Nitrogen Response of Irrigated Sunflowers – 2007

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Introduction: Research in the area of nitrogen response of irrigated sunflowers is limited. Much of the work has been done in rainfed production where yield potential of the crop may be limited due to water stress during the growing season. Zubillaga et al. (2002) found that yield of rainfed sunflowers increased with the addition of fertilizer. The yield of sunflower increased to the maximum amount of N applied (138 kg/ha). Yield content generally decreased with the addition of nitrogen which resulted in similar total oil production for all nitrogen rates. This work was done in a highly productive region with precipitation during the growing season being greater than 450 mm. Within these regions and precipitation patterns, nitrogen may be leached and unavailable to the plant which may be different than that of the High Plains where precipitation is generally limited. Mathers and Stewart (1982) found increasing yields of sunflower with smaller amounts of nitrogen applied and then a small decline in yields with additional fertilizer. Oil content of sunflowers also decreased with the addition of nitrogen. This was done with very limited amounts of water which would prevent observed wilting of the crop. This limited amount of water may have limited the yield potential of sunflowers, which would mask the response of nitrogen. Vigil (2000) observed no yield response of sunflowers to nitrogen during years of limited precipitation. Vigil did observe one year where yield of sunflower did respond to nitrogen but only when the yield potential was greater than 2000 kg/ha. He found that rainfed sunflowers have the ability to utilize soil residual nitrogen from depths beyond 1 meter that most crops cannot access.

Irrigated production in the Central Plains has the ability to produce greater yields as compared to rainfed production. Schneekloth (2005) found that irrigated sunflowers can produce 50% greater yields with full or limited irrigation when timed appropriately. In years with below average precipitation and less than adequate beginning soil moisture, irrigation increases yield by 100 to 200% of rainfed yields. Additions of water early in the growth cycle tend to decrease oil content as compared to rainfed production. However, withholding irrigation until the later reproductive growth stages can increase oil content as compared to rainfed production.

A gap in research for irrigated production of sunflowers and nitrogen management exists. All of the fertility work has also been with fertility applied at planting. With many irrigation systems, the ability to apply nitrogen during the growing season is a possibility and has the potential to increase nitrogen use efficiency and reduce applications.

Methods and Procedures: An irrigated site at Burlington, Colorado was established with a crop rotation of winter wheat, corn, sunflower and soybean. This site included 3 irrigation management strategies for each crop varying full irrigation management to a limited allocation. Currently, the average annual allocation for all crops will be at 9 inches with more irrigation allocated for irrigated corn production (12 inches) and less for wheat, sunflower and soybean (9, 5 and 9 inches respectively). Limited irrigation management will follow strategies developed by Colorado State University and the University of Nebraska for each of the four crops. In 2009, the site was moved to Akron, Colorado. Irrigation management strategies were full irrigation management and an annual allocation of 5 inches.

Within each of the pie shapes treatments, nutrient management strategies and rates will be randomized in a randomized complete block design. Nitrogen rates of 0, 75, 150 and 225 lbs per acre were applied at planting as 32-0-0. Two alternative strategies that will simulate Fertigation will be utilized by splitting applications of nitrogen during the growing season at two different rates. These rates were 0 or 75 lbs N pre-plant with 75 lbs N applied at R3. Chlorophyll readings were taken at the R1 growth stage for full irrigation sunflowers. Soil samples were taken prior to planting and post harvest to determine the nitrogen uptake by sunflowers at each of the nitrogen rates. Soil sampling depths include 0-6 inches, 6-24 inches and 24-36 inches. In 2009, soil samples an addition sample of 36 to 48 inches was included for deeper soil nitrogen. This will also allow for the understanding of the potential reduction of nitrogen within several depths of the soil.

Grain yields were taken by harvesting two rows for a total row length of 12 feet. These samples were thrashed and analyzed for moisture, seed size and oil content.

