IRRIGATION EXPERIMENTS

at

Altus and El Reno, Oklahoma

PROGRESS REPORT

1954-1958

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by

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Large scale irrigation is relatively new in Oklahoma and as a result, many problems remain unsolved. Some of the more important problems concern the management of water and the capacity of irrigation systems.

The Oklahoma Agricultural Experiment Station is currently engaged in studies to learn more about effective use of water on various crops under varying circumstances. This report presents the results of trials at Altus and El Reno from the year 1954 through 1958. The average results may change as additional data is obtained in future tests.

Specific objectives were to determine: (1) Effective seasonal use of water—how much irrigation water is required to produce a crop of cotton, sorghum, etc.? (2) Peak daily use of water—how long will a given amount of water last, and what is the system capacity required to deliver it? and (3) Level of watering with irrigation—what amount of water gives the greatest return per inch of water applied?

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Soil Moisture Treatments

The experiments conducted at the irrigation research station at Altus were on a Hollister clay loam soil. The relationship of soil moisture to the soil moisture tension for that particular soil is shown in the figure below. The one third atmosphere point is usually taken as field capacity of the soil, and the 15 atmosphere point is taken as the wilting point.

Four different water treatments were used in the tests in 1954 and 1956. They were designated as:

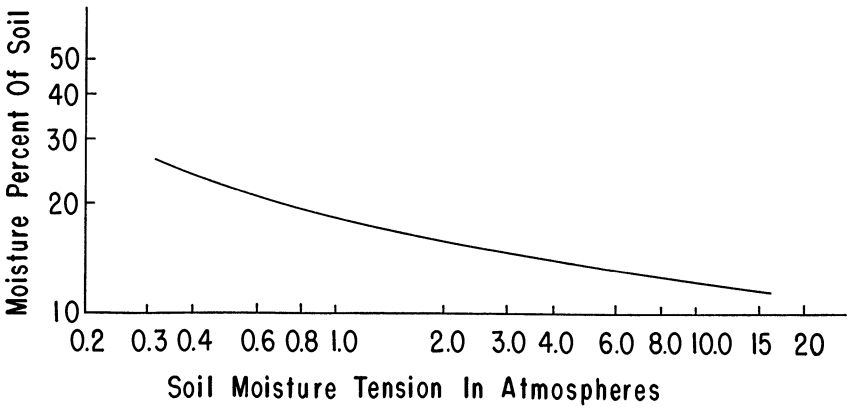
W_1 — No irrigation.

W_2 — Irrigation after the plants definitely wilted at 4 p.m. for one week before each irrigation.

W_3 — Irrigation 24 hours after the plants wilted at 4 p.m.

W_4 — The soil moisture constantly maintained above 17 percent of soil moisture (1.3 atmospheres of tension) in the zone 6 to 12 inches below the soil surface.

The relationship of soil moisture to soil moisture tension for the Hollister clay loam soil at the Irrigation Research Station, Altus, Oklahoma



Determining When To Irrigate

Various levels of irrigation were tested to determine the best time to irrigate to get the best yields. Irrigation responses were measured for cotton, grain sorghum, castor beans, and wheat in the period of 1954 through 1958 at Altus. No results were obtained for cotton in 1955 due to an inadequate stand.

Responses were measured for grain sorghum, forage sorghum, and corn in the period of 1954 and 1955 at El Reno.

Cotton Results

In the hot, dry years of 1954 and 1956, the greatest return per acre and per acre-inch of water occurred when the soil moisture was maintained at the highest level tested (Table 1 and Table 2). Because of these results, a water treatment higher than those in the previous years was added in 1957 and 1958. Then due to the higher than normal summer rainfall in 1957 and 1958, the water Treatment W_5 (soil moisture above 18 percent) did not produce significantly higher yields than Treatment W_4, the highest water level in the previous years. (Table 3 and Table 4).

Although the higher water treatments of these closer to normal years resulted in increased yields per acre, the results differed from 1954 and 1956 in that the highest yields per acre-inch of water were obtained with the drier treatments. These results indicate that one's decision to maintain a certain level of soil moisture should not only be related to the available water supply, but also to the predominating weather conditions. With plenty of water, probably the most economical treatment during any of the four years would have been to maintain the soil moisture above 17 percent (1.3 atmospheres).

