High Frequency Low Pressure In-Canopy Sprinkler Irrigation

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ABSTRACT

One year of data, 1993, has been collected concerning degradation of reservoir tillage (Dammer-Diker)[1], irrigation frequency, and performance of various in-canopy application modes. Field slope ranged from 0 to 6% (average = 2.6%) for a deep silt loam soil. Although the data is limited, implanted reservoirs had nearly no storage volume left in the nozzle row by August 9 for the concentrated application modes of bubble and double ended sock. Nozzles spaced 5 and 10 ft and operated in the flat-spray mode helped to retain 35% of the initial storage volume of the reservoirs, in the nozzle row, by the end of August. Corn yield was generally smaller for the treatments where storage volume was reduced.

INTRODUCTION

LPIC (Low Pressure In-Canopy) irrigation is gaining popularity in the Central High Plains. This irrigation method reduces evaporation loss and energy cost. LPIC may increase

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[1]Mention of trade names or commercial products does not constitute their endorsement or recommendation by the authors, the Kansas Agricultural Experiment Station, or by the Kansas Corn Commission.

application efficiency. Runoff, however, can be a significant problem for LPIC irrigation. When field slope begins to exceed 1-2 percent, even moderate irrigation amounts (0.75 to 1.0 in.) may cause runoff. Research is being conducted to evaluate the performance of LPIC for various application modes in conjunction with reservoir tillage on field slope greater than 1 percent.

OBJECTIVE

The study was initiated to: 1)determine the combination of application mode and irrigation frequency which maximizes corn yield for moderate field slope and 2)evaluate the degradation of implanted reservoirs through the season.

PROCEDURE

Corn (Pioneer 3162) was planted May 7 (emerged May 17) in circular rows to allow nozzles to track down the center of 30 in. rows. The rows were aligned in the same direction as the field slope. Borders were installed between each block of treatments perpendicular to the corn rows (and thus field slope) to allow runoff water to exit the study area.

The study was conducted at the KSU Southwest Research-Extension Center on a deep silt loam soil which is typical of western Kansas. Field slope ranged from 0 to 6 percent, with an average of 2.6 percent. Reservoir tillage (ripping and pitting from a dammer-diker) was installed on all plots on June 24 to help minimize runoff from both rainfall and irrigation.

Nozzles were approximately two feet above the ground surface. The four application mode treatments used were bubble, sock, flat-spray mode with nozzles spaced 5 ft, and flat-spray mode with nozzles spaced 10 ft. The bubble mode concentrates the water into a small area directly beneath the nozzle (approximately 1.7 ft in diameter). The sock mode, as the bubble mode, concentrates the water directly beneath the nozzle, with the difference that it delivers water directly to the ground surface by dragging a double ended sock. The flat spray modes spread the water out over a greater area. Wetted diameters were approximately 20 and 28 ft for the 5 and 10 ft spacings respectively. The pattern was influenced by the crop, which caused a narrower pattern perpendicular to the rows due to crop interference.

Daily irrigation amounts were 0.27 in. and three-day amounts were 0.80 in. These amounts were based on a simulated system capacity of 5 gpm/a. This capacity is less than the average peak water use rate of 6.6 gpm/a for the region. The reduced capacity was used to limit daily application amounts. Yield loss could occur with this reduced capacity in high water use years.

Two irrigations were applied, 0.75 in. on June 16 and 0.50 in. on June 26, in the 5 ft flat-spray mode to all plots prior to initiating the various application mode treatments. The first irrigation was applied to keep depletion down until the application mode treatments could be applied. The second was applied after the reservoirs were installed to help consolidate the air spaces between clods and form more stable reservoirs. Application mode treatments began on July 3. A large amount, 0.75 in. was mistakenly applied to daily treatments during this first irrigation and may have reduced dike volumes more than the standard 0.27 in. amount.

The amount of water applied was based on calculated evapotranspiration (ET or estimated crop water use) which was accumulated daily in a water budget. Irrigation and rainfall was subtracted from the accumulated ET (if the daily balance was negative it was reset to zero). Irrigation began as soon as the calculated depletion exceeded the appropriate irrigation amount. Soil water measurements were taken weekly at 1 ft increments to a depth of 5 ft for each plot.

Implanted reservoir volume was determined by placing plastic in the pits and measuring the amount of water needed to fill the pits. The volume of four pits in each of four rows was measured. Therefore measurements from two nozzle rows (average of 8 pits) and two non-nozzle rows, for the nozzles spaced 5 ft, were used to determine pit volume. Volume measurements were taken on July 2, July 20, August 9, and August 30.

DISCUSSION

The cumulative percent reduction in reservoir volume through the irrigation season is shown in Table 1. Reservoir volume in the nozzle row, for sock and bubble modes, was reduced to nearly zero by early August regardless of irrigation frequency. This reduction was due to the combination of field slope (average 2.6%) and the high application rate which both application modes produce. The flat spray application modes resulted in approximately 65% volume reduction in the nozzle row by the end of August.

Peak application rates for the double ended sock were the highest and were difficult to estimate. Application rates were approximately 94 in./hr for the bubble mode (assumed wetted diameter of 20 in.) and 7.8 in./hr for the 5 ft flat-spray mode (assumed wetted diameter of 20 ft). Peak application rates drop to approximately 5.6 in./hr for the 10 ft flat-spray mode (assumed wetted diameter of 28 ft). All these intensities greatly exceed the long term soil infiltration rate which ranges from 0.3 to 0.5 in./hr.

