RESPONSE OF IRRIGATED SUNFLOWERS TO WATER TIMING

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INTRODUCTION

With declining water supplies in the Central Great Plains Region, conservation of water is an important issue for producers. Many areas have reported declining groundwater levels for 20 or more years within Colorado, Kansas and Nebraska. As groundwater levels decline, well output has declined in some regions to the point that systems are limited in their capability to fully irrigate a single crop under the entire system. When producers are faced with this situation, they are faced with only being able to limit irrigate a single crop or they must irrigate two or more crops under a single system and properly time the water needs of each crop. Sunflowers are a crop that has been proven to be beneficial to dryland producers because of its drought tolerance. However, little is known about the responsiveness of sunflowers to limited water and the timing of water needs for that crop.

Methods and Materials

The experimental site was at the U.S. Central Great Plains Research Station at Akron, CO. Soil was a Weld silt loam (fine, smectitic, mesic, Aridic Argiustolls) with a plant available water holding capacity of 2 inches per foot. The previous crop was rainfed corn in 2003. The irrigated sunflowers were planted May 25, 2004 no-till into the corn stubble. The varieties planted were Triumph 658 Nu-Sun for oil and Triumph 765C for confectionary. Planting rates were 26,000 seeds per acre for oil and 24,000 for confectionary in 30 inch rows. Fertilizer application was 100 lbs/acre of nitrogen and 30 lbs/acre of phosphorous. Furadan was applied at 1 quart per acre in-furrow at planting for stem weevil control. Herbicide application was Spartan at 2 oz/acre, prowl at 2 pt/acre and Round-up at 20 oz/acre applied two weeks before planting and hand weeding for escape weeds.

A split-plot design was used for this experiment with timing of water application being the main plot with sunflower type (oil vs confection) as the sub-plot. Main

plots were 15 ft (6 rows) by 130 feet with sub-plots 65 feet long. Water was applied with a surface drip system on 60 inch centers. The application rate of the system was 0.08 inches per hour and operated to apply 0.8 to 1.0 inches per application. Soil moisture was monitored weekly with the neutron attenuation method to a depth of 5 feet in 1 foot increments for each treatment. Plots were hand harvested on October 7, 2003. The middle two rows were harvested for a total row length of 20 feet.

RESULTS

Weather and Irrigation Amounts

Precipitation during the three year period ranged from excessively dry in 2002 to slightly above normal in 2003. Precipitation for the cropping year of 2004 was characterized by normal precipitation for the cropping season (Table 1). Precipitation for the cropping year was 84% of average. Precipitation from Oct 2003 to June 2004 was 63% of average. Precipitation during June 200 to September 2004 was 103% of average. Precipitation during 2002 was below normal during the entire growing season. Non-growing season precipitation was 33% of normal with growing season precipitation being 80% of normal. Precipitation during 2003 was typified by above normal precipitation during the non-growing season and below normal precipitation during the growing season.

Irrigation amounts for 2002 to 2004 are reported in Table 2. Total irrigation in 2004 was the greatest due to a 3 inch pre-irrigation to increase beginning soil moisture. Irrigation amounts in 2002 and 2003 were similar although total precipitation was less in 2002.

Grain Yield

Grain yields for confection and oil sunflowers are reported in Table 3 and 4. Grain yields for confection and oil generally increased as the amount of water applied increased. Maximum yields for confection sunflowers occurred with irrigation prior to the R5 growth stage. Yields for Full Water, R1-R5, and R4-R5 irrigation strategies were similar in 2003 and 2004. However, in 2002, lack of beginning soil moisture reduced yields for the R4-R5 irrigation strategy as compared to the full water or R1-R5 irrigation strategies. Withholding irrigation until after the R5 growth stage resulted in reduced grain yields as compared to irrigation early but was greater than dryland management.

During years with adequate soil moisture such as 2003, irrigating during any early reproductive growth stage had similar years with a tendency for irrigation during the R1-R5 growth stages being advantageous. During years with marginal soil moisture, irrigation during the vegetative growth stages increased yields slightly, but no significantly. However, during years with inadequate soil

moisture such as 2002, irrigation during the vegetative or early reproductive growth stages increased yields.

Grain yields for full water oil sunflowers were greater than all other strategies two of three years. Only in 2003, when stored soil moisture was adequate, were grain yields for all irrigation strategies equal. Grain yields for the R1-R3 irrigation strategy were significantly lower than all other irrigation strategies in 2004. Irrigating during the early reproductive growth stages had a tendency to create unfavorable growing conditions for the plant later in the growing season that resulted in the lower yields. Irrigation management strategies of R1-R5 and R4-R5 had equal yields which were slightly greater than the R6-R7 growth stage. Withholding irrigation until the R6 growth stage was after the yield determination growth stage for irrigated oil sunflower.