Results: Weather conditions for Burlington were near average for precipitation in 2006. Precipitation in 2007 was below average. Good growing conditions resulted in better than average yields in 2006 and lower yields in 2007. Maximum grain yields were greater than 3000 lbs per acre for both allocation and full irrigation. Grain yields increased with increasing nitrogen to 150 lbs per acre Nitrogen (Table 1a and 1b). Grain yields were maximized with 150 lbs of nitrogen applied pre-plant for both allocated and full irrigation sunflowers. Grain yields increased approximately 400 and 500 lbs per acre from 0 to 150 lbs per acre for allocated and full irrigation respectively. The first 75 lbs of N did not greatly increase yields as compared to 0 lbs N for full irrigation (70 lbs per acre) while yields for allocated irrigation increased approximately 200 lbs per acre Applications of N above 150 lbs per acres resulted in similar or lower yields for both allocated and full irrigation. Grain yields for 0 and 75 lbs N were greater for allocated irrigation as compared to full irrigation sunflowers in 2006 and greater for full irrigation than allocated irrigation in 2007. Precipitation in 2009 was above average and temperatures were below average. In 2009, additions of pre-plant nitrogen decreased yield as compared to no nitrogen additions. Late season applications of nitrogen did increase yield as compared to the application of similar pre-plant nitrogen applications.

Splitting nitrogen applications or applying nitrogen during the early reproductive growth stages increased grain yields. Splitting 150 lbs of N between pre-plant and post resulted in similar yields as compared to applying the entire N pre-plant. However, applying 75 lbs N post in allocated irrigation resulted in similar yields as compare to 150 lbs of N pre-plant in the allocated irrigation. Applying 75 lbs N post for full irrigation did not maximize grain yields but was greater than applying 75 lbs N pre-plant in 2006 and similar yields in 2007. In 2009, splitting applications of N resulted in greater yields as compared to all pre-plant applications with the similar amount of total N applied.

Oil content of sunflowers decreased with addition of nitrogen (Table 2). This is similar to previous work. Oil content decreased by 1.5 to 3% for 225 lbs of N applied as compared to 0 lbs N. Late season applications of N also generally suppressed oil content as compared to similar nitrogen rates applied pre-plant. Nitrogen applications did not affect seed size (Table 3).

Chlorophyll readings of full irrigation sunflowers at or near R1 growth stage indicated less nitrogen in the leaves for all fertilizer rates as compared to 225 lbs N applied (Figure 1). Chlorophyll readings increased with increasing nitrogen applied pre-plant. For corn, a relative reading of less than 95% indicates that nitrogen may be limiting for production. Only the 150 lb pre-plant application was above the 95% threshold. This threshold appears to have maximized grain yields without corrective additions of fertilizer. Readings less than 95% resulted in lower grain yields without additional N applied.

Residual Soil Nitrogen: Soil samples were taken spring and fall for allocated irrigation sunflowers. Spring soil samples for full irrigation were taken but fall samples were not taken at this time. They will be sampled in the spring of 2008.

Spring residual soil nitrogen averaged 62 lbs per acre for the allocation treatments (Figure 2). Fall residual showed that application of 75 lbs per acre N or less resulted in nitrogen reduction in the 3 foot sample. The reduction in N averaged 37 to 47 lbs per acre as compared to spring soil residual. Applications of 150 lbs N had similar soil residual in the fall as compared to spring. Applications of 225 lbs N resulted in an increase of 75 lbs per acre residual N.

Residual soil nitrogen by depth is shown in Figure 2. Applications of 75 lbs per acre N or less resulted in reduced nitrogen amounts in each of the 3 sample depths to 3 feet. Applications of 150 lbs N per acre resulted

in increases in residual N in the 0 to 6 inch sample but reductions in the 6 to 24 and 24 to 36 inch samples. Applications of 225 lbs N per acre increased residual N in the 0 to 24 samples. A split application of 75 lbs pre-plant and 75 lbs reproductive resulted in increase N in the 0 to 6 inch sample with similar N in the 6 to 24 inch sample. All application rates resulted in reduced N in the 24 to 36 inch sample. Applied nitrogen appeared to not leach past the 24 inch sample depth due to irrigation management.