Management of a limited water supply becomes more complicated in order to realize the highest returns. In dry years, restricting the acreage and maintaining a high moisture level was more economical. In wet years, a lower level of irrigation may be more economical.

1954 COTTON YIELDS

TABLE 1. Cotton yield increases following different irrigation water treatments at Altus, 1954.

	W_1	W_2	W_3	W_4
Yield in 500# Bales per Acre*	.15	.48	.82	1.39
Number of Irrigations	0	2	4	6
Inches of Irrigation Water Applied	0	7.0	14.0	21.8
Yield Increase (over W_1) in Bales per Acre		.33	.67	1.24
Yield Increase (over W_1) in Bales per Acre-inch of Water		.047	.048	.057

*Yields not underscored by the same line are significantly different at the 5 percent level. Yields underscored by the same line are not significantly different.

The high water level plots (W_4) required a maximum frequency of application of four inches in 12 days in 1954, four inches in 11 days

1956 COTTON YIELDS

TABLE 2. Cotton yield increases following different irrigation water treatments at Altus, 1956.

	W_1	W_2	W_3	W_4
Yield in 500# Bales per Acre	.34	.65	1.16	2.11
Number of Irrigations	0	3	4	6
Inches of Irrigation Water Applied	0	11.0	15.0	23.0
Yield Increase (over W_1) in Bales per Acre		0.31	0.82	1.77
Yield Increase (over W_1) in Bales per Acre-inch of Water		0.028	0.055	0.077
Gross Returns per* Acre	$42.02	$82.34	$149.74	$284.90
Gross Returns per Acre-inch (over W_1)		$ 3.67	$ 7.18	$ 10.56

* Prices used were the selling price or government loan, whichever was higher.

1957 COTTON YIELDS

TABLE 3. Cotton yield increases following different irrigation water treatments at Altus, 1957.

	W_1	W_2	W_3	W_5	W_4
Yield in 500# Bales per Acre	.94	1.18	1.34	1.70	1.77
Inches of Irrigation Water Applied	0	3.0	11.0	21.5	17.5
Yield Increase (over W_1) in Bales per Acre		0.24	0.40	0.76	0.83
Yield Increase (over W_1) in Bales per Acre-inch of Water		0.080	0.036	0.035	0.047
Gross Returns per Acre	$105.22	$129.63	$160.32	$191.52	$221.19
Gross Returns per Acre-inch (over W_1)		$8.14	$5.01	$4.01	$6.63

in 1956, three and one-half inches in 10 days in 1957, and four inches in 9 days in 1958. This treatment would require 6.3, 6.8, 6.6, and 8.4 gallons per minute per acre respectively, for continuous operation.

1958 COTTON YIELDS

TABLE 4. Cotton yield increases following different irrigation water treatments at Altus, 1958.

	W_1	W_3	W_2	W_5	W_4
Yield in 500# Bales per Acre	1.20	2.16	2.17	2.43	2.44
Inches of Irrigation Water Applied	0	12	4	20	16
Yield Increase (over W_1) in Bales per Acre		0.96	.97	1.23	1.24
Yield Increase (over W_1) in Bales per Acre-inch of Water		0.080	0.242	0.062	0.078
Gross Returns per Acre	$192.28	$358.61	$360.44	$402.17	$403.84
Gross Returns per Acre-inch (over W_1)		$13.86	$42.04	$10.49	$13.22

Grain Sorghum Results

Experiments using the same four moisture treatments described earlier were conducted on grain sorghum at Altus in 1955, 1956, and 1958 (Table 5, Table 6, and Table 7), and at El Reno in 1954 and 1955 (Table 8 and Table 9).

In general, the highest water level in these experiments was not economical. It appears that some level of irrigation slightly higher

1955 GRAIN SORGHUM YIELDS

TABLE 5. Plainsman grain sorghum yield increases following different irrigation water treatments at Altus, 1955.

