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ELMER R. KIEHL, *Director*

Comparison of Irrigation Systems for Alluvial Soils

G. A. THOMPSON, R. B. CURRY AND J. F. THORNTON

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SUMMARY

A comparison of sprinkler and surface methods of application of irrigation water on corn plots was made at the Soil Conservation Service, Plant Materials Center, Elsberry, Mo., from 1955 to 1958. Results were as follows:

1. A mean depth of 1.96 inches of water per irrigation was placed in the root zone by the furrow method as compared with 2.22 inches of water placed there by the sprinkler method. The difference approaches significance (probability level 0.07). The intake rate under sprinkler irrigation averaged 0.30 inches per hour, under furrow irrigation the intake rate was 0.23 inches per hour.

2. Mean water application efficiencies as indicated by these data were 68 percent for the sprinkler method and 62 percent for the furrow method.

3. Both methods of irrigation gave significant increases in yield. (Sprinkler, + 13.30, probability level 0.02; furrow, + 11.56, probability level 0.03 over non-irrigated corn.) The sprinkler method gave slightly higher (+ 1.74, probability level 0.71) but not significantly higher yields than the furrow method. In areas where the soil and topographic conditions are similar to those in these experimental plots, the choice between the sprinkler on furrow method of irrigation would seem to be based mostly on equipment and operational costs.

This bulletin reports on Missouri Agricultural Experiment Station Research project 395, Irrigation. The Soil and Water Conservation Research Division, Agricultural Research Service, U.S.D.A., and the Missouri Agricultural Experiment Station cooperated in the study.

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INTRODUCTION

With increased use of fertilizer, improved crop varieties, and power farming equipment, water has become a limiting factor in consistent high-level crop production.

Investigations are needed for different methods of applying water to soil under the topographic and crop conditions of the Midwest. A study of the performance of both furrow and sprinkler methods of applying water was made on land furnished by the Soil Conservation Service, Plant Materials Center, Elsberry, Mo. The plot area was approximately three-fourths of a mile east of Elsberry.

Soil Description and Soil Treatments

The soil in this area is a Sharon silt loam formed by out-wash from river hills. The average slope for the plot area is 0.25 percent.

Laboratory determinations of moisture capacities at one-third atmosphere of tension (considered field capacity) and at 15 atmospheres of tension (considered permanent wilting point) were 21.9 percent and 9.2 percent, respectively. These moisture percentages represented about 3.8 inches and 1.6 inches of water per foot of soil. The difference, 2.2 inches of water per foot of soil, was considered to be water available for plant use.

The average water intake rate for this soil was 0.2 to 0.4 inches per hour. The bulk density of the soil ranged from 1.3 to 1.6.

The available moisture storage is low in the plastic "gumbo" layer which is found at variable depths in this soil. This buried soil layer is high in clay content and organic matter but evidently low in the number of pores in the size range that contributes to available moisture storage. The silt loam surface layers of this soil above the gumbo layer have a high available moisture-storage capacity. Laboratory tests[1] of silt loam soils have indicated that silt contributes to

*Thompson is an agricultural engineer, U.S.D.A., ARS-SWC; Curry is a former instructor in agricultural engineering, University of Missouri; and Thornton, an agricultural engineer, U.S.D.A., ARS-SWC.

[1]Jamison, V. C. and Kroth, E. M. "Available Moisture Storage Capacity in Relation to Textural Compositions and Organic Matter Content of Several Missouri Soils." Soil Sci. Soc. Amer. Proc. 22:189-192. 1958.

the soil storage reservoir for available moisture and as it is diluted with sand or diluted and clogged with clay the reservoir is reduced. The claypan in these soils may tend to increase the temporary storage of water in the surface layers in wet periods, but this doubtlessly occurs at the expense of soil air capacity and oxygen supply to plant roots.

During the first year of this study a basic soil treatment was applied to bring the soil to the recommended fertility level for this type of soil. Each year soil tests were made to determine any additional requirements. Each year, 3-12-12 was applied at the rate of 300 pounds per acre at planting time. Additional nitrogen was also applied each year at the rate of 150 pounds per acre.

IRRIGATION METHODS

Irrigations were made with a portable system. The sprinkler-irrigated plots were irrigated using part-circle sprinklers on each side of the 40 x 400 foot plots on a 60-foot spacing. The surface-irrigated plots received water from gated pipes. The furrow-irrigated corn received water down each middle. The stream size delivered to each plot was controlled so that the initial stream covered the plot in approximately one-fourth of the estimated total time needed to refill the soil to field capaciy in the root zones. This was a higher rate of application than the sprinkler application rate. When the water reached the lower end of the furrow, the rate of application was reduced to a little less than the sprinkler application rate in an attempt to secure an average rate of application approximately equal for both methods.