Irrigation Water Use Efficiency

How efficient each irrigation strategy was is important in limited water management. Irrigation water use efficiency (IWUE) is defined as the following:

$$IWUE = \frac{\text{Irrigated Yield} - \text{Rainfed Yield}}{\text{Irrigation Amount}}$$

The IWUE shows how efficient irrigation water applied during each growth stage was converted to grain yield. A higher IWUE indicated each inch of irrigation applied was converted to more grain production.

Maximum IWUE for oil sunflowers occurred when the crop was irrigated during the R4-R5 growth stages (Table 5). Each inch of water applied at this growth stage was converted to approximately 244 lbs/acre-in of seed for 2002 to 2004. Only in 2002 did the R4-R5 growth stage not have the greatest IWUE. Irrigation during the R6-R7 growth stage had the next highest IWUE with Full Water management having the lowest IWUE for 2002 to 2004

Maximum IWUE for confection sunflowers occurred when the crop was irrigated during the R4-R5 growth stages (Table 6). Irrigation water use efficiencies for R1-R5 and R1-R3 strategies were similar with approximately 130 lbs/acre-in increase in yield. Full water and R6-R7 management strategies resulted in the lowest IWUE on average. Irrigation after the R6 growth stage was to late to significantly increase yields while irrigation during the vegetative growth stage was not as efficient as waiting until the reproductive growth stages.

The lower IWUE for full water management for both oil and confection sunflower would indicate that irrigation during the vegetative growth stages was not an efficient irrigation strategy for limited water supplies.

Seed Size

Irrigation timing significantly impacted seed size of confection sunflower (Table 7). Irrigation earlier in the growth stages resulted in greater large and jumbo seed size as compared to irrigating after the R5 growth stage. Seed size for the R6-R7 strategy was lower than the early strategies but similar to dryland each of the three years. Seed size for the R4-R5 strategy was similar to full water and R1-R5 strategies in 2003 and 2004 but significantly less in 2002. Stopping irrigation after the R3 growth stage resulted in lower seed size two of the three years. Only in 2003 when soil moisture was adequate did withholding irrigation after the R3 growth stage not reduce seed size.

Oil Content and Production

Oil content of sunflower was significantly affected by irrigation timing (table 7). Delaying irrigation until the R6 growth stage significantly increased oil content each of the three years as compared to the other irrigation strategies. Irrigating during the R4-R5 growth stages increased oil content two of three years. Only in 2004 was oil content of this irrigation strategy significantly lower than full water or dryland oils. Irrigation management strategies that applied water during the early reproductive growth stages generally had lower oil contents. However, ending irrigation at the R3 growth stage significantly reduced oil content as compared to full water management.

Oil contents were greatest in 2002 which was a hot and drier year as compared to 2003 and 2004. Oil contents in 2004 were the lowest in each of the three years with oil contents less than 40% for most strategies. Temperatures during 2004 were lower than average with low temperatures less than 40 degrees F several days.

Total production of oil per acre incorporates yield and oil content (table 8). Average production of oil per acre for 2002 to 2004 was greatest for full water management. If 2002 was not used for the average due to the excessive drought and lack of beginning soil moisture, oil production for full water and R4-R5 management strategies were similar. Although yields for the R6-R7 irrigation strategy were reduced as compared to the full water, R1-R5 and R4-R5 management strategies, oil production was reduced by approximately 150 lbs/acre. The R1-R3 irrigation management strategy produced the lowest amount of oil per acre of the irrigated strategies and oil slightly more than dryland production.

CONCLUSIONS

Total yields of oil and confection sunflower generally increased as irrigation applied increased. However, several water saving strategies have been

identified. Irrigated during the early reproductive growth stage had similar yields and seed sized for confection sunflower as compared to full water management. However, irrigating during the R1-R5 growth stages reduced the amount of irrigation applied by approximately 3.6 inches as compared to full water management. Irrigating during the vegetative and late reproductive growth stages did not significantly increase yields or seed size components. However, irrigation must be continued through the R5 growth stages. Ending irrigation prior to that growth stage reduced grain yield and seed size.

Full water management for oil sunflowers produced the greatest yield and total lbs of oil per acre as compared to all other irrigation strategies. However, the irrigation strategy of R4-R5 produced only slightly less yield and lbs of oil per acre. The irrigation strategy of R4-R5 required approximately 6 inches less irrigation. If water is limited, this irrigation strategy may be economically viable due to the potential of increasing irrigated acres.

Table 1. Growing year precipitation from October to September 2002 to 2004.

