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LIMITED IRRIGATION OF CONVENTIONAL AND BIOFUEL CROPS

Gary W. Hergert
University of Nebraska Panhandle Research and Extension Center
Scottsbluff, NE 69361
email: ghergert1@unl.edu

BACKGROUND

Declining ground water is not a new dilemma in Nebraska or throughout the Great Plains. The drought across the High Plains and inter-mountain west from 1999 to 2008 magnified the seriousness of the problem, however. The passage of Nebraska legislation to conjunctively manage groundwater and surface water has changed ground and surface water management. In many areas it simply means less water for producers. The economic reality is that irrigation provides more stability and income than dryland farming. UNL research suggests that applying limited water to an optimum number of acres provides more profit potential and has less impact on the local economy than converting some land to dryland (Schneekloth et al., 2001).

Under limited irrigation, less water is applied than is required to meet full ET demand and the crop will be stressed. The goal is to manage cultural practices and irrigation timing such that the resulting water stress has less of a negative impact on grain yield. Previous NE research on the concepts of moisture conservation from dryland no-till ecofallow (Burnside et al., 1980) and the timing of limited irrigation (Garrity et al., 1982; Klocke, et al., 1989; Maurer et al., 1979) were combined in a project at North Platte, NE in the 1980's (Hergert et al, 1993; Schneekloth et al., 1991). Yields with 6 inches of irrigation for winter wheat (*Triticum asetivum* L.), corn (*Zea mays* L.) and soybean (*Glycine max* L.) were 99%, 86% and 88% of the fully irrigated yields (Hergert et al, 1993).

The western portion of the Central Great Plains is defined as the High Plains region. It presents challenges when converting to limited irrigation compared to eastern portions of the Great Plains because of lower rainfall, sandier soils and higher elevation. Alternative crops that use less water than corn and are adapted to this region include winter wheat, chickpea, canola, camelina, crambe, dry beans, sunflower, dry or forage pea, and millets and forage sorghums. Grain sorghums often do not perform because of lack of cold tolerance or inability to mature before killing frost. These crops use 16 to 18 inches of ET versus 23 to 25 inches for corn in the NE panhandle.

METHODS AND MATERIALS

Based on earlier research with limited irrigation at North Platte, NE experiments were initiated at Scottsbluff, NE in 2005. The soil is a Tripp very fine sandy loam (Coarse-silty, mixed, superactive, mesic Aridic Haplustolls) with a pH of 7.8 and an organic matter content of 1.2**%.** Slope ranges from 0.8 to 1.5%. Plant available water holding capacity of this soil is 1.5 in/ft for the 0 to 4 foot normal rooting depth. The 30-yr average precipitation at Scottsbluff (elevation 3900 ft) is 15.5 in with a mean annual temperature of 48^0 F. The frost-free period (50% probability) is 125 days. The primary objectives of this experiment were (1) to determine yields from limited-irrigated corn, winter wheat, dry beans and canola grown in a no-till cropping system versus full irrigation and (2) to determine the agronomic feasibility and problems encountered in using no-till on crops that have primarily been grown under conventional full tillage in this area.

The cropping system initially included winter wheat, corn, and dry beans (*Phaseolus vulgaris*) grown under no-tillage. In 2006, spring canola (*Brassica napus*) was added following wheat. This provided a cropping system with two grass crops and two broadleaf crops. Inclusion of canola also allowed for more timely planting of winter wheat. Canola is harvested in August. Planting winter wheat after dry beans is a challenge some years due to late maturity of the beans which delays wheat planting beyond optimum time (mid-September) and affects wheat stand and ultimate yield potential, especially under full irrigation.