All irrigation water was pumped from wells within the test area.

DESIGN OF EXPERIMENT

The experimental area was divided into 20 plots, 40 feet wide and 400 feet long. Ten of the plots were planted each year with Kansas 1639 corn. The other ten plots were in Buffalo alfalfa. Two plots of each crop were not irrigated and were used as a check on the irrigated plots. This gave four replications of the two methods of irrigation in each crop. Data taken at each irrigation were time, amount of water applied, and the runoff from each plot. The amount applied was determined by meters placed in pipe leading to each plot. For the sprinkler system the amount of water actually reaching the soil surface was measured in quart oil cans placed on the plots. Runoff was measured by calibrated flumes with recording devices.

Rainfall runoff was recorded from five of the alfalfa plots and from five of the corn plots. Each of these plots was equipped with a 0.75′ type H flume with flat floor and attached waterlevel recorder. A recording rain gauge and a U. S. Weather Bureau Standard Rain Gauge were located within the test area to record rainfall. Evaporation was recorded with a U. S. Weather Bureau Class A, pan. Evaporation and rainfall were recorded only during the growing season.

The minimum and maximum temperature were recorded at an official U. S. Weather Bureau Substation, located at the Plant Materials Center Headquarters Building, approximately three-fourths of a mile west of the test area.

Soil moisture determinations were made gravimetrically. Soil samples were taken from the center four rows at planting time and every two weeks thereafter until September 15. There were sample areas located within both the upper and lower halves of both the corn and the alfalfa plots. The corn plots were sampled with one sample hole between the rows and one sample hole in the row within each sample area. The alfalfa plots were sampled not less than 6 feet from either side of the plots during the first week of April and after each cutting.

Irrigation was planned to start at a calculated moisture deficiency of approximately 4 inches and continued until there were approximately 2 inches of absorption. Plots were irrigated as near the same time as possible to maintain equal moisture levels.

Corn yield samples were taken from each half of each plot. The sample area was one one-hundredth of an acre.

RESULTS

Tables 1 and 2 give the amounts of irrigation water applied to corn per irrigation. The depth of water applied ranged from 2 to 4 inches. A mean depth of 1.96 inches of water per application was placed in the root zone by the furrow method as compared with 2.22 inches of water placed there by the sprinkler method. The difference of 0.26 inches approaches significance (probability level 0.07). There was thus a slight difference in the amount of moisture provided for plant growth. Mean water application efficiencies as indicated by these data were 68 percent for the sprinkler method and 62 percent for the furrow method. The difference of 6 percent in application efficiency was primarily due to a greater amount of runoff from the furrow irrigated plots. The greater runoff was caused by a lower intake rate under furrow irrigation resulting from less contact between the soil and irrigation water. The intake rate under sprinkler irrigation averaged 0.30 inches per hour. Under furrow irrigation the intake rate was 0.23 inches per hour.

Alfalfa irrigation and yield data are not presented in this bulletin. The water table in the test area was never more than 10 feet from the surface and at one time it was within 2 feet of the surface for an extended period, resulting in a crop failure. In the other years the water table was high enough to provide ample moisture for the alfalfa.

Both methods of irrigation gave significant increases in yield of corn when compared with the non-irrigated check plots. The sprinkler method resulted in slightly but not significantly higher yields (Table 3). This can probably be attributed to the slightly greater amount of moisture provided to the root zone.

Climatic data are presented in Tables 4 and 5. In general, the amount and distribution of rainfall was favorable to crop production.

TABLE 1-SPRINKLER IRRIGATION EFFICIENCY ON CORN PLOTS, 1955-1957.

Plot	Water Pumped Inches	Amount to Surface 1/ Inches	Runoff Inches	Infiltration Inches	Application Efficiency Percent
		1955			
2	3.40	2.99	.36	2.63	77
5	3.50	3.08	.15	2.93	84
6	4.00	3.52	.34	3.18	80
8	4.01	3.53	.34	3.19	·80
Avg.	3.73	3.28	.30	2.98	80
		1956			
2	2.56	1.92	.14	1.78	70
5	2.56	1.92	.04	1.88	73
6	2.58	1.94	.01	1.93	75
8	2.58	1.94	.02	1.92	74
Avg.	2.57	1.93	.05	1.88	73
		19 July 1957			
2	3.93	2.95	.05	2.90	74
5	2.80	2.10	.09	2.01	72
6	3.29	2.47	.32	2.15	65
8	3.52	2.64	.01	2.63	75
Avg.	3.39	2.54	.14	2.42	72
		6 August 1957			
2	2.92	2.19	.53	1.66	57
5	2.84	2.13	.45	1.68	59
6	2.91	2.18	.97	1.21	42
8	3.75	2.81	.52	2.29	61
Avg.	3.10	2.33	.62	1.71	55
		21 August 1957			
2	3.17	2.38	.42	1.96	62
5	3.20	2.40	.32	2.08	65
6	3.16	2.37	.89	1.68	53
8	4.11	3.08	.34	2.74	67
Avg.	3.41	2.56	.49	2.12	62
57 Avg.	3.30	2.48	.42	2.08	63
Mean	3.24	2.53	.32	2.22	68

1/ Determined by catchment cans.

