LIVING WITH LIMITED WATER
SUNFLOWERS AND COTTON AS ALTERNATIVE CROPS

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INTRODUCTION

The extreme heat and drought of 2002 in western Kansas resulted in many disappointing yields and too many outright crop failures in irrigated fields. Many areas in the central great plains experienced the driest year in the last 50 to 100 years, depending on location. Compounding the effect, temperatures were above normal for most of the growing season, particularly so in the first half of the season. Along with drought effects, the above average temperatures during pollination in many corn fields resulted in pollination failure in hybrids that had not previously experienced such problems. While one extreme year does not signal the end of irrigated corn production, prudent producers will adjust their management and repair inefficient sprinkler systems to lessen financial risk if the drought continues. Such steps should enhance profitability in average precipitation years and conserve irrigation water.

This paper reports two years irrigated sunflower (*Helianthus annus*) research with limited amounts of water in northwestern Kansas and to a lesser degree, will discuss irrigated cotton (*Gossypium hirsuitum* L.) production in the southern half of Kansas under limited water conditions. Low capacity irrigation wells, i.e. less than 350 gallon per minute, are becoming more common in western Kansas. These wells typically do not supply enough water to economically produce a full circle of corn. However, these wells are quite adequate for sunflower production. A cooperative field study was conducted in eastern Sherman county, KS in 2001. A replicated plot at the Colby research station was utilized to test water response of semi-dwarf versus standard height hybrids in 2002.

MATERIALS and METHODS, 2001

Plots were established under center pivot irrigation in a producer-cooperator's field approximately eight miles northwest of Brewster, KS. The irrigation treatments consisted of rain-fed dryland or limited irrigation consisting of irrigation for stand establishment, followed by one inch of water each two weeks for a month, then one inch of water per week until growth stage R5, no irrigation during bloom, then one inch of water at R6 and one more at R7. Plots were 10 by 30 feet with four replications in a randomized design. Triumph 545 sunflowers were seeded on May 29, 2001 at a final population of 21,000 plants/a. Weed control was accomplished by cultivation prior to planting and a PPE application of pendimethalin and sulfentrazone. The soil was a Keith silt loam (pH 7.7, O.M.

1.1) with a water holding capacity of approximately 2 inches per foot. Stand counts were made on June 27 and 17.5 feet of one row was hand harvested in each replicate on Oct. 12 and threshed in a stationary threshing unit approximately one week later.

RESULTS and DISCUSSION

Sunflower populations were uniform across all irrigation treatments. Head diameter on the irrigated plots ranged from 6.5 to 8.5 inches while dryland head diameter ranged from 3.5 to 5.5 inches. Precipitation from May 1 through harvest was 10.85 in., which produced 1510 lb./a average dryland yield, while the average irrigated sunflower yield was 2780 lb./a with 8.35 in. of additional water. The limited irrigation yielded 152 lb./a for each inch of irrigation which is in close agreement with work done by David Nielsen and others at the USDA ARS unit at Akron, CO. Irrigated replication 2 yielded only 2490 lb/a due to non-uniform plant spacing (bunching and skips) even though the population was 21,000 plants/a. The remaining three irrigated replications averaged 2880 lb/a, which underscores the need for uniform plant spacing and emergence. Test weight was 28.85 lb./bu for dryland and 31.9 lb./bu for irrigated treatments. Oil content was 51.2 % in dryland and 44.75 % in irrigated treatments. Gross returns, based on a $9.80/cwt cash price plus premium for oil content, were $162.02/a for dryland and $298.29/a for irrigation.

CONCLUSION

The dryland yield in this plot was about 200 to 300 lb./a more than average in the area this year, which would indicate that the amount and timing of rainfall was quite beneficial to yield and oil content. Irrigation increased yield by 152 lb./a per inch of irrigation. Oil content is believed to be the last component developed during seed fill and the lower oil content of irrigated sunflowers relative to dryland prompts the speculation that one more watering at R8 might have increased oil content as well as yield. Plans for 2002 include adding sites at the NWREC in Colby and west of Goodland with expanded irrigation treatments and population treatments, and with more and better observations.

Table 1. Seasonal precipitation for eastern Sherman county, KS

month	May	June	July	Aug.	Sept.	Oct.	Total
2001	3.35*	0.5	3.0	1.5	2.0	0.5	10.85

*2.35 received prior to May 10.

