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

- Conference Proceedings:
  - Klocke, N.L., G. A. Clark, S. Briggeman, L.R. Stone, and T.J. Dumler. 2004. Crop water allocator for limited irrigation. In Proc. High Plains Groundwater Conference. Lubbock, TX. Dec. 7-9, 2004. 196-206.
  - Klocke, N. L., Schneekloth, J. P., Melvin, S. R., Clark, R. T., and Payero, J. O. 2004. Field scale comparison of limited irrigation strategies. American Society of Agricultural Engineers Paper No. 042280. Aug. 2004.13 pp.
  - Klocke, N.L., Clark, G. A., Briggeman, S., Dumler, T.J., and Stone, L.R. 2004. Crop water allocation program. [abstract] 21st Annual Water and the Future of Kansas Conference. Kansas Water Resources Research Institute. p.19.
  - Melvin, S. R., Payero, J. O., Klocke, N. L. ,and Schneekloth, J. P., 2004. Irrigation management strategies for corn to conserve water. In: Proceedings Central Plains Irrigation Short Course & Exposition Proceedings. Feb. 17-18, 2004. Kearney, NE. pp 37-44.

Report Follows

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

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Descriptors

Limited irrigation; Decision support; cropping system; Evapotranspiration; Irrigation allocation

Problem and Objectives

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?"

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.

Description of Methods

Objective 1:

A computerized model, the crop water allocator (CWA), has been developed to assist in planning cropping patterns and targeting irrigation to those crops. It is an agronomic/economic model that will predict the net returns of possible cropping options. The model uses crop yield and irrigation relationships that were generated from the Kansas Water Budget, a water balance simulation model for western Kansas. The Kansas Water Budget results were based on yield-evapotranspiration relationships for each crop and annual rainfall from 280 to 530 mm across western Kansas as inputs (see Figure 1 for corn results). Crop production costs can be completely controlled by the user with inputs to CWA or the user can rely on default values from Kansas State surveys of typical farming operations in western Kansas.

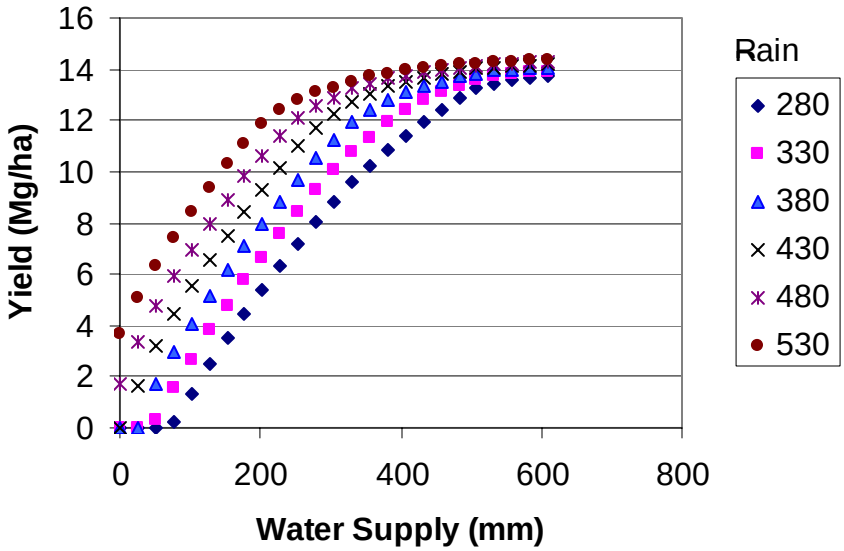

Fig.1. Corn yield in response to irrigation for annual precipitation zones in western Kansas.

The user first selects possible proportions of crops in the land considered in percentages of splits such as: 50-50, 75-25, 33-33-33, 50-25-25, and 25-25-25-25. The crop species, maximum crop yields, irrigation water costs, crop production costs, and maximum water applied for the season are then entered. The program then iterates, by 10% increments of the irrigation amounts, all possible net income solutions over all crop combinations. Multiple runs of the model give the user indications of the sensitivities of net returns to commodity prices, production cost inputs, crop selections, and land allocations.