TABLE 2-FURROW IRRIGATION EFFICIENCY ON CORN PLOTS, 1955-1957.

Plot	Water Pumped Inches	Amount to Surface Inches	Runoff Inches	Infiltration Inches	Application Efficiency Percent
			1955		
3	3.55	3.55	1.30	2.25	63
4	4.52	4.52	2.22	2.30	51
7	4.60	4.60	2.02	2.58	56
9	4.68	4.68	2.29	2.39	51
Avg.	4.34	4.34	1.96	2.38	55
			1956		
3	2.53	2.53	.60	1.93	76
4	2.53	2.53	.68	1.85	73
7	2.53	2.53	.77	1.76	70
9	2.53	2.53	.72	1.81	72
Avg.	2.53	2.53	.69	1.84	73
			19 July 1957		
3	3.08	3.08	.62	2.46	80
4	2.41	2.41	.87	1.54	64
7	3.52	3.52	.53	2.99	85
9	3.78	3.78	.61	3.17	84
Avg.	3.20	3.20	.66	2.54	78
			6 August 1957		
3	2.16	2.16	1.12	1.04	48
4	2.03	2.03	1.04	.99	49
7	3.06	3.06	.76	2.30	75
9	2.61	2.61	.89	1.72	66
Avg.	2.46	2.46	0.95	1.51	60
			21 August 1957		
3	3.02	3.02	2.72	.30	10
4	3.42	3.42	1.98	1.44	42
7	3.64	3.64	1.80	1.84	51
9	3.68	3.68	1.07	2.61	71
Avg.	3.44	3.44	1.89	1.55	44
57 Avg.	3.03	3.03	1.17	1.87	61
Mean	3.19	3.19	1.23	1.96	62

TABLE 3-ANNUAL CORN PRODUCTION OBTAINED FROM IRRIGATED PLOTS (bushels per acre at 15.5% moisture).

1955	1956	1957	1958 1/	Mean 2/
		Non-Irrigated Check Plots		
98.25	120.35	145.20	128.85	121.27
		Sprinkler Irrigated Plots		
116.62	140.80	146.28	128.02	134.57
		Furrow Irrigated Plots		
109.25	139.62	149.62	120.87	132.83

1/ No irrigation water applied.
2/ 1958 yield data not included.

TABLE 4-MONTHLY RAINFALL AT PLOT AREA

Month	Rainfall (inches)				
	1955	1956	1957	1958	26 yr. avg.
January	1.64	0.31	0.95	.73	2.30
February	3.07	1.92	2.57	1.13	1.68
March	1.47	0.61	3.10	2.22	2.67
April	3.28	4.47	7.04	2.45	3.23
May	3.05	5.21	7.26	3.50	3.55
June	3.04	3.42	6.06	6.37	3.65
July	3.43	6.11	4.41	9.31	2.52
August	2.12	1.40	0.10	1.95	3.02
September	2.84	0.88	1.00	1.88	2.80
October	4.49	0.38	2.60	1.39	2.39
November	.66	3.40	1.69	2.64	2.79
December	.15	3.39	2.85	.45	2.21
Total	29.24	31.50	39.63	33.84	32.81

TABLE 5-MEAN MONTHLY TEMPERATURE

Month	Mean Temperature (°F)				
	1955	1956	1957	1958	Normal
January	31.0	25.8	22.9	28.8	30.9
February	32.3	32.3	37.0	23.5	33.5
March	42.5	43.3	40.9	36.9	43.1
April	60.0	50.0	54.9	52.8	53.5
May	65.8	65.6	64.5	63.2	64.7
June	69.2	74.0	73.8	69.8	74.2
July	81.1	76.1	78.4	74.4	79.0
August	78.6	77.0	76.8	76.2	76.5
September	70.8	68.8	66.1	67.8	69.1
October	57.1	61.7	52.8	56.8	57.5
November	39.6	42.8	41.8	47.2	43.5
December	28.4	34.9	38.0	27.8	34.3
Average	54.7	54.4	54.0	52.1	55.0