Table 2. Date and amount of irrigation for eastern Sherman co. KS, 2001.

Date	5/31	6/6	6/20	7/5	7/12	7/19	7/26	8/10	8/16	Total
Amount(in.)	0.6	0.75	1.0	1.0	1.0	1.0	1.0	1.0	1.0	8.35

Table 3.
Effect of Irrigation on sunflower yield components at eastern Sherman co. KS.

Treatment	Head dia.[1] Range (in.)	Test wt. Lb./bu	Yield lb./A	Oil %	Gross Return[2] $/A
Dryland(avg)	**3.5-5.5**	**28.85**	**1510**	**51.2**	**162.02**
rep 1		28.5	1570	51.0	
rep 2		28.7	1520	51.2	
rep 3		29.1	1530	51.5	
rep 4		29.1	1430	52.3	
Irrigated(avg)	**6.5-8.5**	**31.9**	**2780**	**44.75**	**298.29**
rep1		32.4	2920	45.1	
rep 2		31.5	2490	45.4	
rep 3		31.0	2900	43.7	
rep 4		32.6	2840	44.8	

[1] Range in diameter in inches of 10 consecutive heads at a random location in plot.
[2] Base price of $9.80/cwt + oil premium of 2% price increase/each 1% oil above 40%.

MATERIALS and METHODS, 2002

Plots were established with surface line source irrigation (soaker hose) at the Northwest Research and Extension center at Colby, KS. The plots were established in a growing, dryland wheat crop which was terminated on 15 May 2002 by glyphosate herbicide application. All plots received a 1.5 in. irrigation on 18 June and 5 July to insure adequate moisture for germination and establishment. Thereafter, control treatments were rain-fed dryland while the limited irrigation treatments were scheduled to maintain soil water content above 40 % using the KanSched irrigation scheduling software (Kansas State University) and data from the weather station on the Colby research station. Two identical irrigated treatments were maintained until 3 Sept. when the late irrigation treatment was given 1in. more water. Triumph 545A (standard height) and Triumph 567DW (semi-dwarf) sunflowers were seeded on 18 June, 2002 at a final population of 17,500 plants/a. This was less than desired (24,000plants/a) due to extreme drought and grasshopper pressure. Weed control was accomplished by a PPE application of pendimethalin (32 oz/a) and sulfentrazone (3 oz/a) and hand hoeing. The soil was a Keith silt loam (pH 7.7, O.M. 1.1) with an available water holding capacity of approximately 2 inches per foot. Stand counts were made on 2 July and 17.5 feet of two rows were hand harvested in each replicate on 24 Sept. and threshed in a stationary threshing unit approximately two weeks later.