Spring residual soil nitrogen averaged 88 lbs per acre in 2009 (Figure 3). Applications of N up to 150 lbs per acre resulted in reductions in residual N by 20 to 60 lbs N per acre for allocation irrigation. Increasing N applications resulted in less N removal. Pre-plant applications of 225 lbs per acre resulted in increases of N residual by 5 lbs per acre. However, an increase in the 6 to 24 inch soil depth was reported with decreases in all other depths. Application of 75 lbs N at the R1 growth stage resulted in similar or greater soil residuals in the fall compared to spring in the 6 to 24 depth with overall decreases in N residual. These results were similar in the full irrigation management as well.

Conclusions: Grain yields for sunflowers increased with nitrogen. In 2006 and 2007, grain yields were maximized with applications of 150 lbs of N pre-plant. However, the economics of nitrogen applications was marginal at today's price of N. With limited irrigation, late season applications of nitrogen appear to have added benefits to yield as compared to pre-season applications. Water management practices appear to impact the economic application of N. However, in 2009 pre-plant applications of N decreased grain yields as compared to 0 N. Applications of 75 lbs at R1 growth stage did result in yields equal to or greater than 0 bls N. When irrigation is limited in the vegetative growth stage, application of N greater than 75 lbs per acre did not increase revenues. However, when full irrigation practices are used, applications of 150 lbs per acre generated the greatest returns.

Table 1a. Grain yields for nitrogen rates for allocation irrigation sunflowers.

	Grain Yield (lbs/acre)			
N Rate	Year			
lbs/acre	2006	2007	2009	Average
0	2784	2335	2722	2614
75	2804	2779	2607	2730
150	3085	2736	2393	2738
225	3037	2726	2347	2703
75+75	3180	2848	2823	2950
0+75	3099	2694	2739	2844

Table 1b. Grain yields for nitrogen rates for full irrigation sunflowers.

	Grain Yield (lbs/acre)			
N Rate	Year			
lbs/acre	2006	2007	2009	Average
0	2597	2472	2641	2570
75	2670	2532	2371	2524
150	3073	2941	2485	2833
225	2274	2785	2151	2403
75+75	3035	3045	2505	2862
0+75	2823	2514	2614	2650

Table 2. Oil content for nitrogen rates for allocation and fully irrigated sunflowers

N Rate lbs/acre	Oil Content (%) 2006		2009	
	Alloc	Full	Alloc	Full
0	50.4	50.5	48.5	50.2
75	50.1	50.4	48.2	50.2
150	49.4	50.0	47.2	48.9
225	48.7	48.9	45.7	48.7
75+75	48.5	50.0	47.4	50.1
0+75	49.3	49.5	46.6	48.7

Table 3. Seed size for nitrogen rates for allocation and fully irrigated sunflowers (2006).

Nitrogen Rate lbs/acre	Seed Size g/100 seed	
	Alloc	Full
0	9.4	9.3
75	8.7	9.0
150	10.4	9.1
225	10.1	8.4
75+75	9.5	10.5
0+75	9.5	8.8

Figure 1. Chlorophyll readings of full irrigation sunflowers relative to 225 lbs of N applied.