Each phase of the rotation is present each year under a linear move sprinkler irrigation system. A randomized complete block design with four replications was used. The irrigation levels for the crops were 4, 8 and 12 inches per crop per growing season. In 2007, the irrigation levels for the corn were changed to 5, 10 and 15 inches. The highest irrigation level was designed to be near the long-term average non-ET limiting irrigation. Individual plots are 40 ft by 70 ft. All crops were surface planted with no-till equipment. A Monosem® planter fitted with finger-spoke disk furrow openers and a single-disk starter fertilizer attachment 2 in to the side of the row were used for corn and dry beans. A no-till drill was used to plant winter wheat and canola (7.5 in row spacing). Plant populations for dry beans (96,000/ac), canola (7 lb/ac) and winter wheat (110 lb/ac) were the same for all water levels, but were modified for corn based on prior research. Corn plant populations for the low, medium and high irrigation levels were 16,000/ac, 24,000/ac and 32,000/ac.

The lowest level limited irrigated corn was usually not irrigated until tassel emergence based on conclusions from Maurer et al. (1979) but in extremely dry years (2007 and 2008) some water was applied earlier. Irrigations of 1 to 2 in per week approximating farmer practice were applied from late vegetative stage until water was used. For the medium irrigation level, irrigation was started earlier in the vegetative period. Similar strategies were used for winter wheat. For canola at the lowest water level, irrigation was applied during flowering and early pod-fill as noted periods of stress sensitivity (Nielsen, 1997). For higher levels irrigation began earlier and was extended through pod-fill.

For dry bean, the lowest irrigation level presented a management challenge as there was not published information on irrigation timing for limited water. After our first two years, we learned that we could not withhold water until the reproductive period because it slowed development and delayed maturity which significantly reduced yield. After 2007, we applied limited amounts of irrigation (usually ½ in per week) beginning about 50% cover to keep the crop growing and developing with limited stress. Irrigation was usually completed just as pod-fill began. Irrigation scheduling was modified depending on rainfall, but during this experiment with drought in 2006 through 2008, that was not a consideration during the high water use periods except during 2005 and 2009. Rainfall for the five years was: 2005: 19.6 in; 2006: 13.3 in; 2007: 8 in; 2008: 11" and 2009: 19.76 in.

Herbicides were selected to provide optimum weed control in the current crop without carryover that would injure the next crop. Roundup®-ready corn and canola were used. Plots were routinely scouted during the summer for insect problems. Helix seed treatment was required for canola to protect against flea beetle but no other insects were a problem. Because of the crop rotation there were not major insect problems in the other crops and plant diseases were not a problem. There was some spider mite infestation on corn, but it did not reach economic thresholds that required treatment.

RESULTS AND DISCUSSION

Wheat Yields

Winter wheat yields are shown in Table 1. For the initial year (2005) spring wheat was planted as the plot area was in corn during the fall of 2004 so winter wheat could not be planted. Spring wheat was planted early, stands were excellent but the low yields compared to what we can grow using winter wheat show why irrigated spring wheat is not an economically viable option for the panhandle.

Table 1. Wheat yields at Scottsbluff.

	2005*	2006	2007	2008	2009**
Irrig	------Bushels per acre------				
0 in	40	45	20	25	50
4 in	53	83	45	55	58
8 in	58	91	75	78	72
12 in	57	100	100	99	72

*Spring wheat yields, winter wheat 2006 and later.
**Sooty mold and black point reduced yields due to wet conditions

The 0 inch irrigation data is provided only as a comparison and in most cases is a county-average from NE Agricultural Statistic or represents data from companion studies in the plot area that are true dryland. The 0 inch irrigation yields also show that continuous dryland yields in this environment are very low many years, ranging from 0 to only 25% of fully irrigated yields. The average relative yields for the four years of winter wheat were 67% for the 4 in treatment and 88% for the 8 in treatment. Because both 2006 and 2007 were so dry, maximum yields were not attained unless full irrigation was applied. In an 'average' year or wetter year such as 2005 or 2009, the 8 inch irrigation or less would produce near maximum yields.