RESULTS and DISCUSSION

Sunflower populations were uniform across all irrigation treatments, but had uneven spacing between plants characterized by four to five 2 ft. skips per 100 ft. of row. Head diameter on the irrigated plots ranged from 6.5 to 8.5 in. for 545A and 8 to 9 in. for 567DW while dryland head diameter ranged from 3.5 to 5.5 inches. Precipitation from 12 May through harvest (24 Sept.) was 9.39 in. When combined with 3.0 in. of irrigation the dryland control plots averaged 708 lb./a (545A) and 1719 lb/a (567DW). The early termination (R-7) treatment produced 1205 lb./a (545A) and 2356 lb/a (567DW) with 9.6 in. of irrigation plus 9.39 in. rainfall. The late termination (R-8) treatment produced 1530 lb/a (545A) and 2515 lb/a (567DW) with 10.6 in. irrigation and 9.39 in, rainfall. The cumulative Evapo-Transpiration(ET) for this crop location was calculated by KanSched software (KSU) as 28.84 in. which leaves a 8.6 to 9.7 in. moisture deficit. The soil at planting time was too dry to allow penetration of a steel rod probe. The soil moisture content prior to irrigation is assumed to near permanent wilting point within the top three feet of soil. After 3 in. of irrigation just after planting , which all plots received, the steel rod probe penetrated to a depth of 42 to 46 in. It is estimated that the soil profile from three to six ft. contained as much as three in. available water for crop growth. The 2002 growing season was about 5°F. hotter average and precipitation was 5 to 7 in. less than average. The plots were not sprayed for insect control. While head moth damage was slight, stem weevil, *Cylindrocopturus adspersus*(LeConte), and stem borer, *Dectes texanus* (leConte), pressure was heavy. Hybrid 545A had 25 % lodging and the majority of pith eaten away in the lower 2 ft. of stem. Hybrid 567DW had less than 5 % lodging and less than one ft. of the lower stem pith eaten. Recent research by Rob Aiken at Colby indicated that yields are reduced 600 to 1200 lb/a by not controlling stem pests. Notably, examination of 30 stems of each hybrid revealed no spotted stem weevil larvae in 567DW compared to about 25 per stem in 545A (data not shown). Soybean stem borer larvae were found in both hybrids equally. Hybrid 545A matured about 10 days earlier than 567DW, which may have been a result of the differences in stem weevil pressure. Also, deer and bird predation of 25% in 545A and 10% in 567DW was recorded. Again, the difference in maturity date could account for the predation difference. The lodging difference could be partially due to maturity, partially due to less insect damage to the interior of the stalk and partially due to less mechanical wind force on the shorter hybrid. Also, the stalk diameter of 567DW was slightly larger than that of 545A. Yields were adjusted to account for lodging and predation to show the true irrigation effect. Hybrid 545A's adjusted yields were 1259 lb/a dryland, 2143 lb/a early irrigation termination and 2720 late termination. Hybrid 567DW's adjusted yields were 2010 lb/a dryland, 2756 lb/a early irrigation termination and 2941 late termination. Hybrid 545A's oil content was 46.5 % in dryland and 46.0 % in irrigated treatments. Hybrid 567DW's oil content was 37.5 % in dryland and 36.6 % in irrigated treatments. It is speculated that decreasing soil water contents late in the season hurt the oil yield of 567DW to a greater degree due to its later maturity. Gross returns, based on a $12.75/cwt cash price(27 Nov. 02) plus premium for oil content, or on $13.50/cwt for bird seed quoted the same day are reported in table 4. These prices were higher than long-term averages, however 2003 NuSun contracts are available locally for $11.50/cwt. Seed yield response to irrigation is reported in Figure 1 and range from 125 lb/a in to 199 lb/a in., based on adjusted seed yield

CONCLUSION

The adjusted dryland yield of 545A was similar to the average yield in the KSU dryland sunflower variety plots, located less than a half mile away, while 567DW yielded about 200 lbs/A more than the best yielding hybrid in the KSU variety plots. Seed yield response to irrigation ranged from 125 to 153 lb/A in. for 545A and from 165 to 199 lb/A in. for 567DW, which is in agreement with other reports. The lower oil content of 567DW compared to 545A is assumed to be a result of the drought and heat stress of the year and/or possibly a characteristic of the particular hybrids. Hybrid 545A is known to be a high oil hybrid, frequently ranging from 45 to 50% oil. Hybrid 567DW is relatively new and does not have as many years data on oil content. The differences in lodging and as-harvested versus adjusted seed yields underscore the importance of controlling stem pests. It is not known whether hybrid 567DW has a physiological or morphological resistance to stem weevil and the observations of one site-year are not sufficient to draw conclusions, but it is a possibility that needs further investigation. Recent research (Charlet, et al., 2001) shows 600 to 1200 lb/a seed yield increase for one insecticide application to control stem pests. Part of that increase is due to decreased lodging, but part is due pre-mature death of plants caused by insect damage and associated diseases vectored by the insects. Thus, it is possible that the best adjusted yields reported in this study could have been 300 to 500 lb/a better with timely insect control. Seed yield was reduced by 450 lb/a due to less than desired population and skips and doubles in row in 2001, and could have been reduced for the same reason in this plot, but there was no control to aid documentation. The adjusted seed yields could have possibly been 600 to 1000 lb/a higher and such yields have been seen in 2001 and 2002 in the NWREC irrigated NuSun sunflower performance trials and other trials in the area. Plans for 2003 at the NWREC in Colby call for continued work comparing standard height and semi-dwarf (short statured) hybrids, and possibly adding one more irrigation treatment.

