt.	Dripline Ratio in relation to 60-inch	Corn Yield (bu/a) Garden City 1989-91	Corn Yield (bu/a) Colby 1990-91
30-inch	Full Irrigation	2.00	230	---
60-inch	Full Irrigation	1.00	218	216
90-inch	Full Irrigation	0.67	208	204
90-inch	Reduced Irrigation (67%)	0.67	---	173
120-inch	Full Irrigation	0.50	194	194
120-inch	Reduced Irrigation (50%)	0.50	---	149

DRIPLINE LATERAL LENGTH

Most types of driplines currently on the market have been designed for use with high-value crops such as fruits and vegetables. The dripline laterals are short to reduce friction losses and, thus, ensure a high degree of irrigation uniformity. This makes little difference for high-value crops for which the expense of additional mainlines for additional subareas can be justified. However, to make drip irrigation economically feasible for corn, it may be necessary to increase the length of dripline laterals to decrease installation and management costs.

A study was conducted in 1990 and 1991 to compare the performance of 330- and 660-ft driplines on slopes less than 0.5%. In 1990, the study was fully irrigated with an amount equal to that required to meet the full crop-water use (1.0 * ET). In 1991, the study was deficit irrigated to meet 75% of the crop-water use needs (0.75 * ET). Yields were excellent in both years, and there were no appreciable differences among treatments. Also, there was no consistent pattern in yields with distance from the water-flow entry point. This indicates that water distribution along the lateral was adequate enough to not affect yields, even in 1991 when the crop was irrigated at 75% of ET.

FREQUENCY OF IRRIGATION

Drip irrigation is often characterized by small frequent irrigation events. This represents a significant change from the larger and more infrequent events used with surface and sprinkler irrigation systems. However, increased frequency may require more management by the irrigator. A study was conducted during 1990-91 at Garden City, Kansas on a deep silt loam soil to evaluate the effect of irrigation event frequency on corn yields and water use.

Corn yields were excellent regardless of whether a 1, 3, 5, or 7 day frequency was used for irrigation events. In each case the soil profile was returned to the calculated field capacity. As a result, the more frequent the irrigation event, the less opportunity to capture and utilize precipitation. Overall approximately 16% irrigation was saved by the 7-day frequency as compared to the 1-day frequency. It should be emphasized that all plots were managed at full irrigation levels. There could be an advantage for the more frequent events if the corn was managed at a different irrigation level. These results indicate that there is little need to perform frequent drip irrigation events for fully irrigated corn on the deep silt loam soils of western Kansas.

DRIP IRRIGATION FERTILIZATION

One of the more significant advantages of drip irrigation may be its ability to "spoon feed" the crop its nutrient needs. Accurately supplying the crop's nitrogen needs throughout the season reduces the potential for groundwater contamination from nitrates. A study was conducted during 1990-91 at Colby to examine the fertilization requirements of drip-irrigated corn. Preplant, surface-applied nitrogen was compared both to nitrogen injected into the driplines throughout the season and to a combination of the two fertilization methods. Nine different fertilization levels ranging from 0-595 lbs/acre of nitrogen were examined within three different irrigation levels--0.75 ET to 1.25 ET.

Yields approached a plateau of approximately 245 bu/acre at the higher irrigation levels with 220-250 lbs/acre of nitrogen applied either preplant or injected in the water (Figure 3). The results show that the total nitrogen needs of the corn could be injected during the crop season. If crop potential is lowered by weather, disease or crop pests, further application of fertilizer could be reduced or eliminated using this weekly injection technique. In addition, the potential for groundwater contamination could be reduced by the smaller amount of N available at any particular time.

There was a slight trend toward higher yields when nitrogen was increased over 220-250 lbs/acre with increased irrigation. However, soil profile N was also higher for the increased N plots, indicating that a sizable pool of N was left in the soil profile, increasing the chance for contamination of the groundwater.

