WATER SAVING TECHNIQUES

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INTRODUCTION

In areas like eastern New Mexico, the total water resource includes irrigation water plus rainfall. Therefore, water saving techniques should be directed toward maximizing the efficient utilization of both sources of water. The objective of the irrigation-soil-crop system should be that of storing the maximum amount of both rainfall received and irrigation water pumped in the soil root zone for timely crop utilization.

In order to efficiently utilize a resource requires a certain degree of control over that resource. Normally, the greater the degree of control, the higher the resulting efficiency. Conventional furrow and sprinkler systems cannot maintain the control necessary for consistently high irrigation efficiencies. In furrow or flood irrigation, variables such as soil intake rate, soil non-homogenity, length of run, slope, pumping capacity and varying water management skills make precise control of applied water difficult. Climatic conditions also have a significant effect on the irrigation efficiencies of a sprinkler system. In high wind conditions, both the distribution uniformity and the application efficiency of a sprinkler system can be lowered drastically.

In order to alleviate these problems an irrigation system was designed with the objective of maintaining a high degree of control over the total water resource. This system is characterized by and has been labeled a low energy-precision application (LEPA) system, which rather than spraying water into the air at moderate to high pressures, distributes it directly to the furrow at very low pressure through drop tubes and orifice controlled emitters. This occurs as the system continuously moves through the field in a linear or pivotal fashion. The system is used in conjunction with microbasin land preparation which also optimizes the utilization of rainfall by minimizing runoff. The combined system was designed to minimize the effect of soil and climatic variables which adversely influence furrow and sprinkler irrigation efficiencies.

Since 1979, the LEPA system has undergone evaluation in terms of irrigation efficiency, water use efficiency (yield per gross unit of water delivered to the field), and energy saving potential. An equal gross application of water was applied by impact sprinklers installed on the same system and by furrow methods for comparative purposes. These results will be reviewed briefly along with a slide presentation of producer adoption of the concept. Irrigation efficiency was evaluated in terms of distribution uniformity and application efficiency.

DISTRIBUTION UNIFORMITY

Timed volumetric catchments were taken from each drop tube in a series of 14 field tests to determine Christiansen's coefficient of uniformity (C_u) for the LEPA system. Nozzle discharge rates ranged from one to 2.5 gpm. The range of C_u measured was from 94.2 to 97.2 with a mean of 96.1.

Sprinkler C_u values were obtained from water catch cans placed 6.6 feet apart and parallel to the system (perpendicular to the direction of movement). The volumes of water caught in catch cans were adjusted according to volumetric figures obtained in separatory funnel gauges which were filled with diesel oil and located at four catch can sites. Sprinkler C_u values ranged from 66.4 to 96.6 with an average of 90.2.

Furrow irrigation uniformity was estimated by the change in soil moisture storage down the irrigation run as determined by neutron moisture measurements made prior to irrigation and again two days following irrigation. Furrow C_u estimates ranges from 24.5 to 75.2 with an average of 53.9.

APPLICATION EFFICIENCY

Application efficiency (E_a) was defined for these tests as the ratio of water stored in the root zone to the water delivered to the field and was thus influenced by: (a) evaporation losses from water flowing on the soil surface or in the air from sprinkler nozzle spray; (b) deep percolation below the root zone; (c) runoff; and (d) soil surface evaporation during irrigation.

The only measurable water loss occuring during LEPA testing was evaporation from the ponded water in the micro-basins following irrigations. A free water surface remained between 30 and 90 minutes following irrigation on loam and clay loam soils. Pan evaporation measurements indicated these losses to be less than 1 percent of the water applied in all tests. Deep percolation losses were absent as confirmed by neutron soil moisture measurements extending below the root zone. The furrow dikes successfully eliminated runoff except after three or four consecutive irrigations without rediking. Between 2 to 3 percent runoff was normally experienced on the fourth or fifth consecutive irrigation due to dike erosion. However, the resulting average application efficiencies still remained above 98 percent as defined herein (not considering soil surface evaporation following irrigation).

The drop tube application of water without the furrow basins had an average E_a of only 87.6 percent due primarily to runoff. This points out the necessity of using micro-basin tillage with this water application method.

Sprinkler application efficiency was influenced primarily by spray evaporation losses. Measured application efficiencies ranged from a low of 5.9 percent to a high of 98.9 percent. A two-year average of 85 percent resulted where furrow basins were employed and 82.8 percent where conventional tillage was used. Some runoff, although slight, did occur in the absence of basin tillage. An average daily windspeed of 22.1 mph was responsible for the 5.9 percent E_a figure. However, peak gusts of 40 mph were measured during the day.

The light irrigations (from 1 to 2.5 inches) that were applied by all methods resulted in high furrow application efficiencies. Furrow E_a

values ranged from 57.8 percent to 99.3 percent with the two-year average being about 86.4 percent for both tillage treatments. The micro-basins were removed to allow furrow irrigation. The major loss was runoff with very little deep percolation being detected.

