Report for 2003KS31B: Reduced Irrigation Allocations in Kansas from Grain Yield -- ET Relationships and Decision Support Model

- Conference Proceedings:
  - Klocke, N.L., J.P. Schneekloth, SR. Melvin, R.T. Clark, J.O. Payero. 2004. Field scale comparison of limited irrigation strategies. ASAE Paper No. 042280. Aug. 2004, Ottawa, Ontario, Canada. 13 pp. (Kansas Experiment Station Contribution No. 04-362-A).
  - Klocke, N.L., G.A. Clark, S. Briggeman, T.J. Dumler, and L.R. Stone. 2004. Crop water allocation program. Abstracts of: 21st Annual Water and the Future of Kansas Conference. March 11, 2004. Lawrence, KS. (Kansas Experiment Station Contribution No. 04-361-A).
  - Klocke, N.L., C. Hunter, Jr., M. Alam, 2003. Application of a linear move sprinkler system for limited irrigation research. 2003. ASAE Paper NO. 032012. July, 2003, Las Vegas, NV, 13 pp. (Kansas Experiment Station Contribution No. 03-402-A)
- Other Publications:
  - Klocke, N.L. Soybean and grain sorghum irrigationùsummer 2002. 2003. In Report of Progress 910. Kansas State University, AES and CES, Aug. 28, 2003, Garden City, KS. pp. 11-15.

Report Follows

"Reduced Irrigation Allocations in Kansas from Grain Yield--ET Relationships and Decision Support Model"

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Problem

Many irrigators in Kansas are facing immediate challenges with declining water yields from their wells. Estimates have been made that 30-50 of irrigation wells in western Kansas are pumping below original capacity. Irrigators in Kansas also face the possibility of shrinking water allocations with changes in water policy or simply enforcement of current water policy. Any of these scenarios will mean more limited irrigation than has been used in the past.

To make these reductions in water use, irrigators will need to consider shifts in cropping patterns. Irrigators who have shrinking water supplies need to know what cropping combinations to select and in what proportions for best water use and profitability. Not every combination of every cropping pattern that an irrigator dreams up can be examined experimentally with research. An agronomic/economic model is needed to predict results for an individual irrigator's situation.

This project is designed to deliver a tool to irrigators for making decisions about allocating scarce water on their land and among their crops. An irrigator's questions might be:

> "I have a limited amount of water, should I put it all on one crop or on two or three crops, how much acreage in each crop, and how much water on each crop?"
>
> "I have a limited amount of water, should I use deficit irrigation on all of my cropped land or should I try to meet the full irrigation needs of my crops on less land?"

Objectives

The answers to these questions are not straightforward and have many economic and policy-based implications. In order to help agricultural irrigators with these questions and to improve on their beneficial use of our limited water resources, the objectives are:

1. Develop a computerized tool for irrigators to assist in their decisions regarding the best use of limited water supplies or reduced water allocations.

2. Update irrigation and grain yield relationships for corn, wheat, soybean, grain sorghum, and sunflower crops using current varieties and no-till management to support the continued implementation of the decision tool.

Methods/Results

Objective 1: During the first year of this project a computerized decision tool was created based on scientifically developed crop responses to water and formalized budgeting techniques. It has been tested internally and is ready for external testing. There are two distinct resources that were used as building blocks for the water allocation model. The first component was an irrigation-yield relation relationship for each crop (figure 1) developed from a yield-evapotranspiration (ET) relationship that was based on past research in western Kansas. The yield-ET relationships were converted to yield-irrigation relationships over a range of rainfall zones with a simulation model. Similar relationships were developed for grain sorghum, wheat, sunflower, and soybean. These relationships were developed using a simulation model from are at the heart of allocating water and land to crops.