Relative yield levels were calculated each year and are presented in Figure 1. Over the course of the experiment we have established an upper and lower boundary that hopefully encompasses the range of wet to dry conditions we might see. This information can be used to check against current optimization programs as verification and provide information for economic analysis.

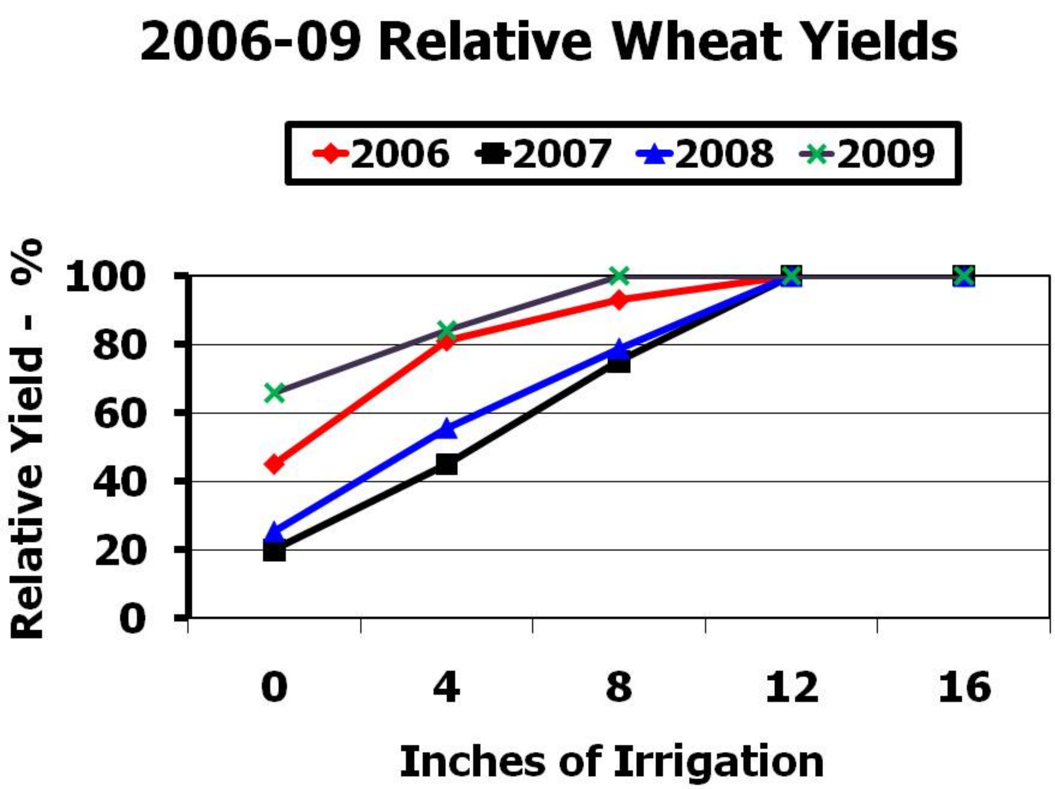

Figure 1. Relative winter wheat yields 2006 through 2009.

Table 2 shows corn yields for the five years. During 2007, a late freeze on June 8 caused severe damage, but plants did recover. Maturity was not affected, but overall yield potential was decreased.

Table 2. Corn grain yields at Scottsbluff.

Irrigation	2005	2006	2007	2008	2009
	----------------Bushels per acre----------------				
0 in	81	30	30	60	90
5 in	133	139	97	115	149
10 in	153	172	139	165	185
15 in	174	188	172	183	194

The average relative yields over five years were 69% for the low irrigation treatment and 90% for the medium treatment. Good yield increases were obtained for the last increment of water for corn which is why most producers try to fully irrigate. Relative corn grain yields are shown in Figure 2.