Objective 2:
The experimental field (8.1 ha) was subdivided into six cropped strips that were irrigated by a 4-span linear move sprinkler irrigation system. Since the cropping strips were not replicated, they were treated as individual experiments statistically. The cropping sequence among the croppin strips was corn-corn-soybean-winter wheat-grain sorghum-sunflower. The soil was a silt loam with a slope of less than 1%. However, soil pH of 8.3 created a challenge for soybean production.

Irrigation amounts were varied within each cropping strip. The six irrigation treatments, replicated four times, ranged from 76 to 458 mm in depth, if needed. Pre-designated amounts of water were applied during vegetative, flowering, and grain fill growth stages. If rainfall was sufficient to fill the soil profile to field capacity, irrigation was not applied. Unused irrigation allocation was rolled over to the next growth stage. If there was unused allocation at the end of the year, it was not carried over to the next year.

Soil water was measured once every two weeks with the neutron attenuation method in increments of 30 cm to a depth of 2.4 m. There was one sampling site per plot. These measurements along with irrigation and rainfall were used to calculate evapotranspiration for

each two week period during the season. Irrigation application was calibrated from catch cans, the percent timer, and a totalizing flow meter.

Work Accomplished

Objective 1:
Crop Water Allocator (CWA) was released on the World Wide Web during December 2004 at www.oznet.ksu.edu/mil. It is available to users to download to their individual computers. Training sessions through the KSU Mobile Irrigation Lab will bring more feedback and initial reactions from users. The program was also introduced to Kansas independent crop consultants who may be another avenue for presenting water planning ideas to their clientele. It is too early to determine the usage of this decision tool. Reaction to its introduction at workshops has been very favorable. Individual farmers as users of the program can influence outcomes by their own preferences and strengths. The program is sensitive to commodity prices and maximum yields which will swing results based on user inputs.

Several model simulations were executed to examine the effects of various input factors on net return while annual water allocations were varied from 102 to 610 mm (4 to 24 in). The input factors considered were irrigation costs (85% increase from 2004 costs), commodity prices, and maximum crop yield. Multiple executions of the model with incremental input of one variable can lead to trend analysis (Fig. 2). An example simulation demonstrated that high water allocations led to monoculture corn cropping systems while low water allocations promoted crop rotations. High commodity prices for soybean and lower maximum yields for corn shifted crop choices to soybean and in favor of sunflower in the case of better yield potential for sunflower. All scenarios of over irrigation led to diminishing net returns at the same irrigation amount (410 mm) where the yield-irrigation relation reached a maximum. This is just an example of a multitude of customized scenarios possible.

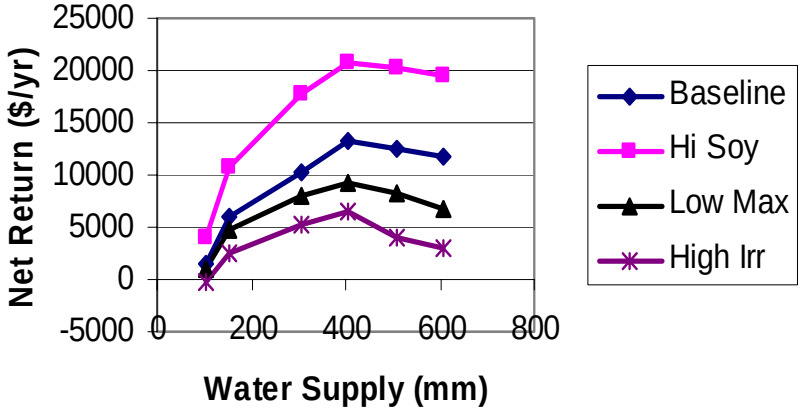

Figure 2. Net return in response to water allocation for irrigation when input variables of high soybean price (Hi Soy), low maximum corn yield (Low Max), high irrigation costs (High Irr).