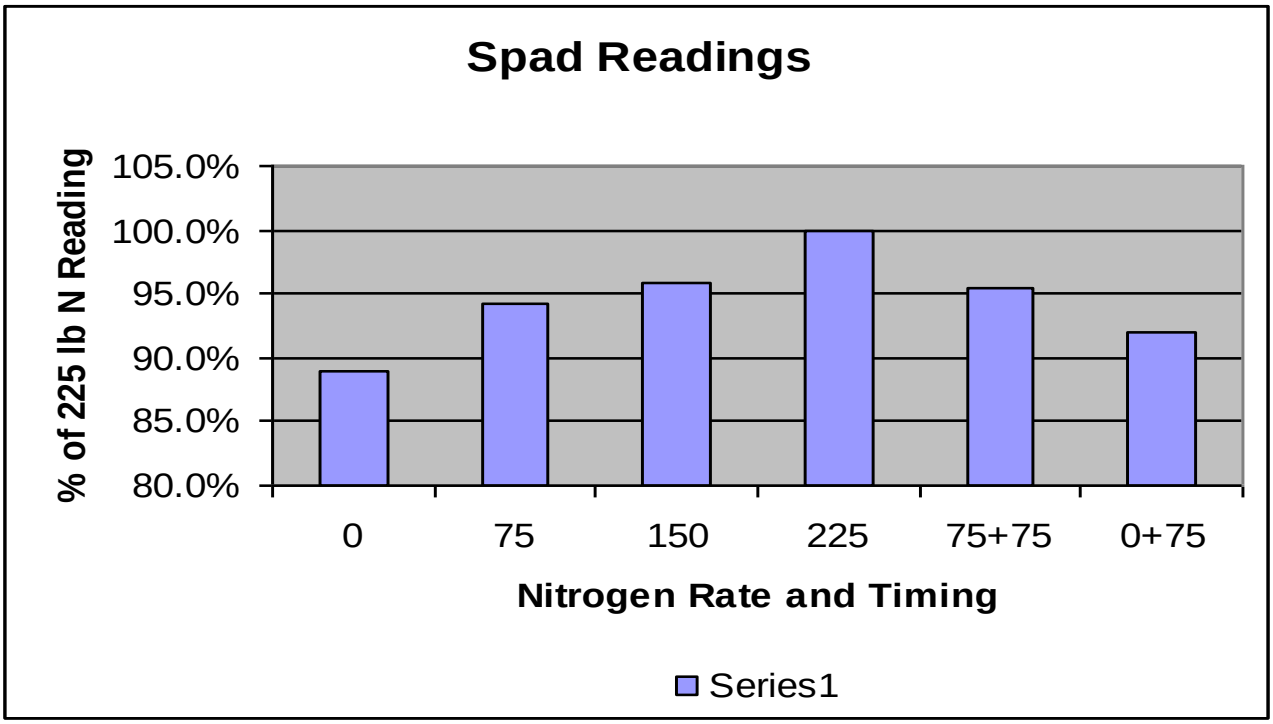

Figure 2. Residual soil nitrogen for allocation irrigation sunflowers 2006.

