LIMITED IRRIGATION RESEARCH AND DEMONSTRATION IN COLORADO

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The combination of climate variability, drought, groundwater depletion, and increasing urban competition for water has created water shortages for irrigated agriculture in Colorado and is driving the need to increase water use efficiency. A statewide water supply survey predicts that 428,000 irrigated farm acres will be converted to dryland cropping or pasture within the next 15 years, mostly due to transfer of water from agricultural uses to meet the water needs associated with population growth (Colorado Water Conservation Board, 2004). A shift from irrigated to dryland cropping would significantly impact the economic viability of agricultural producers and have far reaching indirect effects on businesses and communities that support irrigated agriculture.

Water conservation options other than complete land fallowing are desirable because of the potential economic and environmental concerns associated with conversion to dryland. One approach to reducing consumptive use of irrigation water is adoption of limited irrigation cropping systems. With limited irrigation, less water is applied than is required to meet the full evapotranspiration demand of the crop. Crops managed with limited irrigation experience water stress and have reduced yields compared to full irrigation, but management is employed to maximize the efficient use of the limited irrigation water applied. These systems are a hybrid of full irrigation and dryland cropping systems and are currently of great interest to Colorado farmers. Successful limited irrigation systems are based on the concepts of: 1) managing crop water stress, 2) timing irrigation to correspond to critical growth stages for specific crops, 3) maximizing water use efficiency by improving precipitation capture and irrigation efficiency, and 4) matching crop rotations with local patterns of precipitation and evaporative demand. Research in the Great Plains illustrates that limited irrigation cropping systems are significantly more profitable alternatives than dryland (Schneekloth, 1991 and 1995).

METHODS

Two demonstration sites were developed in 2006. Site 1 is located near LaSalle, Colorado on a sandy loam soil. This field is furrow irrigated and the crop rotation is continuous corn. Irrigation management strategies include full irrigation management and limited irrigation management. Limited irrigation management tries to limit water during the vegetative growth stage and irrigate during the reproductive growth stage. Cultural practices such as populations were also studied at this site. Impacts on reducing plant populations with limited and full irrigation management were observed.

A second site was located near Burlington, Colorado on a silt loam soil. This field is center pivot irrigated. Alternative water management strategies were studied at this site within a 4-year crop rotation of corn-sunflower-soybean and winter wheat. This study looked at full irrigation management, an average allocation of 10 inches per year and an intermediate irrigation management strategy that limits water applied between that of full irrigation and allocation management.

RESULTS

LaSalle

Reduced irrigation compared to full irrigation reduced corn yields for limited irrigation (Figure 1). Full irrigation grain yields were 182 and 190 bu/acre for 2006 and 2007 respectively. Reducing irrigation during the vegetative growth stage reduced grain yields to 155 and 151 bu/acre for 2006 and 2007 respectively. This was an average yield reduction of 18% for limited irrigation compared to full irrigation. Irrigation was reduced from an average of 28 inches for full irrigation to 15.5 inches for limited irrigation (Table 1). The irrigation for limited irrigation was 55% of full irrigation. Precipitation for both 2006 and 2007 was below average. Average growing season precipitation is approximately 7 inches.

Reducing plant populations may be a strategy to reduce input costs and limit crop evapotranspiration during the growing season. Plant populations did impact grain yield for each of the irrigation strategies. For full irrigation management, 34,000 plants per acre resulted in slightly greater yields as compared to 26,000. Reducing the population to 20,000 plants per acre reduced grain yield by 15 bu/acre. However, with limited water, reducing plant population from 34,000 to 26,000 did not impact grain yield on average. Reducing the plant population to 20,000 plants per acre reduced the grain yield for limited water by 14 bu/acre, which was similar to that of full irrigation. Reducing plant populations below 26,000 plants per acre is not regarded as an economical practice for limited irrigation. If a water savings and increase in yield was to be obtained, 2006 and 2007 should have been optimal years due to the limited amounts of precipitation during the growing season.

Grain yield components such as kernels per ear, ear length and kernel weight were taken. At the optimum plant population for each of the irrigation strategies, the number of kernels per ears was not significantly greater for full irrigation as compared to limited irrigation. Ear length was slightly greater for limited irrigation compared to full irrigation, but was offset by a reduction in the number of kernels around the ear. Kernel weight was less for limited irrigation than full irrigation by almost 20%. This reduction is similar to the reduction in grain yield for limited irrigation compared to full irrigation.

Burlington

Average grain yields for corn and soybeans were reduced when irrigation was limited as compared to full irrigation. However, in 2006, corn grain yields for all irrigation strategies were similar. Precipitation during 2006 was above average for the growing season by 1.0 inches. Timing of irrigation for the reproductive growth stage did increase early season utilization of stored soil moisture (Figure 2). Approximately 1.4 inches of stored soil moisture was utilized for allocation irrigation as compared to full irrigation. Irrigation requirements for allocation management were 8 inches while full irrigation required 12 inches. This is less than what is estimated for full irrigation management in a normal year. However, there is a potential savings of 4 inches of applied irrigation when limiting water during the vegetative growth stage.