Objective 2:
Cropping year 2004 had above normal rainfall during May through September (442 mm vs. 314

mm normal). Stone et al., 1995, developed a hydrologic simulation model, the Kansas Water Budget, which was used to generate yield-irrigation relationships for conventional crops in Figure 2. A family of curves was generated (Fig .1) for a range of annual rainfall from 280 to 530 mm. These relationships for corn, grain sorghum, and sunflower were based on yield-ET relationships derived from 1980 to 1990 research data for conventionally grown crops. The simulation results shown in Fig. 3 are based on 530 mm of annual rainfall. The 2004 data points for no-till management are generally above and to the left of the simulated relationships from conventional management. The possible influence of crop residue management and improvements in other management techniques may explain these improved yield-irrigation relationships. More years of data are needed to confirm these early results.

These results are promising. More years of data are needed to confirm the effects of crop residue management. Dry matter harvest results will help understand the trade-offs between using forage for livestock feed or water conservation.

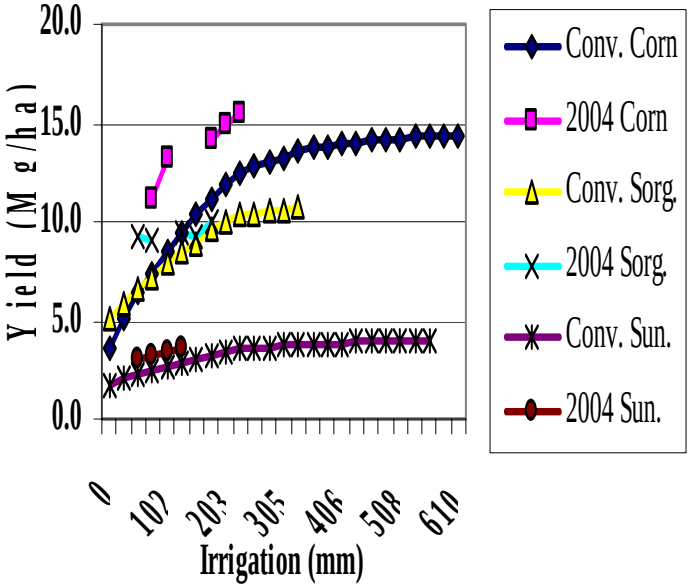

Figure 3. Crop yield responses to 530 mm of annual rainfall with conventional management in western Kansas compared to 2004 no-till management with similar rainfall at the Kansas State University SWREC.

References

Stone, L.R., O.H. Buller, A.J. Schlegel, M.C. Knapp, J.-I. Perng, A.H. Khan, H.L. Manges, and D.H. Rogers. 1995. Description and use of KS Water Budget v. T1 software. Resource Manual, Dep. of Agron., Kansas State Univ., Manhattan, KS.

Publications and presentations:

High Plains Groundwater Resources Conference
Kansas State University—SWREC Field Day
2004 & 2005 Central Plains Irrigation Conference
Kansas State University—SWREC Research Advisory Council Meeting
Groundwater Management District Meeting
Soil Conservation District Board Meeting
Producer meeting at Healy, Kansas
Kansas Water Resources Advisory Meeting
2004 & 2005 Irrigation Technology Seminar, Dodge City
2004 KSU SWREC Research Reviews
Kansas Water Authority Meeting

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Information transfer

KBUF radio presentations for live 1 hour interviews on three occasions

KSU news release used by High Plains Journal, Kansas Farmer

Klocke, N.L., Clark, G. A., Stone, L.R., Dumler, T.J., and Briggeman, S. 2004. Crop Water Allocator (CWA). [World Wide Web]. Version 1.5. www.oznet.ksu.edu/mil. Kansas State University, AES.

Students Supported

Three college students and two college prep students were supported with part-time employment through this grant. They were exposed to various facets of water resources research from daily planning and coordination of research activities, execution of research protocols, to data processing and data quality control.