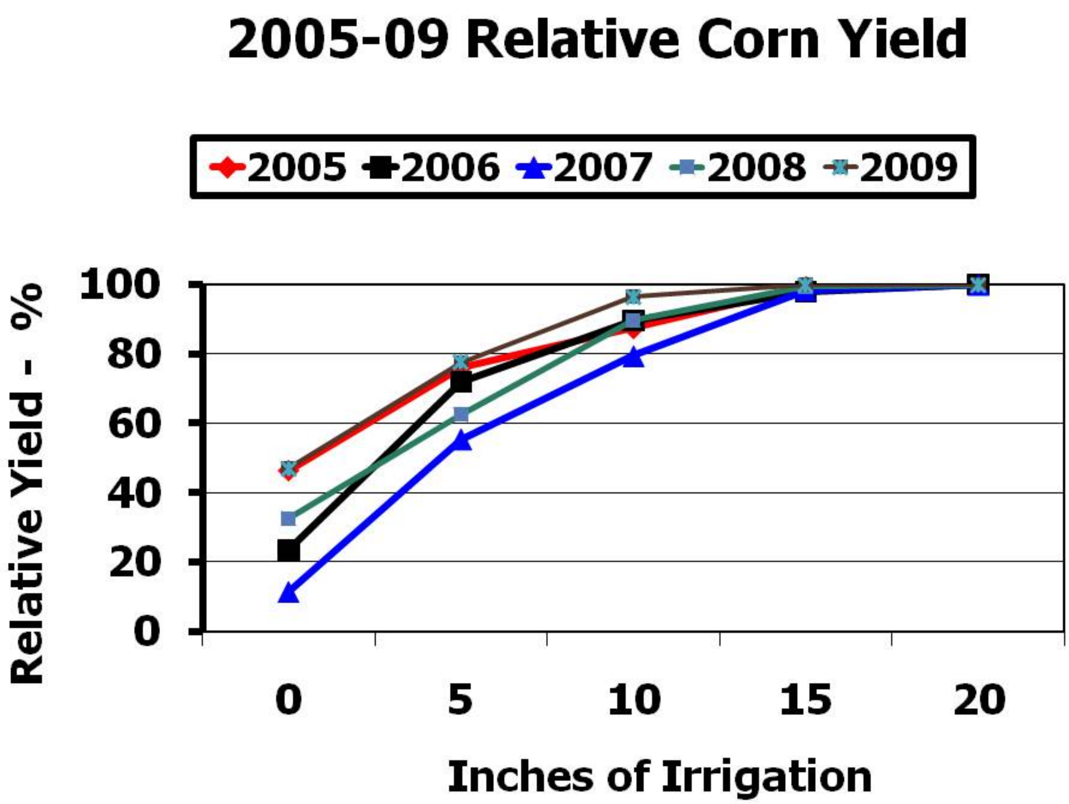

Figure 2. Relative corn grain yields 2005 through 2009.

Dry bean yields are shown in Table 3. During 2006, herbicide damage decreased plant vigor and delayed maturity but because of a warm and late fall beans did mature before frost. Maturity was not affected, but overall yield potential was decreased compared to other years.

Table 3. Dry bean yields at Scottsbluff.

Irrigation	2005	2006	2007	2008	2009
	----------------Pounds per acre----------------				
0 in	1,000	400	300	300	1500
4 in	2,140	1,310	1,050	1562	2280
8 in	2,580	1,560	1,640	1783	2660
12 in	2,560	1,800	2,265	2160	2950

For dry beans, average relative yields over five years were 71% for the 4 in treatment and 87% for 8 in irrigation. As with winter wheat, in more normal years, the 8 in application would normally produce 90% of maximum yields. Relative yields are shown in Figure 3.