Grain yields in 2007 were less than in 2006. Approximately two weeks prior to tassel, a severe infestation of corn rootworm was noted in the entire field with 6 larvae per plant being observed. The allocated and intermediate corn was more severely impacted as compared to full irrigation. An insecticide was applied at planting but apparently failed due to insect pressure. After visual observations of damage were taken, it was noted by entomologist that the reduction in grain yield by damage to the roots was approximately 20% for full irrigation. This would have increased yields too approximately 200 bu/acre which was observed in adjacent fields with this variety. The yield reduction for the allocation irrigation was adjusted at approximately 40%.

Soybean grain yields (Table 2) were greater for full irrigation than either intermediate or allocation irrigation by 7 to 10 bu/acre. Grain yields in 2006 were substantially less than would be expected due to herbicide damage. Residual dicamba was in the farmers' sprayer and damage was done when the soybeans were sprayed with glyphosate. Evidence of herbicide damage was evident by leaf cupping on the top of the soybean plants. Soybean yields of a test plot near this region had soybean yields for this variety average near 70 bu/acre.

In 2007, soybeans were drilled. Grain yields for full irrigation were 56 bu/acre with intermediate and allocation management yields of 50 and 45 bu/acre. Although yields were greater than 2006, harvest loss was significant. A fixed 30 foot wheat header was used for harvest. The ability to adjust the location of the head in the field was difficult and losses for the entire field averaged 28 plus bu/acre. The potential yield of the soybean was 70 to 80 plus bu/acre. These yields were also verified by crop adjuster estimates. After further discussion with the producer, harvesting of the soybeans will be changed to include a flex-header. This harvesting equipment floats along the soil surface and automatically adjusts to terrain differences. Irrigation requirements for full irrigation soybeans in 2007 were 13 inches with 9 inches applied to allocation management.

Sunflowers respond well to limited amounts of irrigation. Sunflower grain yields in 2006 averaged 2500 to 2600 lbs per acre for allocation and intermediate irrigation management (Table 2). Full irrigation yields were 2400 lbs per acre. These yields were 400 to 500 lbs per acre less than hand harvested yield. Harvest losses were greater than expected due to increased lodging from insect pressure. Oil content for the allocation and intermediate management averaged 47% while full irrigation management oil content was 42%. This yield response is similar to previous research which has shown in average precipitation years, sunflowers do not respond to irrigation during the vegetative growth stage. Irrigation requirements for full irrigation management were 8 inches while the allocation management had 4 inches of applied irrigation.

In 2007, grain yields for sunflower were less than 2006. Full irrigation management averaged 2050 lbs per acre while allocation and intermediate irrigation management averaged 1700 and 1550 lbs per acre respectively. Harvest losses were again a significant impact on grain yields. Hand harvested yields were approximately 2500 lbs per acre for each of the three management strategies. The full irrigation management sunflowers were planted approximately 1 week later than the intermediate and allocation management sunflowers due to rainfall. The full irrigation management sunflowers did stand better than the earlier planted sunflowers which may have increased harvested yield of the full irrigation compared to allocation management.

CONCLUSION

Limited irrigation management of crops is management intensive and is potentially more risky than full irrigation management. However, research and demonstration projects in Colorado have successfully shown that irrigation water can be reduced and economical yields obtained. Alternative crops such as sunflower and soybeans can reduce the amount of irrigation needed as compared to corn. Education and marketing will play an important factor in the acceptance of these crops for irrigation conservation.

However, under current water law and regulations, water management such as limited water is not practical in years other than water short years in ditch and reservoir systems. In groundwater management areas, declining water resources and compact litigation may force limited irrigation changes with less water in the future.

Figure 1. Grain yield for irrigation strategies and plant population at LaSalle, Colorado.