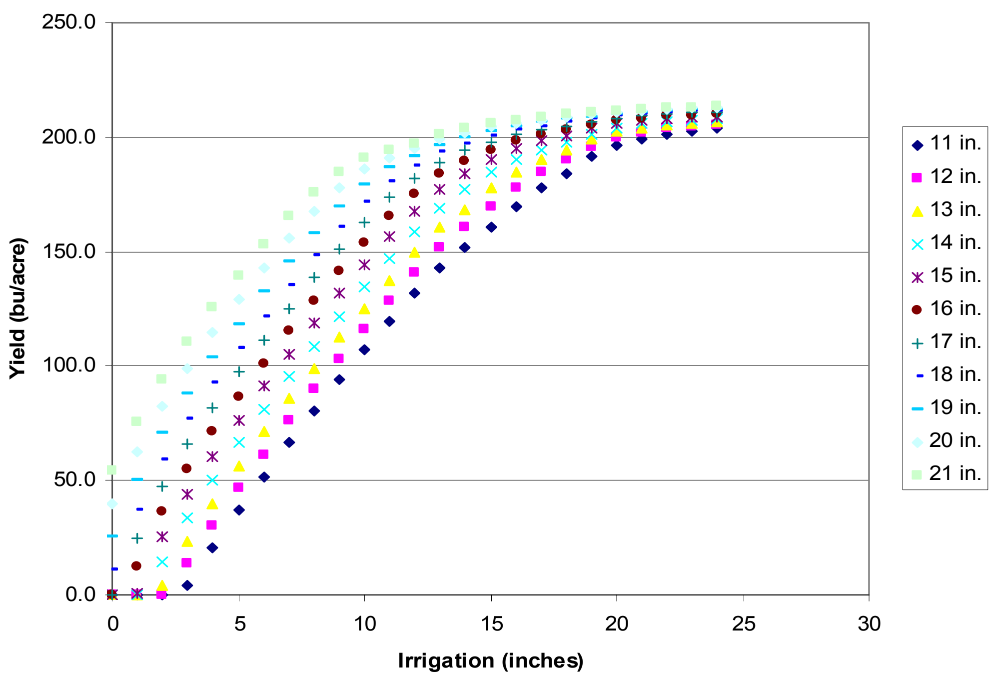

Fig.1. Corn yield in response to irrigation for annual precipitation zones in western Kansas.

The Kansas crop production budgets provide foundations for the second component of the decision model. Extensive crop production budgeting has been conducted by agricultural economists to guide producers in economic decisions concerning their operations. The economic realities of producing irrigated crops at all levels of irrigation inputs must be factored in to decisions about water allocations. The user will have the option to input crop production costs. However, the decisions become complex with multiple cropping choices.

The decision for allocating water is to divide it among one to several crops and allocate it over all the irrigated land or part of the land. We chose to take an iterative approach to the solution, and solve all of the combinations of possibilities that made senses and then rank them in order of highest net return.

The starting point for the model was to divide the land base into logical proportions of cropping base that might be farmed: 50-50, 75-25, 33-33-33, 50-25-25, and 25-25-25-25-25. The program user chooses the cropping pattern, maximum crop yields, irrigation water costs, crop production costs, and maximum water applied for the season. The program then iterates the water allocation by 10% increments over all possible combinations of crops and land allocations. For each iteration, the program calculates net return and then ranks the net returns from largest to smallest at the end of the calculations. The net return used in this program is the return to land, management, and irrigation equipment. The operating expenses are subtracted from the gross returns that make comparisons of the cropping systems possible. The program does not get to a profit or loss characterization of each system.

Five user friendly input and output screens were designed to include crop pricing and background information, irrigation cost inputs, crop production cost inputs, detailed production cost outputs, and summary net returns. Users can scroll through net returns of cropping options of the highest 15 combinations to see the possibilities and changes in net returns.

The program is in a WINDOWS based shell and will ultimately be made available by CD and a WEB site. We have demonstrated it at three professional/producer meetings to obtain feedback. This has been important during development. The most frequent comment is "when can I get a copy or where is the WEB site?" Extension agents, bankers, extension economists, irrigation specialists, producers, and consultants want to use this decision tool. Their feedback has been important to the design of this tool.

<u>Objective 2</u>: A four span linear move sprinkler irrigation system has been equipped with a segmented triple pipe manifold system for limited irrigation research. The design goals for the system included: research water management schemes to simulate center pivot management; limited irrigation experimental protocols for stage of growth or percentage of ET scheduling; random pattern of water applications; rectangular experimental plots; replicated experimental treatments; multiple crop planting patterns with access to plots; generation of crop response functions from a range of water inputs; and no-till farming practices.

The major accomplishment during 2003 was to bring the modified linear move irrigation system into full operation and to test its capabilities. There were several design and operational hurdles to overcome early in the season. The linear move on-board booster pump proved to be non-functional, which led to installation of high pressure underground water supply pipe directly from the well to the hose drag risers. The capacity of the system was also increased by increasing the size of the drag hose, risers, and nozzle orifices. The most formidable challenge during 2003, as far as the research protocol, was the revelation that a long duration residual herbicide had been applied to the experimental field during spring 2002. This affected all of the summer annual crops planned for research in 2003. We needed to uniformly apply water to the field during 2003 to remove the effects of the herbicide for the 2004 season; therefore, we could not apply differential water treatments in 2003. However, we did fully test the operational capabilities and application uniformity of the irrigation system. The experience gained from 2003 will enhance the experimental success for future years.

During 2004 we have fully implement the cropping plans for the research. During 2003 we raised corn and soybeans in the five cropping blocks. The later planted soybean and corn blocks were established with more herbicide tolerant varieties after the carryover symptoms were evident on the earlier plantings. Full irrigation was applied to all plots all season to promote as much vegetative growth as possible and leach as much chemical residue as possible. We planted winter wheat following soybean harvest during fall 2003 and will plant corn, soybean, grain sorghum, and sunflower during spring 2004.