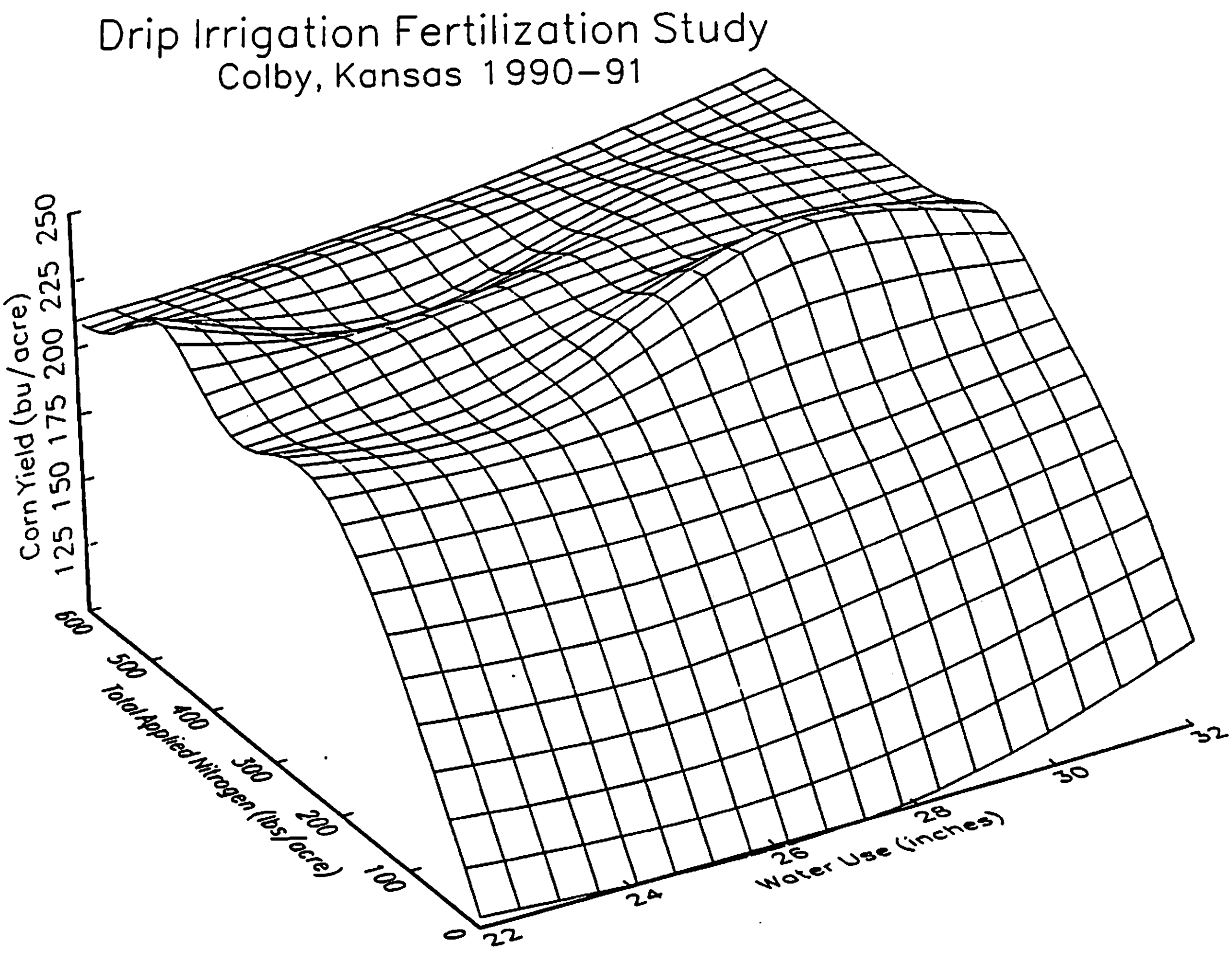

Figure 3. Corn yield as affected by water use and applied nitrogen in a drip irrigation study, KSU Northwest Research Extension Center, 1990-91.

ECONOMICS

An effort was made to determine the differences in investment costs for a drip and center pivot sprinkler systems for irrigated corn in western Kansas. It was assumed that the pumping plants already existed. Center pivot sprinkler costs were estimated for a new 128-acre LEPA system with the minimum recommended design features, complete with installation. The drip system was also designed for a 128-acre block. It was assumed installation labor would be absorbed by the irrigator with the exception of trenching costs for the mains and submains. The analysis showed a cost of $340/acre for the LEPA system and $446/acre for the drip irrigation system. If the drip irrigation system can be properly managed and maintained for a number of years, it may be worth serious consideration by irrigators.

EXTENSION OPPORTUNITIES

In addition to the sites being excellent field laboratories for multiple types of drip irrigation research, the sites are also centrally located in the major western Kansas irrigated regions, serving as excellent outdoor classrooms for the educational and extension thrusts related to drip irrigation. Although, drip irrigation for row crops plays a very minor role at the present time in western Kansas, irrigator interest is keen. Irrigators are progressive individuals, ready to embrace new technology that will help them to manage the precious water resource. The large installations at Colby and Garden City, will not only help to develop but will help to extend the management techniques needed to successfully apply drip irrigation.

CONCLUDING STATEMENT

The research results are extremely encouraging. However, there are many questions left to be answered before this practice should be adopted on a large scale. Kansas State University is taking a forward looking approach by finding many of these answers before a crisis arises. This is the best way to serve the irrigators, because the investment in drip irrigation is too high to make with limited information.