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug	Sep.
	Inches											
2001-02	0.63	0.78	0.00	0.09	0.06	0.08	0.50	0.55	1.71	0.10	3.44	1.50
2002-03	1.04	0.39	0.03	0.22	0.41	2.34	2.47	4.05	4.34	0.90	1.54	0.26
2003-04	0.00	0.12	0.20	0.32	0.39	0.69	1.37	1.89	2.50	1.74	2.85	1.67
Average	0.90	0.55	0.40	0.33	0.34	0.83	1.64	2.96	2.45	2.67	2.08	1.23

Table 2. Irrigation amount for irrigation strategies.

	Dryland	R6-R7	R4-R5	R1-R3	R1-R5	Full Water
Year	Inches of Water					
2002	0	2.6	3.7	4.5	6.4	9.0
2003	0	1.8	3.0	3.8	5.3	9.3
2004	3.0	7.0	6.7	6.0	9.3	13.5
Average	1.0	3.8	4.5	4.8	7.0	10.6

Table 3. Confection Sunflower grain yields (2002 to 2004).

	Average Grain Yields			2002-2004	2003-2004
	2002	2003	2004	Overall Avg	Overall Avg
	lbs/acre	lbs/acre	lbs/acre	Lbs/acre	Lbs/acre
Dryland	299d	2550ab	1193c	1347	1871
R6-R7	688c	2249b	1778b	1572	2014
R4-R5	883bc	2875ab	2063ab	1940	2469
R1-R3	1137ab	2847ab	1797b	1927	2322
R1-R5	1192a	3139a	2173ab	2168	2656
Full Water	1335a	2617ab	2463a	2138	2540

Table 4. Oil Sunflower grain yields (2002 to 2004).

	Average Grain Yields			2002-2004	2003-2004
	2002	2003	2004	Overall Avg	Overall Avg
	lbs/acre	lbs/acre	lbs/acre	Lbs/acre	Lbs/acre
Dryland	468d	2387b	967d	1274	1677
R6-R7	771cd	2540ab	1956bc	1756	2248
R4-R5	1022bc	3031a	2297bc	2117	2664
R1-R3	1327b	2530ab	1803c	1887	2166
R1-R5	1287b	2701ab	2411bc	2133	2556
Full Water	1981a	2728ab	3147a	2619	2938

Table 5. Irrigation Water Use Efficiency for oil sunflowers (2002 to 2004).

	Average Oil Yield			2002-2004	2003-2004
	2002	2003	2004	Overall Avg	Overall Avg
	lbs/acre-in	lbs/acre-in	lbs/acre-in	lbs/acre-in	lbs/acre-in
R6-R7	117	88	250	174	200
R4-R5	150	215	361	244	295
R1-R3	191	37	283	163	144
R1-R5	128	59	231	143	152
Full Water	168	37	207	140	127

Table 6. Irrigation Water Use Efficiency for confection sunflowers (2002 to 2004).

	Average Oil Yield			2002-2004	2003-2004
	2002	2003	2004	Overall Avg	Overall Avg
	lbs/acre-in	lbs/acre-in	lbs/acre-in	lbs/acre-in	lbs/acre-in
R6-R7	150	-172	148	81	50
R4-R5	158	108	236	171	179
R1-R3	186	78	204	154	133
R1-R5	140	111	157	137	135
Full Water	115	7	120	82	67

Table 7. Seed size and oil content for confection and oil sunflowers.

	Confection Seed Size						Oil Content		
	2002		2003		2004		2002	2003	2004
Irrigation	% Large	% Jumbo	% Large	% Jumbo	% Large	% Jumbo	%	%	%
Dryland	0.4d	0.0d	70.3b	30.9b	29.5c	3.6c	48.5ab	43.9b	36.8b
R6-R7	9.5d	0.2d	70.8b	31.8b	32.8bc	6.5c	49.7a	47.3a	41.4a
R4-R5	22.9c	0.5d	75.0ab	44.7ab	78.0a	35.9b	47.2b	47.7a	35.1c
R1-R3	55.0b	16.6c	80.9ab	43.5ab	45.5b	14.4c	43.3d	41.3c	34.5c
R1-R5	64.2ab	30.2b	82.1ab	49.6ab	85.7a	60.1a	45.2c	43.4bc	34.8c
Full Water	72.2a	48.5a	85.6a	61.8a	78.3a	50.7a	45.3c	42.5bc	37.9b

Table 8. Oil yield for oil sunflowers (2002 to 2004).

	Average Oil Yield			2002-2004	2003-2004
	2002	2003	2004	Overall Avg	Overall Avg
	Lbs oil/ac	Lbs oil/ac	Lbs oil/ac	Lbs oil/ac	Lbs oil/ac
Dryland	227	1047	356	543	702
R6-R7	383	1202	809	798	1006
R4-R5	483	1446	806	911	1126
R1-R3	574	1045	621	747	833
R1-R5	581	1171	839	864	1005
Full Water	897	1160	1193	1083	1176