	W_1	W_2	W_3	W_4
Yield, Bushels per Acre	5.6	32.1	36.2	37.2
Number of Irrigations	0	2	3	5
Inches of Irrigation Water Applied	0	5.5	8.5	15.5
Yield Increase (over W_1) per Acre		26.5	30.6	31.6
Yield Increase (over W_1) per Acre-inch of Irrigation Water (Bushels per Acre)		4.82	3.60	2.04

1956 GRAIN SORGHUM YIELDS

TABLE 6. Plainsman grain sorghum yield increases following different irrigation water treatments at Altus, 1956.

	W_1	W_2	W_3	W_4
Yield, Bushels per Acre	5.3	10.8	34.1	36.8
Number of Irrigations	1*	2	3	4
Inches of Irrigation Water Applied	3.0	7.0	10.0	14.0
Yield Increase (over W_1) per Acre		5.5	28.8	31.5
Yield Increase (over W_1) per Acre-inch of Irrigation Water (Bushels per Acre)		1.37	4.12	2.86

*All plots were irrigated during the first irrigation in order to obtain a stand.

1958 GRAIN SORGHUM YIELDS

TABLE 7. Plainsman grain sorghum yield increases following different irrigation water treatments at Altus, 1958.

	W_1	W_2	W_3	W_4
Yield, Bushels per Acre	55.4	59.2	62.8	63.8
Inches of Irrigation Water Applied	0	4.0	4.0	12.0
Yield Increase (over W_1) per Acre		3.8	7.4	8.4
Yield Increase (over W_1) per Acre-inch of Irrigation Water (Bushels per Acre)		0.95	1.85	0.70

1954 DWARF KAFIR YIELDS

TABLE 8. Dwarf Kafir 44-14 yield increases following different irrigation water treatments at El Reno, 1954.

	W_1	W_2	W_3	W_4
Yield, Bushels per Acre	0.9	76.9	85.9	86.5
Inches of Irrigation Water Applied	0	9.0	15.0	18.0
Yield Increase (over W_1) per Acre		76.0	85.0	85.6
Yield Increase per Acre-inch of Irrigation Water (Bushels per Acre)		8.44	5.67	4.75
Peak Daily Transpiration (Inches per Day)*		0.19	0.29	0.39

*Assumed to be soil moisture depletion from the fourth day after irrigation until the next irrigation.

than Treatment W_2 (wilt one week) may be the economical level in these locations.

Forage Sorghum Results

A similar experiment was conducted on forage sorghum at El Reno in 1954 and 1955 (Table 10 and Table 11). The highest water level gave the highest yield per acre, but it did not give the highest return for

1955 DWARF KAFIR YIELDS

TABLE 9. Dwarf Kafir 44-14 yield increases following different irrigation water treatments at El Reno, 1955.

	W_1	W_4	W_3	W_2
Yield, Bushels per Acre	32.4	44.4	50.5	50.8
Number of Irrigations	0	6	5	4
Inches of Irrigation Water Applied	0	13.6	10.5	6.4
Yield Increase (over W_1) per Acre		12.0	18.1	18.4
Yield Increase per Acre-inch of Irrigation Water (Bushels per Acre)		.088	1.72	2.86

each acre-inch of water applied.

A higher level of moisture would be justified when a plentiful water supply is available. However, if water is not plentiful, a lower level may be more economical.

1954 FORAGE SORGHUM YIELDS

TABLE 10. Sugar drip forage sorghum yield increases following different irrigation water treatments at El Reno, 1954.

	W_1	W_2	W_3	W_4
Yield, Tons per Acre (Corrected to 72% Moisture)	4.4	22.2	28.3	35.8
Inches of Irrigation Water Applied	0.0	9.0	15.0	21.0
Yield Increase (over W_1) per Acre		17.8	23.9	31.4
Yield Increase per Acre-inch of Irrigation Water (Tons per Acre)		1.98	1.59	1.50
Peak Daily* Transpiration (Inches per Day)		0.22	0.34	0.38

*Assumed to be soil moisture depletion from the fourth day after irrigation until the next irrigation.