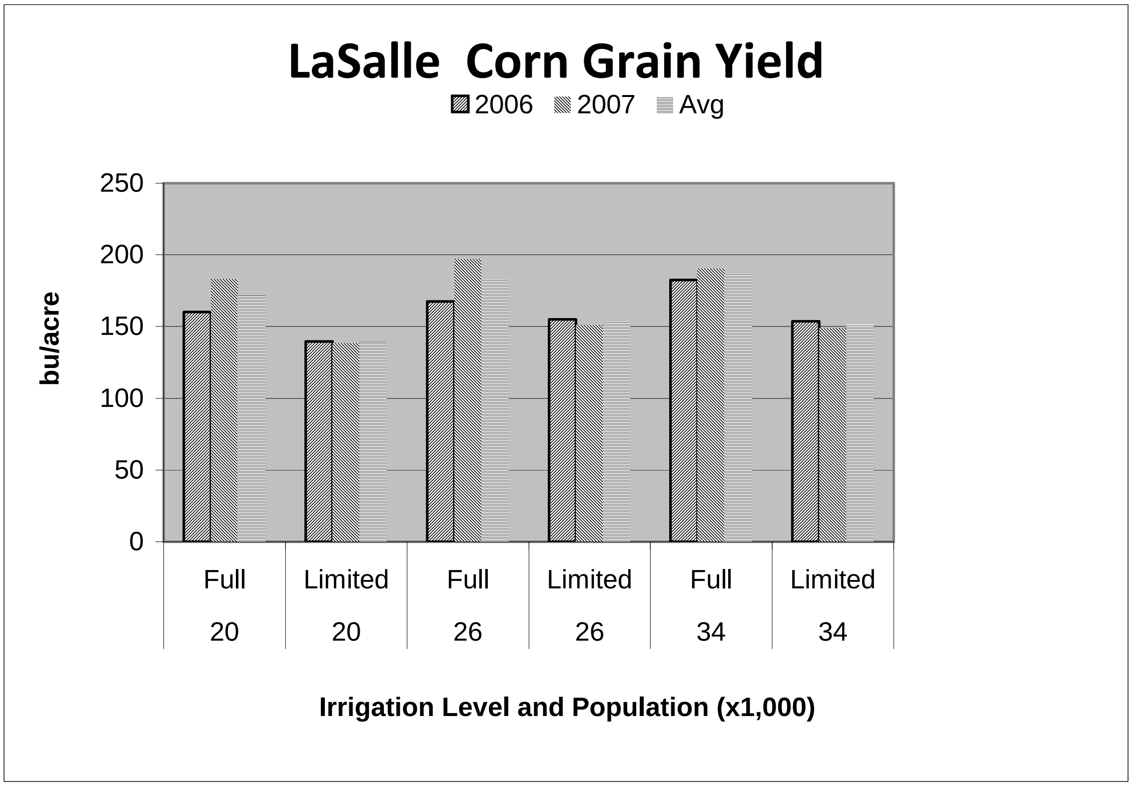

Figure 2. Soil moisture for irrigated corn on July 6, 2006.

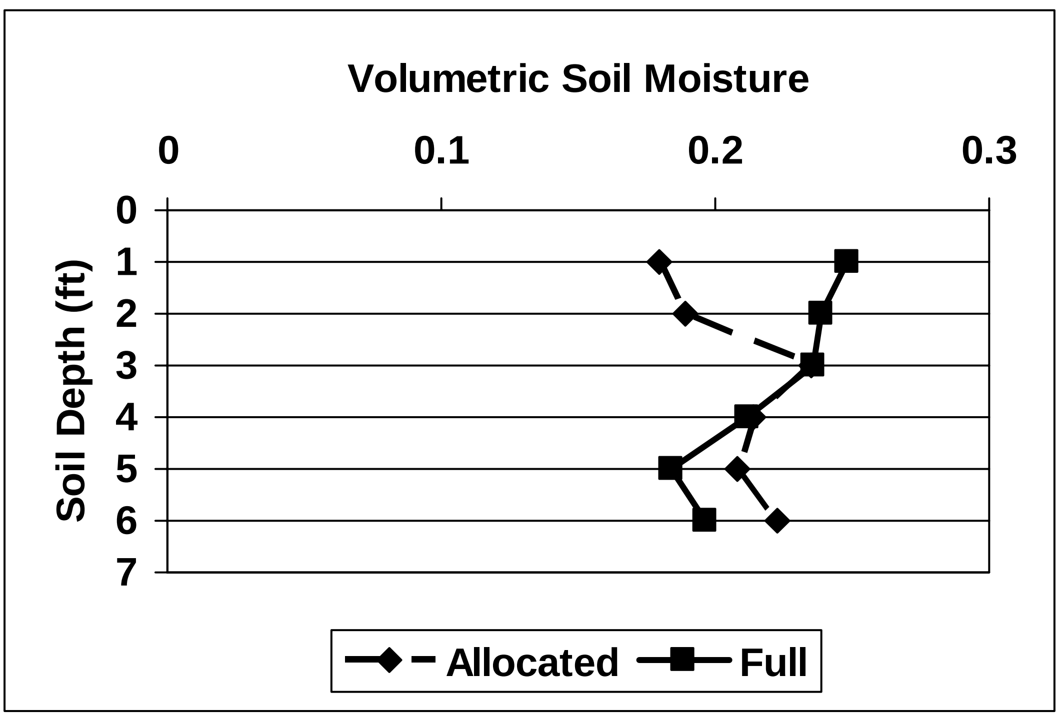

Table 1. Irrigation and precipitation for LaSalle, Colorado.

Year	Full	Limited	Precip.
		Inches	
2006	34.5	18.1	3.0
2007	21	13.1	4.0
Average	27.75	15.6	3.5

Table 2. Grain yields for corn, soybean and sunflower at Burlington, Colorado.

Irrigation	Corn, bu/acre			Soybean, bu/acre			Sunflower, lbs/acre		
Strategy	2006	2007	Avg	2006	2007	Avg	2006	2007	Avg
Allocation	193	127	160	40	45	42.5	2490	1710	2100
Interm.	203	145	174	37	50	43.5	2580	1560	2070
Full	198	160	179	47	56	51.5	2390	2050	2220