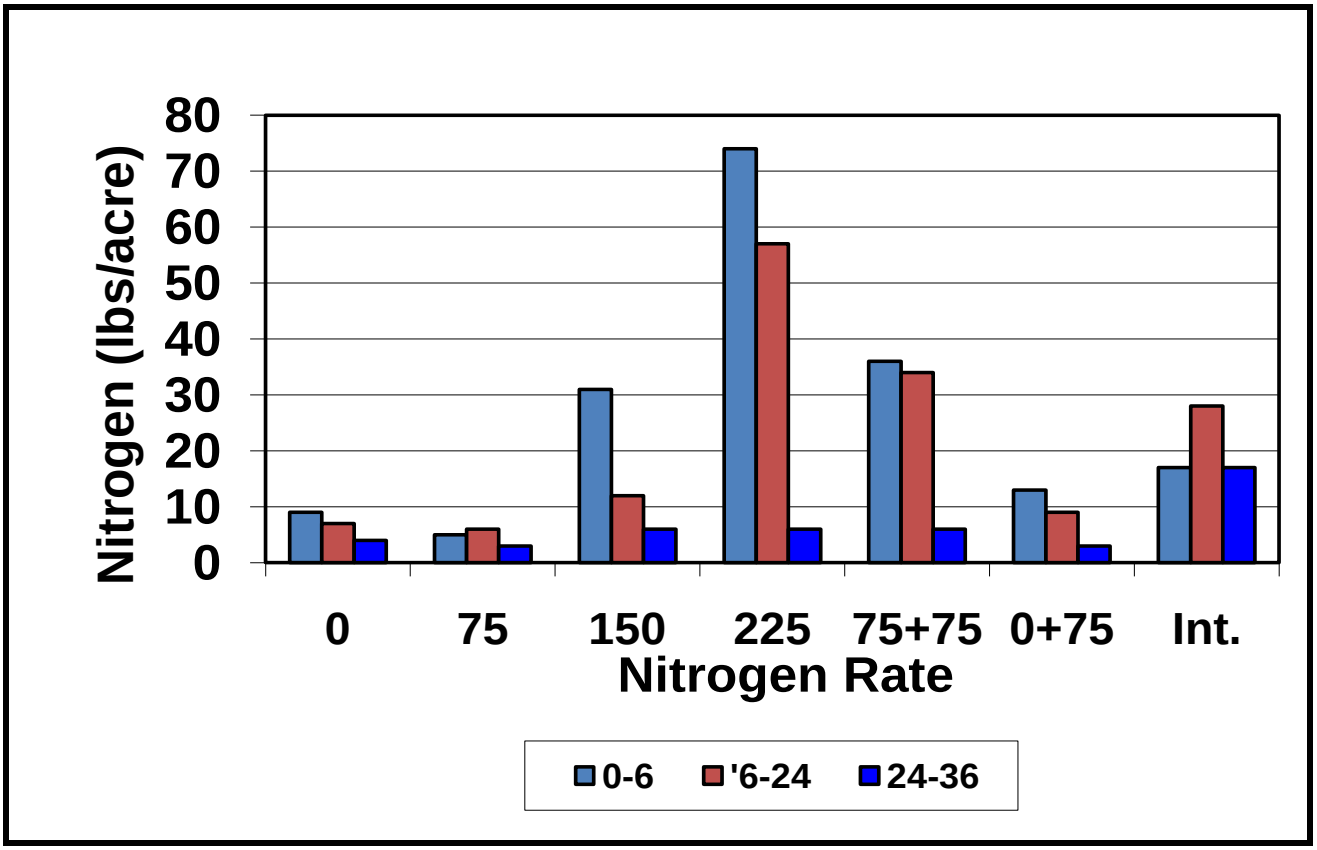

Figure 3. Residual soil nitrogen for allocation irrigation sunflowers 2009.

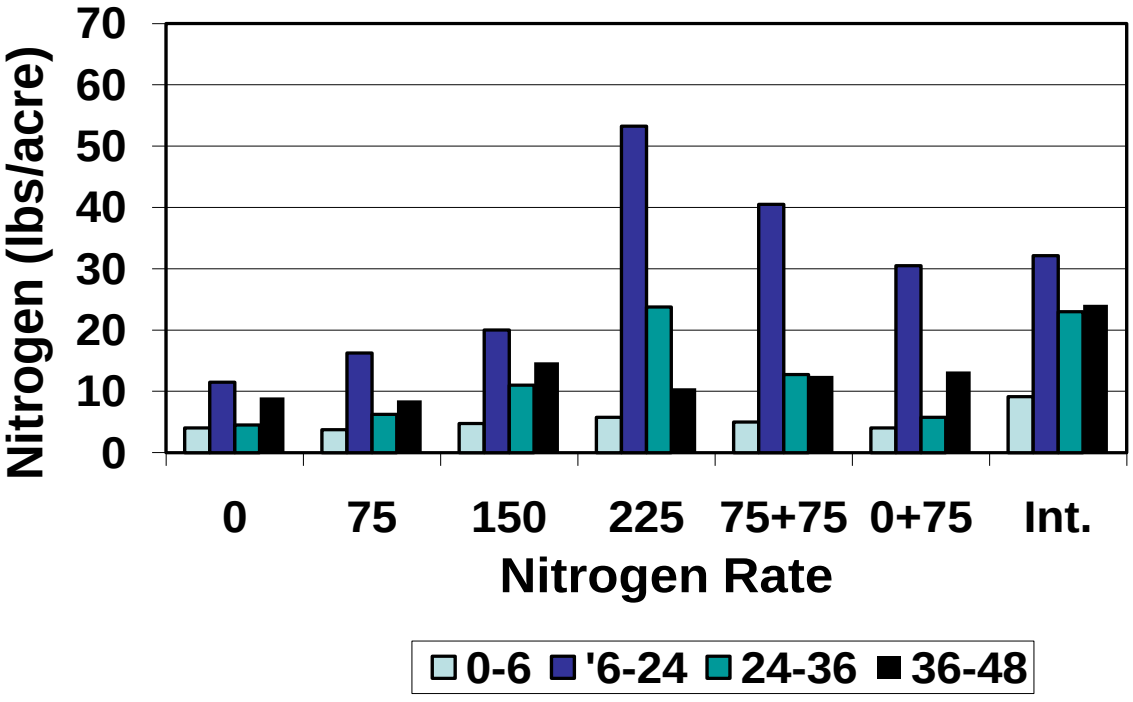

Figure 4. Residual soil nitrogen for full irrigation sunflowers 2009