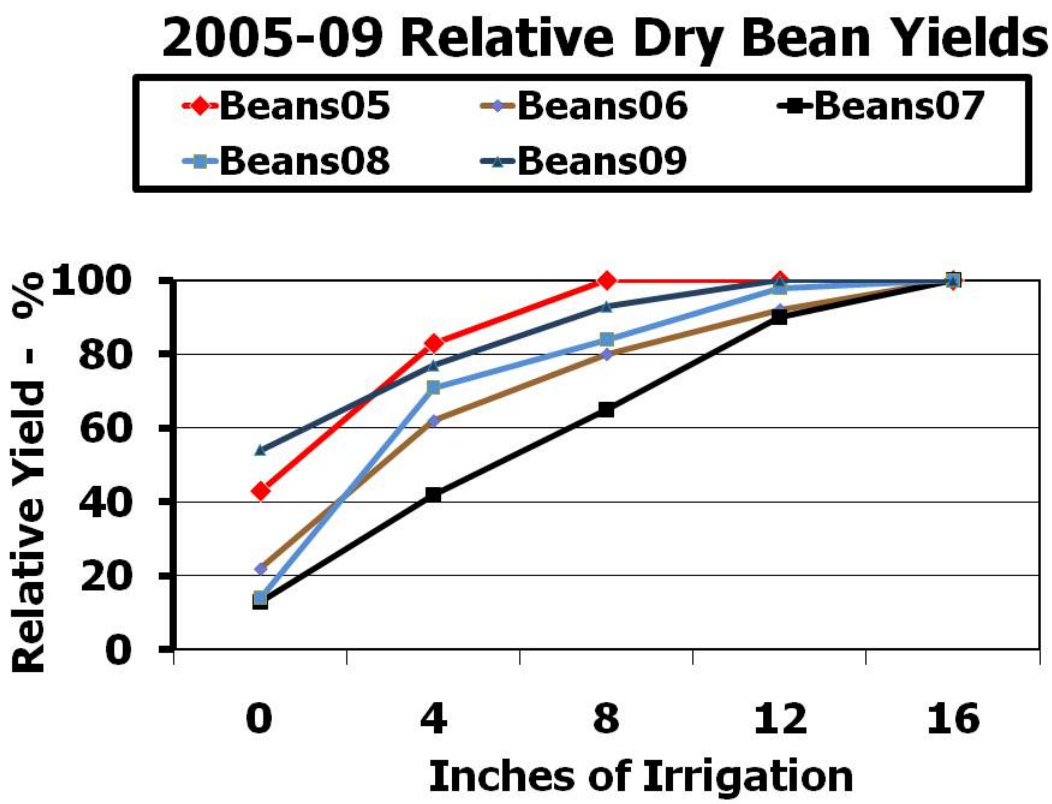

Figure 3. Relative dry bean yields for 2005 through 2009.

Spring canola yields are shown in Table 4. Canola was not grown until 2006. Canola is a new crop for the area and yields did improve after our first learning year determining appropriate cultural practices, especially planting date and irrigation. Yield levels are good for this area and compared to major canola regions in the southern Canadian provinces and the Northern Great Plains but are not as high as could be obtained with winter canola grown in climates with less extreme winters. The problem with winter canola is that it does not fit these rotations well. The only crop it can follow is winter wheat as it must be planted in mid-August. It also is subject to winter-kill about 50% of the time in this area.

Table 4. Spring canola yields.

Irrigation	2006	2007	2008	2009
	----------------Pounds per acre----------------			
0 in	1,000	1,000	300	2450
4 in	2,050	2,040	1562	2650
8 in	2,110	2,485	1783	2630
12 in	2,140	2,740	2160	2650

The average relative yields for canola over four years were 82% for the low irrigation treatment and 92% for the medium treatment. These higher yields reflect the ability of canola to use residual soil moisture from the 3 to 4 foot depths not used by the previous dry bean crop. Soil water data shows that canola effectively roots to 5 feet at this site. Canola has the potential to fit in limited irrigated rotations and is a viable oil seed crop for this region as it produces about twice as much oil per acre than soybean. Relative yields are shown in Figure 4.