Reservoir pits averaged 2 ft apart down the furrow. Average initial volume was 1.3 gallons per pit. Pit volume

Table 1. Percent cumulative reservoir volume reduction for the 1993 season. NZ=nozzle row, NX=row next to the nozzle, FR=row halfway between 10 ft nozzles. The 10 ft average is a weighted average. The last column is the average cumulative reduction for both irrigation frequencies.

	Daily Irrigation				3 Day-Irrigation				
Treatment	**NZ**	**NX**	**FR**	**Ave**	**NZ**	**NX**	**FR**	**Ave**	**Ave**
Bubble									
July 2-20	**68**	23	--	46	**83**	36	--	60	53
July 2-Aug 9	**97**	44	--	71	**94**	56	--	75	73
July 2-Aug 30	**100**	60	--	80	**100**	67	--	84	82
Sock									
July 2-20	**72**	26	--	49	**75**	33	--	54	52
July 2-Aug 9	**94**	37	--	66	**94**	42	--	68	67
July 2-Aug 30	**95**	48	--	72	**97**	51	--	74	73
5 ft Flat									
July 2-20	**32**	16	--	24	**33**	38	--	36	30
July 2-Aug 9	**45**	36	--	41	**57**	55	--	56	49
July 2-Aug 30	**66**	52	--	59	**65**	67	--	66	63
10 ft Flat									
July 2-20	**23**	31	20	26	**45**	35	34	37	32
July 2-Aug 9	**52**	45	37	45	**57**	55	59	57	51

averaged over the representative area, one row (2.5 ft) and distance between pits (2 ft), results in a storage depth of 0.42 in. This is the amount of water that could have been stored by the pits initially during rainfall or flat-spray events. The concentrated application modes of bubble or sock reduce the available storage by half. Only 0.21 in. could have been stored initially during an irrigation because half of the pits did not receive any irrigation water. Because soil infiltration rates are high initially, larger amounts than the calculated storage depths can be applied.

Irrigation and rainfall amounts during the various time periods and for the season are shown in Table 2. Irrigation was slightly greater, 0.82 in., for the daily irrigation as compared to the 3-day irrigation. Rainfall during the measurement period, July 2 to August 30, totaled 4.88 in. The seasonal cumulative percent reduction in volume of non-nozzle rows for the sock treatment is an indicator the rain effect. Cumulative seasonal reduction averaged 50% over both frequency treatments.

Table 2. Rainfall and irrigation amounts, inches, for various periods of the 1993 season.

Time Period	Rain	Daily Irr.	3-Day Irr.	Daily Total	3-Day Total
May 17-June 23	2.89	0.75	0.75	3.64	3.64
June 24-July 1	1.68	0.50	0.50	2.18	2.18
July 2-July 19	2.18	4.34	3.90	6.52	6.08
July 20-August 8	1.00	4.59	4.00	5.59	5.00
August 9-August 29	1.70	4.59	4.80	6.29	6.50
August 30-September 29	3.10	0.00	0.00	3.10	3.10
Total for Season	12.55	14.77	13.95	27.32	26.50

Since these rows did not receive irrigation water, this is a baseline value of reservoir degradation due to rainfall. Volume reduction in the row next to the nozzle was slightly higher for the bubble mode (64%) since the bubble pattern occasionally overlapped into the adjacent row due to alignment problems.

Table 3 shows corn yield and average field slope for the different treatments. Yield was generally greatest for the flat spray treatments as expected. The 3-day/bubble mode treatment combination tended to yield less than most treatments. This was due in part to reservoir volume degradation and subsequent runoff from plots. Daily irrigations with the bubble mode performed well because the applied water was either infiltrated or stored minimizing runoff.

Table 3. Average corn yield and field slope for frequency and application mode treatments, 1993.

	Daily Irrigation		3-Day Irrigation		Average	
Application Mode Treatment	Yield Bu/a	Slope %	Yield Bu/a	Slope %	Yield Bu/a	Slope %
Bubble	173	1.9	152	3.0	163	2.5
Sock	146	2.5	163	2.8	155	2.7
5 ft Flat	176	2.2	166	2.8	171	2.5
10 ft Flat	167	2.5	172	2.8	170	2.7
Average	166	2.3	163	2.9	165	2.6

Daily irrigations with socks quickly eroded a channel because of the constant contact of the sock with wet soil. Double ended socks are designed to work for large dikes (furrow dams). This treatment was included to evaluate the effectiveness of socks with the implanted reservoirs. Yield was lowest for daily irrigations with socks. Daily irrigations quickly eroded the small pits forming a channel.

CONCLUSION

Daily irrigations with double ended socks and implanted reservoirs performed poorly. A large, 0.75 in., initial irrigation to the daily plots may have caused increased degradation. The effect of field slope was difficult to evaluate with the limited data. As expected, yield was generally greatest when field slope was small and either the 5 ft or 10 ft flat spray modes was used.

Implanted reservoir volume was reduced to nearly zero in the nozzle row by August 9 for sock and bubble mode treatments regardless of irrigation frequency. Reservoir volume in the nozzle row for flat spray modes was reduced 65% by the end of August. Reservoir volume was reduced 50% in non-nozzle rows of the sock treatment indicating the degradation effect due to 4.88 in. of rainfall during July and August.