Sustainable Irrigation and Cropping Systems for Areas with Limited Water in Colorado and the West

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Introduction

The influence of drought and rapid urban growth in Colorado have placed increasing competition on a limited water supply. The majority of the population growth is occurring along the Colorado Front Range in the South Platte River basin. Agriculturally dependent rural communities in the basin are concerned about current and future losses of irrigated cropland due to shifts in water rights to urban and industrial uses. The long-term objective of this integrated, multi-disciplinary, multi-agency research project is to develop the sustainability and profitability of irrigated agricultural production systems in an environment of increasing competition for water.

Previous Research

A few reported research projects have evaluated cropping systems in limited irrigation scenarios in the Great Plains. The following are examples of the findings from these related research projects:

- Limited irrigation corn yields (average irrigation of 150 mm) increased by 75% when compared to dryland corn (Schneekloth et al., 1991)
- Studies have confirmed that the yield increase per unit of irrigation declines with increasing irrigation amounts (Klocke et al., 1996; Norwood and Dumler, 2002)
- Yield increase from limited irrigation over dryland corn ranged from 38% in a wet year to 120% in a dry year (Schneekloth et al., 1991)
- A four-fold increase in yields for wheat under irrigation over dryland wheat occurred in two out of four years (Schneekloth et al. 1995)

Project Objective:

- Develop sustainable and profitable irrigated agricultural production systems in an environment of increasing competition for a limited water supply.

Specific Objectives:

- Develop cropping systems that improve the efficiency and sustainability of water use by optimizing irrigation water use at the farm scale.
- Evaluate the interaction of optimizing irrigation in cropping systems with arthropod pest profiles.
- Use integrated GIS and agricultural system modeling to evaluate the long-term impact of optimizing irrigation water through cropping systems and conservation technologies.
- Analyze the profitability of potential irrigation systems in an uncertain precipitation and farm price environment.
- Project the economic impacts of rural to urban water transfers in the South Platte River Basin, given potential changes in irrigated cropping patterns.

Methodology

The field research pilot project consists of two replicated sites:

1. Linear-move sprinkler irrigation system
2. Furrow irrigation system

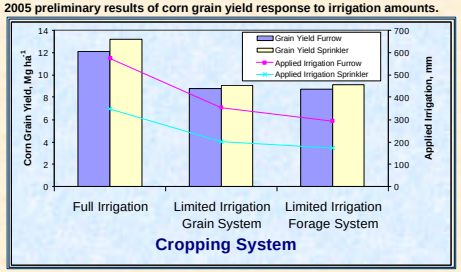
- These sites are in an area with long term average precipitation of 330 mm and a mean annual temperature of 10 C with well drained, loamy textured soils.
- A second irrigated site on a private farm, within the South Platte Basin in 2006, include different soil types and precipitation patterns.
- Four cropping systems represent a wide spectrum of potential crop productivity, water use, and water savings relative to conventional practices under full irrigation (Table 1).
- Research will compare crop production and water use / timing criteria for two reference cropping systems (dryland, full irrigation) with two limited irrigation cropping systems (grain, forage) (Table 1).

Table 1. Estimated irrigation amount and timing for various cropping systems.

Cropping system / Irrigation Scenario	Growth stage of irrigation	Fully Irrigated ET* (mm)	Target ET Min.** (mm)	Est.Saved ET*** (mm)
Dryland (Zero Irrigation Reference)				
Wheat	none	480	180	560
Fallow		0	0	740
	Average annual values for cropping system	240	90	650
Limited Irrigation - Grain Based System				
Wheat	Feekes stage 10 (boot stage) Early flower	470	300	440
Corn	V 12 (12 leaf, stage) VT (Tasseling stage) Early Blister	560	360	380
Sunflower	R1 (Bud Initiation) R3 Beginning Flower	510	300	440
	Average annual values for cropping system	390	320	420
Limited Irrigation - Forage Based System				
Corn grain	Irrigate for consumptive use (CU) after V 12	560	420	320
Corn silage	Irrgare for CU between V12 and R1	500	360	380
Alfalfa (4 years)	Irrigate for CU until July 1, no irrigation after July 1	790	420	320
	Average annual values for cropping system	700	410	330
Full irrigation Reference				
Corn	Irrigate for consumptive use all season	560	560	–
Alfalfa (4 years)	Irrigate for consumptive use all season	790	790	–
	Average annual values for cropping system	740	740	–

* Estimated evapotranspiration (ET) of a fully irrigated crop at Longmont, CO (Bronner and Schneekloth, 2004)
** Target ET is calculated as Effective Precip + Planned Irrigation*Non*Irrigation Efficiency. Effective Precip. = 178 mm (based on full irrigation mgmt.)
*** An estimate of the potential ET savings relative to the full irrigation reference.

2005 preliminary results of corn grain yield response to irrigation amounts.



➢**Corn yields harvested for grain, under the limited furrow and sprinkler irrigation system, were approximately 70 percent of corn yields irrigated to full ET, but received 40 percent less water.**

➢**Corn yields harvested for forage, under the limited furrow and sprinkler irrigation system, were approximately 70 percent of corn yields irrigated to full ET, but received 50 percent less water.**

Sunflowers under a limited furrow irrigation system

Corn under limited (left) and full (right) linear irrigation systems

Sunflowers, barley (cover crop), and corn under linear irrigation

Project Collaborators:

Colorado State University
Department of Soil and Crop Sciences
Department of Agricultural and Resource Economics
Department of Bioagricultural Sciences and Pest Management

United States Department Agriculture
ARS - Water Management Unit
Great Plains Systems Unit
Colorado Natural Resource Conservation Service

Northern Colorado Water Conservancy District

Connected Research

Other aspects of this research program include some of the following investigations:

- Detailed evaluations of crop water stress and insect pest profiles in order to make sound crop management plans for each cropping system.
- Development of a comprehensive and innovative outreach and education plan to transfer the study findings to traditional and non-traditional audiences, including students, farmers, rural communities, and urban policy makers.
- Additional endeavors include student training, curriculum development, a web delivered information database, a broadly represented stakeholder focus group, and extension based outreach.

Lessons Learned

A number of lessons were learned during the first year of the field research pilot project. Listed below are some of the successes and challenges our research team encountered at both the linear sprinkler and furrow irrigation sites:

Sprinkler Irrigation Successes

- Irrigation was simple to measure because of automated sprinkler settings
- Uniform irrigation application was possible with sprinkler drop nozzles
- Minimal time/labor involved in operating the sprinkler system
- Easy to start seedlings because of overhead irrigation application

Sprinkler Irrigation Challenges

- Drop nozzle irrigation height created variance in crop growth
- Coordinating irrigation times with other research plots was sometimes difficult
- Amount of irrigation applied was sometimes limited because of having to share water with other research projects

Furrow Irrigation Successes and Challenges

- Good demonstration site for irrigation outreach activities
- Irrigation amount difficult to measure in a furrow irrigated system
- More time/labor involved in maintaining flow of water through furrows
- Difficult to evenly irrigate crops because of advance time in furrows
- Southeast corner of field commonly received tail water from neighboring plots – thus over-applying water to several plots
- Coordinating irrigation times with other water users was challenging
- Difficult to start seedlings with a furrow irrigated system

Applying knowledge to improve water quality
Northern Plains & Mountains Regional Water Program
A Partnership of USDA CSREES & Land Grant Colleges and Universities

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