1955 FORAGE SORGHUM YIELDS

TABLE 11. Sugar drip forage sorghum yield increases following different irrigation water treatments at El Reno, 1955.

	W_1	W_2	W_3	W_4
Yield, Tons per Acre (Corrected to 72% Moisture)	12.6	19.4	19.4	22.8
Inches of Irrigation Water Applied	0.0	6.0	10.5	13.5
Yield Increase (over W_1) per Acre		6.8	6.8	10.2
Yield Increase per Acre-inch of Irrigation Water (Tons per Acre)		1.13	0.65	0.76

Corn Results

A similar experiment was conducted on corn at El Reno during the hot, dry year, 1954. The highest yields per acre and per acre-inch of water were obtained with the highest moisture level (Table 12).

1954 CORN YIELDS

TABLE 12. Corn yield increases following different irrigation water treatments at El Reno, 1954.

	W_1	W_2	W_3	W_4
Yield, Bushels per Acre	0.0	25.6	48.6	68.7
Inches of Irrigation Water Applied	0	8.0	12.0	16.0
Yield Increase (over W_1) per Acre		25.6	48.6	68.7
Yield Increase per Acre-inch of Irrigation Water (Bushels per Acre)		3.20	4.05	4.29
Peak Daily Transpiration (Inches per Day)*		0.19	0.32	0.34
Ears per Stalk	0	0.86	1.20	1.57
Weight per Ear (Pounds)	0	0.18	0.24	0.27

*Assumed to be soil moisture depletion from the fourth day after irrigation until the next irrigation.

Castor Bean Results

In 1955, an experiment was run on castor beans at Altus. In addition to the four moisture levels used in the previous experiments, a fifth level of moisture (Treatment W_5) was added. This level was the same as Treatment W_4 for the first half of the season, and Treatment W_3 for the last half (Table 13).

The higher yields were obtained with the higher water treatments. However, the dryer treatments resulted in the higher returns per acre-inch of water.

1955 CASTOR BEAN YIELDS

TABLE 13. Custer Castor Bean yield increases following different irrigation water treatments at Altus, 1955.

	W_1	W_2	W_3	W_5	W_4
Yield, Pounds of Shelled Beans per Acre	106.1	565.9	919.8	923.2	1032.7
Inches of Irrigation Water Applied	0	6.5	13.5	14.5	18.5
Yield Increase (over W_1) per Acre		459.8	813.7	817.1	926.6
Yield Increase (over W_1) per Acre-inch of Irrigation Water (Pounds per Acre)		70.7	60.3	56.4	50.1

Wheat Results

A wheat watering experiment was conducted for three years at Altus. The timing of the applications was not optimum, because water was not always available in the ditch. Approximately five inches of water were applied at each irrigation. The results appear in Table 14.

The value of increased wheat pasture should be considered with the fall irrigations. During some years, two or more spring irrigations would be desirable.

WHEAT YIELDS

TABLE 14. Wheat yield increases following different irrigation water treatments at Altus.

	No Irrigation	Fall Irrigation	Spring Irrigation	Fall & Spring Irrigation
1954*	12.9	23.0	25.8	34.2
1955	1.2	11.3	7.3	13.9
1956**	22.1	---	28.4	---

* 1954 experiment was not replicated
**1956 11 inches of rainfall in 4 weeks at the time for the fall irrigation.

Consumptive Use Studies

Some studies on irrigation water requirements were conducted in 1954 on plots of corn, grain sorghums, and forage sorghums at the El Reno animal husbandry station.

Triplicate soil samples were taken to a three foot depth before each irrigation. Soil samples were also taken two, three, and four days after irrigation, and at intervals between irrigations.

Grain Sorghum Results

The highest daily soil moisture use for water Treatment W_2 for one grain sorghum irrigation period (July 16 to August 7) was 0.19 inches a day (Table 8). Six gallons per minute per acre would be required if the application efficiency was 65 percent and the system was operated 22 hours per day. Average daily soil moisture use for the season was 0.16 inches per day for water Treatment W_2.

The soil moisture consumption for the month of August totaled 5.2 inches. The total consumptive use for the season was 15.0 inches.