Table 1. Seasonal precipitation, irrigation and ET at NWREC, Colby, KS*

month	May	June	July	Aug.	Sept.	Total
Rain	1.31	1.26	1.49	4.17	1.16	9.39
Irrigation	0.00	1.50	1.50	6.60	1.10**	9.6/10.7**
Reference ET	5.48	10.8	10.91	9.00	5.73	41.92
Sunflower ET	1.24	6.05	10.26	8.13	2.15	27.83

*12 May, 2002 to 24 Sept., 2002
**Late irrigation treatment only

Table 2. Date and amount of irrigation at NWREC, Colby, KS, 2002.

Date	6/18	7/5	8/1	8/5	8/14	8/21	9/3**	Total
Amount(in.)	1.5	1.5	1.8	1.8	1.5	1.5	1.1**	9.6/10.7**

**Late irrigation treatment only

Table 3.
Effect of Irrigation on sunflower yield components at NWREC, Colby,. KS, 2002.

Treatment	Head dia.[1]	Yield	Oil	Income[2]	Adjusted yield[3]	Income
	Range (in.)	lb./A	%	$/A	lb/A	$/A
Dryland(avg)						
545A	3.5-5.5	708	46.5	102.00	1259	186.42
567DW	3.5-5.5	1719	37.5	232.07B	2010	271.35B
9.6" Irrigation(avg)						
545A	6.5-8.5	1205	45.8	171.46	2143	304.95
567DW	8 - 9	2356	37.3	318.06B	2756	372.06B
10.7" irrigation(avg)						
545A	6.5-8.5	1530	46.2	219.26	2720	392.50
567DW	8 - 9	2515	35.9	339.53B	2941	397.04B

[1] Range in diameter in inches of 10 consecutive heads at a random location in plot.
[2] Gross income based on cash price of $12.75/cwt (27 Nov., 2002) + oil premium of 2% price increase/each 1% oil above 40%, or bird seed price quote for the same time of $13.50/cwt denoted 'B', whichever produces the greatest gross income.
[3] Yield adjusted to compensate for lodging and predation to better evaluate effect of irrigation. Lodging was 25%(545A) or 5%(567DW) and predation was 25%(545A) and 10%(567DW).

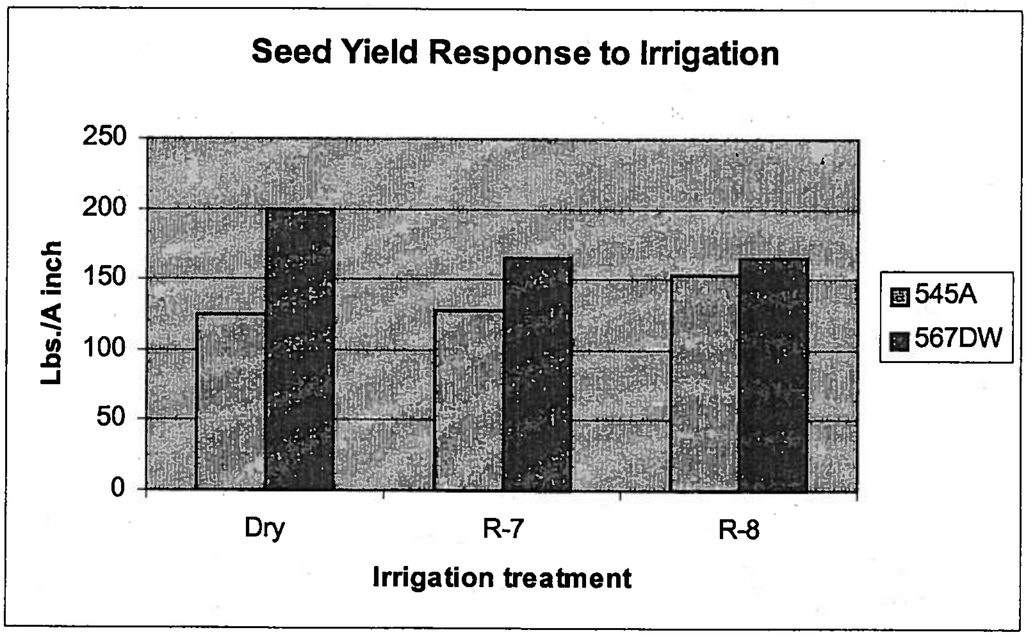

Fig. 1. Seed yield response to irrigation of two sunflower hybrids. Yield response values are based on adjusted seed yield and assume no water available in the top three feet of soil and 3 in. water available in the three to six foot deep profile and 5.3 in. water use to develop plant prior to seed development. All treatments received 9.39 in. rain from 12 May '02 until 24 Sept. '02 and 3.0 in. irrigation for stand establishment. Treatment R-7 received an additional 6.6 in. irrigation. Treatment R-8 received an additional 7.7 in. irrigation.