Late planted corn results from 2003 (table 1) show that there were uniform grain yields across the plots. The non-uniformity in the early corn grain yield results were attributed to herbicide carryover. The contribution of the combination of stored soil water and rainfall reduced the need for irrigation in a year with 17 inches of annual rainfall (figure 2). Comparison of the late corn grain yield data in table 1 (199 bu/ac) with the 180 bu/ac yield response to 11 of irrigation in the 17 inch rainfall zone (figure 1) shows the potential of new corn varieties and no-till management for improving yield-irrigation relationships and ultimately irrigation water use efficiency. This is only one point on a response curve. Future years of research are needed for confirmation.

Table 1. Fully irrigated corn and soybean grain yields for 2003 at Garden City, Kansas.

Rep	Early Corn	Late Corn	Soybean
	--------	bu/ac	---------
I	191	205	54
II	200	204	43
III	145	192	44
IV	181	194	44
Avg.	179	199	46

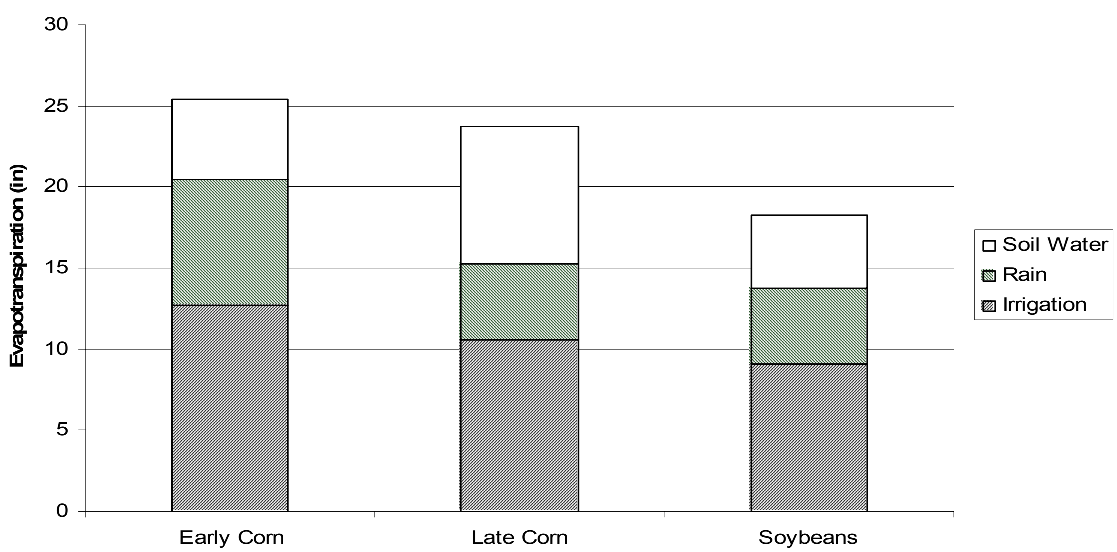

Fig. 2 Irrigation, growing season rain, and growing season stored water, used for evapotranspiration during 2003 at Garden City, Kansas.

Significance

We have a decision planning tool (water allocation model) for farmers, water resource planners, researchers, and water policy makers to examine a multitude of cropping options and limited irrigation options to maximize net economic return. This tool needs to go though final testing, be made available to the public and be supported with training assistance. The decision model is not scale dependent so that it can serve a field a farm or a watershed a river basin or an economic region.

We have an irrigation system in place to serve research for differential application of water on six levels of treatments in a random replicated pattern. The results of these experiments are to describe the yield-irrigation relationships for corn, soybean, wheat, grain sorghum, and sunflower crops which are grown in sequence in a no-till management system at the SWREC of Kansas State University at Garden City. These data will support the water allocation with new yield-irrigation relationships for no-till management. Farmers who are moving to water conserving management techniques such as no-till will need this new information. The simulation model used earlier will help extend this information into other rainfall zones.

Publications and presentations:

2003 SWREC Field Day-paper in proceedings and presentation;
2003 ASAE international meeting-paper on meeting CD on Web Library and presentation;
2004 Kansas Water Conference-published abstract and presentation;
2004 SWREC Advisory Council-meeting notes and presentation;
2004 Groundwater Management District Meeting-presentation;
2004 Finney County Soil Conservation Council-presentation;
2004 Ford County Irrigation Technology Day-presentation and demonstration of software;
2004 Central Plains Irrigation Conference-paper in proceedings and presentation
2004 ASAE international meeting-paper on meeting CD on Web Library and presentation;

Klocke, N.L., J.P. Schneekloth, SR. Melvin, R.T. Clark, J.O. Payero. 2004. Field scale comparison of limited irrigation strategies. ASAE Paper No. 042280. Aug. 2004, Ottawa, Ontario, Canada. 13 pp. (Kansas Experiment Station Contribution No. 04-362-A).

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Information transfer
Radio Interview on KBUF, March 3, 2004