Forage Sorghum Results

The highest daily soil moisture use for water Treatment W_2 was 0.22 inches per day during the period August 5-25 (Table 10). Seven gallons of water per minute per acre for forage sorghum would be required if the application efficiency was 65 percent and the system was operated 22 hours a day. The average for the irrigation season was 0.15 inches per day for water Treatment W_2.

Soil moisture consumption totaled 5.9 inches during August. The total consumptive use for the season was 16.0 inches.

Corn Results

Highest daily soil moisture use for one corn irrigation period (July 12-20) was 0.34 inches per day for water Treatment W_4 (Table 12). A total of 10.8 gallons per minute would be required if the application efficiency was 65 percent and the system was operated 22 hours a day. The average rate of use for the season was 0.28 inches per day.

Total soil moisture use during the month of July was 9.2 inches. Seasonal consumptive use totaled 26.7 inches.

Miscellaneous Experiments

Water Application Depth

The water supply was limited at Altus in 1955. The question arose as to how much water should be applied at each irrigation.

An experiment was set up to apply 15 inches of water on furrow irrigated cotton with three different treatments. The treatments were: (1) Six 2½-inch applications, (2) three 5-inch applications, and (3) two 2½-inch applications and two 5-inch applications.

Although the 1955 differences were not significant, the three 5-inch irrigations resulted in slightly higher yields (Table 15). This was probably due to reduced evaporation losses with the larger applications.

In 1957, again there were no significant differences. However, the 2½-inch applications required 2½ inches less water during the growing season due to the fact that lighter applications make more effective use of the rainfall.

Effects of Soil Chiseling

Two tests were conducted on chiseled plots of irrigated cotton and grain sorghum on a Hollister clay loam soil. The plots were chiseled at right angles to the rows with a John Deere pan breaker.

The same treatments had been applied in the same location the year before the test. The following treatments were used.

T_1 — No chiseling.
T_2 — Chiseled 40 inches apart and 18 inches deep.
T_3 — Chiseled 20 inches apart and 18 inches deep.

In the cotton experiment, Lockett No. 1 variety was planted on June 3, 1954. Two hundred pounds of 16-20-0 fertilizer were applied at planting time, and 30 pounds of nitrogen were used as a side dressing. Twenty-one inches of irrigation water were applied during the test. The total yields (Table 16) were from the first pulling on October 13 and the second pulling on November 16.

DIFFERENT WATER APPLICATION RESULTS

TABLE 15. Yield of cotton in bales per acre following different depths of water application at Altus.

Year	Six-2½-inch Irrigations*	Two 2½-inch and Two 5-inch Irrigations	Three 5-inch Irrigations
1955	1.32 bales	1.33 bales	1.42 bales
1957*	0.93 bales	0.93 bales	0.93 bales

*Only five (5) 2½-inch irrigations were applied in 1957.

CHISELED COTTON YIELDS

TABLE 16. Yield of snapped cotton in pounds per acre after chiseling treatments, 1954.

	T_1	T_2	T_3
Yield in lb./ac.	3758	3788	3680

Approximately the same results were obtained in the Redlan grain sorghum test (Table 17). Yields revealed no significant difference from treatments at the five percent level of probability.

Two years of chiseling on the Hollister clay loam soil did not significantly increase the yields when irrigated crops were grown.

CHISELED GRAIN SORGHUM YIELDS

TABLE 17. Yield of Redlan grain sorghum in pounds per acre after chiseling treatments, 1953.

	T_1	T_2	T_3
Yield in lb./ac.	2078	2160	2442

Harvesting Irrigated Cotton With a Stripper

The largest major item of expense that has a possibility of being significantly reduced when growing irrigated cotton is the harvest cost. Cotton strippers have been used successfully on dryland cotton in southwestern Oklahoma in a once over harvesting operation, and also to harvest the second pulling. A test was initiated in 1954 on irrigated cotton to determine the feasibility of stripper harvesting as a once over operation and as a second pulling after hand harvesting.

The four treatments used were:

T_1 — Hand pull both times.