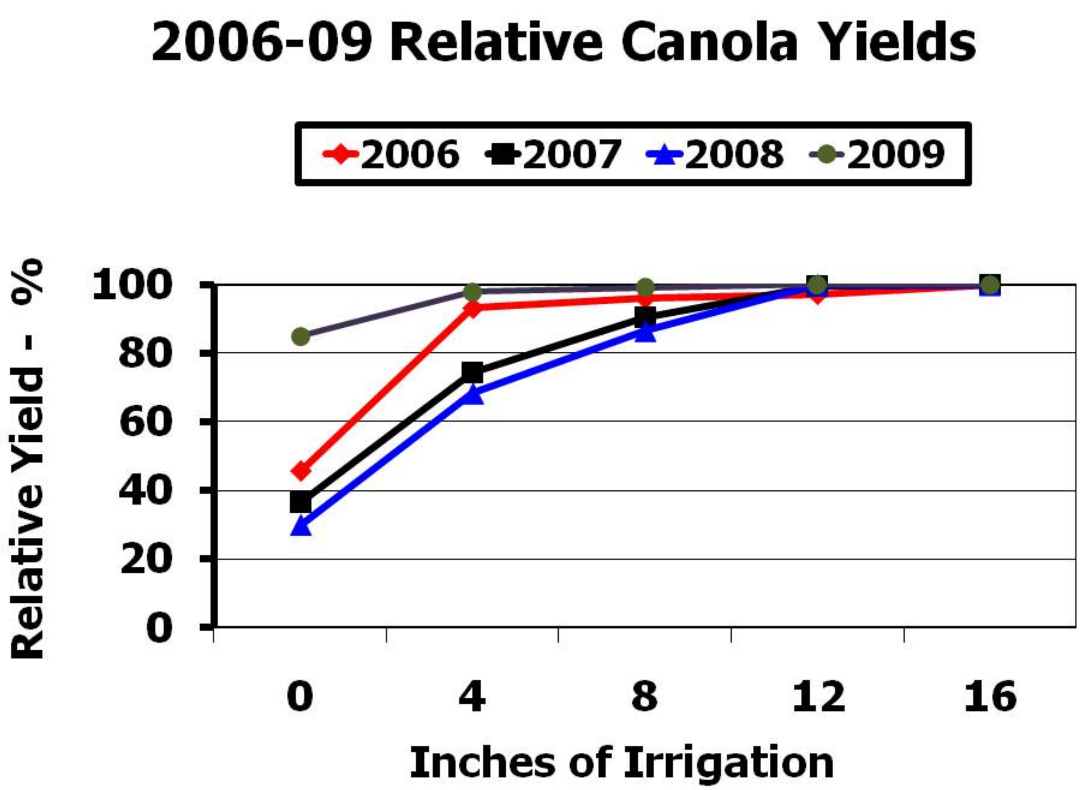

Figure 4. Relative canola yields for 2006 through 2009.

Conclusions

The data confirm much of the previous research on limited irrigation in higher rainfall regimes (Hergert et al, 1993). The shape of the irrigation response functions (relative yield versus irrigation) was generally curvilinear but they were much steeper than those at North Platte. Because three of the five years of this experiment received precipitation that was on average only 66% of the 30-year average, it was a severe test and there were much higher responses between the medium and high irrigation level than in the North Platte research. Winter wheat is a drought tolerant crop, but in this environment (higher elevation than North Platte) it has a 20% higher yield potential and will respond to additional water to reach that maximum yield level. At the lowest irrigation levels, most crops yields were only 45-50% of maximum yield except canola which produced at 76%. At the medium irrigation level corn, dry beans and wheat produced 70-75% of maximum yield whereas canola produced 90%. The data provide an excellent basis for determining the economic value of irrigation water and show the potential of no-till limited irrigated systems to sustain higher levels of productivity than most producers would deem possible with much less water than they have become accustomed to.

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