COTTON PRODUCTION IN KANSAS

Cotton production in Kansas is relatively new, having started in the early 1980's. The area of adaptation is roughly the southern half of the state, minus the higher altitude areas in western Kansas. Cotton production is possible in Kansas because of new, earlier maturing hybrids and growth regulators. Cotton is a perennial tropical plant that is grown like an annual crop in the southern great plains due to frost killing the plant in the fall. Cotton fiber is used in the textile industry, while the seed is sued for oil and livestock feed. Cotton is extremely sensitive to 2, 4-D and other growth regulator herbicides, as well as carryover residues from sulfonylurea and imidazolinone herbicides.

Optimum planting dates in Kansas range from May 1 to June 1, or when soil temperature is 60 °F. at the 8 in. depth for three consecutive days or more. Seeding rates for irrigation range from 65,000 to 85,000 per acre. Seed should be placed in moist soil, from 1 to 2 in. deep. Cotton will not tolerate crusting and will require rotary hoeing if crust develops. Planting seed should be treated with fungicide and insecticide to insure good stands. Weed control is necessary in early season growth because cotton is not very competitive during the first month and a half. Control of bur or sticker weeds in late season is important since these weeds interfere with harvest and ginning of the lint. Cotton grown in Kansas is harvested by stripper machines that remove all of the bolls at once. It is then packed in module builders at the field edge and transported to the gin on schedule. The gin removes the lint and seeds from the cotton bur (boll) and then removes the seed from the lint, which is baled into 500 lb. bales. The grower pays the ginning costs and sells the lint at a price determined by the grade, fiber length, color and cleanness of lint. Cotton prices generally range between 35 and 70 cents/lb.

Cotton has some similarities to soybeans, both crops abort half or more of their blooms and both crops continue to bloom until late in the season. Cotton will begin blooming about 30 days after emergence and it takes about 75 days for a boll to mature. Thus, it takes about 100 days for the plant to mature its first bolls. The length of growing season in Kansas is 120 to 140 days, making it critical to relieve stress during the first 30 days of bloom to decrease abortion during the early boll growth stages. Most bolls that set after the first 30 days of bloom will not mature before frost. Growth regulators are used to restrict vegetative growth and discourage late blooms. Using less water and resources for vegetative growth should help the plant partition more resources into reproductive growth. Cotton uses about 60 lb. of N per bale of production and about 30 lb of P_2O_5 . Excess nitrogen, especially early in the season, encourages excessive vegetative growth and lodging. Breakeven yields of cotton in Kansas are about 3/4 bale/a dryland and about 1.5 bales/a irrigated, depending on price and grade. Irrigated cotton yields of 1.5 to 2.5 bales/a have been reported in Kansas recently. But, like soybeans, cotton yields are dramatically affected by heat. While soybeans don't tolerate temperatures above 95 during seed fill very well, cotton needs warm, tropical temperatures throughout the first 100 days of growing season for efficient fruiting. In a cooler than average growing season, such as 1999, cotton will struggle to mature before frost, while soybeans will do well, but the 2002 growing season with its above average heat, favored cotton production, with many irrigated yields in excess of 2 bales/a being reported.

Irrigation scheduling for cotton should be similar to sunflower irrigation. Both crops need pre-watering if rainfall is not sufficient for germination and emergence. Normal rainfall is usually sufficient for vegetative growth in both crops. Excessive water during vegetative stages of both crops will encourage excessive stalk and foliage growth, possibly detracting from reproductive growth, i e. changing the harvest index. At the initiation of reproductive growth, both crops should be watered to maintain at least 50% available soil water content until near physiological maturity. Anecdotal accounts from producers, are indicating profitable production with 10 to 14 in. of irrigation, similar to sunflower. However, since sunflower is native to the great plains and does not abort blossoms, it is much more tolerant of slow irrigation or watering interrupted by mechanical difficulties than cotton. Cotton may experience cold shock from application of cold well water to plants on hot (≥100 °F.) days, although no literature was found to support that. Both crops share many similar requirements and offer profitable alternatives to Kansas and great plains producers.

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