T_2 — Hand pull, then strip second pulling.
T_3 — Strip once over and leave losses.
T_4 — Strip once over and pick up losses.

Irrigated cotton yields for the five-year period ranged from 1.14 to 2.19 bales per acre (Table 18). Using rather generous allowances for stripping costs, stripping the second pulling after hand harvest returned an average of $8.75 per acre over hand pulling both times. Stripping once over was a break even proposition if the losses were left on the ground. If the losses were picked up at the prevailing labor prices, the once over stripping returned an average of $19.33 per acre over hand pulling both times.

The losses were rather high because the machinery available was not adapted to the large plants and high yields under irrigation. Even so, stripping has been economical, and as machinery improves, stripping should become more economical.

DIFFERENT METHODS OF HARVESTING

TABLE 18. Gross returns minus harvest costs, yields, and total losses per acre from irrigated cotton at Altus when using four different methods of harvesting.*

		1954	1955	1956	1957**	1958	Avg.
T_1	Hand pull twice	$221.74	$187.05	$121.78	$68.57	$270.24	$173.88
T_2	Hand pull, then strip	212.12	207.03	140.45	68.57	285.00	182.63
T_3	Strip once over, leave losses	221.98	188.24	121.67	57.08	282.19	174.23
T_4	Strip once over, pick up losses	247.39	208.12	136.60	57.08	316.84	193.21
	Yield, 500# Bales per Acre	2.00	1.79	1.14	1.31	2.19	1.69
	% Total Losses	17.0	16.2	14.9	___	19.6	16.9
		$T_2 - T_1 = \$8.75$		$T_3 - T_1 = \$0.35$		$T_4 - T_1 = \$19.33$	

* Assuming $3.00 per bale stripper costs, $2.00 per hour labor for 2 men, $1.00 per hour for tractor, 6 Bales per day second time over, 12 Bales per day once over, 9 hours per day harvesting time. Prices used were the selling price or government loan, whichever was higher. Harvest labor was figured at the prevailing rate for that year.

**Because of the low grade of the 1957 crop, it was not worthwhile to strip after hand pulling or to pick up after once over stripping.

Summary

The research results reported in this bulletin indicate that various crops differ in their response to different levels of irrigation. Also, the response of a given crop to a given level of irrigation is related to the amount and timeliness of rainfall.

If an irrigator has a plentiful water supply, a higher level of irrigation may be justified on some crops than if he has a scarcity of water. He must determine the level of irrigation according to the limiting resource, whether it be the land or the water.

In general, in these experiments, cotton yields were higher per acre and per acre-inch of water at a high level of irrigation during dry years. During the wet years, the yields per acre were also higher at high levels or irrigation, but the yields per acre-inch of water were higher at lower levels of irrigation.

Study of the grain sorghum results revealed that the higher moisture levels were not economical. Temporary moisture stresses did not greatly decrease the yields. During the two years of tests on forage sorghum, the higher yields per acre occurred with the higher water levels, but the higher yields per acre-inch of water came with the lower levels of irrigation.

Corn, during the one year it was tested, produced the highest yields per acre and acre-inch at the highest level of irrigation. Castor beans in the one year tested, produced the highest yields with the greater amounts of water, but the lower levels of irrigation produced the highest yields per acre-inch of irrigation water.

No significant difference in cotton yields resulted between 2½-inch and 5-inch irrigations, either separately or in combination.

Two years of chiseling produced no significant differences in yield of cotton or grain sorghum.

Even with the high losses using the presently available equipment, machine stripping of irrigated cotton has been economical.

Appendix

APPENDIX TABLE I. Rainfall at irrigation research station, Altus, Oklahoma, from June 1 to October 1.

Month	Long Time Average	1954	1955	1956	1957	1958
June	3.42	1.37	1.88	0.09	4.54	5.42
July	1.68	0.00	1.23	0.89	3.89	5.60
Aug.	2.03	0.00	1.89	0.86	0.63	2.03
Sept.	2.51	0.08	4.43	0.10	1.97	2.09
Totals	9.64	1.45	9.43	1.94	11.03	15.14