IRRIGATION WATER USE EFFICIENCY

Irrigation water use efficiency was obtained by dividing the average yield obtained from each irrigation treatment by the gross water applied to the treatment. The numbers are quite different for the two years due to below average rainfall in 1980 and above average rainfall in 1981. A total of 19.4 inches of irrigation water was applied in 1980 compared to 9.3 inches applied in 1981. Total water delivered to the crop (rainfall plus gross irrigation) averaged 26.2 inches in 1980 and 24.4 inches in 1981.

These data can best be described by tables along with values previously given concerning irrigation efficiency. Table I contains 1980 data, Table II that data obtained in 1981, and the two-year combined data in Table III. Each irrigation treatment was applied to land which was either basin tilled or conventionally tilled with the results reported for each land treatment.

ENERGY SAVING POTENTIAL

Energy required for the application of water for irrigation is proportional to the gross water delivered and to the pumping head or pressure required for the application as follows:

$$E_r \approx Qh \qquad \text{Eq. [1]}$$

where E_r is the required energy, Q is the gross application, and h is the head or pressure required. The head (h) referred to in this case is that required by the application system and is a function entirely of the operating constraints of that system. The gross water application (Q) is

TABLE I

1980 IRRIGATION EVALUATION DATA

(April-Sept. Rainfall - 7.2 inches)

	BASIN TILLAGE			CONVENTIONAL TILLAGE		
	LEPA	SPRINKLER*	FURROW	LEPA	SPRINKLER*	FURROW
Gross Water Delivered, A-in/A	19.36	19.37	19.63	19.16	19.37	19.63
Application Efficiency (%)	98.70	78.80	91.00	90.80	80.00	89.00
Distribution Efficiency (%)	96.10	91.00	53.80	96.10	91.00	51.90
Average Yield, bu/A	33.70	29.60	21.90	23.00	23.90	24.50
Water Use Efficiency, bu/A-inch	1.70	1.53	1.12	1.20	1.23	1.25
Pumping Energy/A (kw-hrs)	668	892	630	661	892	630
Energy Ratio, kw-hrs/bu	19.80	30.10	28.80	28.80	37.30	25.70
Energy Cost/bu	$ 0.99	$ 1.51	$ 1.44	$ 1.44	$ 1.87	$ 1.29

*Sprinkler irrigation with Royal Coach 10122 sprinkler head with 7/32" x 1/8" 20° nozzle operating at 55 psi.

TABLE II

1981 IRRIGATION EVALUATION DATA

(April-Sept. Rainfall - 15.3 inches)

	BASIN TILLAGE			CONVENTIONAL TILLAGE		
	LEPA	SPRINKLER*	FURROW	LEPA	SPRINKLER*	FURROW
Gross Water Delivered, A-in/A	9.09	9.37	9.08	9.35	9.38	9.08
Application Efficiency (%)	99.00	90.00	82.00	84.40	85.60	83.40
Distribution Efficiency (%)	--	89.40	--	--	89.40	--
Average Yield, bu/A	44.70	36.20	49.10	45.20	35.70	48.60
Water Use Efficiency, bu/A-inch	4.82	3.90	5.29	4.90	3.85	5.24
Pumping Energy/A (kw-hrs)	315	358	291	325	358	291
Energy Ratio, kw-hrs/bu	7.05	9.89	5.93	7.19	10.03	5.99
Energy Cost/bu	$ 0.35	$ 0.30	$ 0.30	$ 0.36	$ 0.50	$ 0.30

*Sprinkler irrigation with Nelson F33AA sprinkler head with diffuser nozzle operating at 20 psi.

TABLE III

COMBINED IRRIGATION EVALUATION DATA (1980 - 1981)

	BASIN TILLAGE			CONVENTIONAL TILLAGE		
	LEPA	SPRINKLER	FURROW	LEPA	SPRINKLER	FURROW
Total Gross Water Delivered, A-in/A	28.45	28.74	28.71	28.51	28.75	28.71
Average Application Efficiency (%)	98.90	84.40	86.50	87.60	82.50	86.20
Average Distribution Efficiency (%)	96.10	90.20	53.80	96.10	90.20	51.90
Total Two-Year Yield, bu/A	78.40	65.80	71.00	68.20	59.60	73.10
Water Use Efficiency, bu/A-inch	2.76	2.28	2.47	2.39	2.07	2.54
Total Pumping Energy/A (kw-hrs)	983	1250	924	986	1250	921
Energy Ratio, kw-hrs/bu	12.54	19.00	12.97	14.46	20.97	12.60
Energy Cost/bu	$ 0.63	$ 0.95	$ 0.65	$ 0.72	$ 1.05	$ 0.63

a function of the net application desired and the overall irrigation efficiency.

Numerous researchers have proposed the use of the product of application efficiency and distribution efficiency to determine the total amount of water which should be applied to satisfy the net requirements throughout the designated root zone for the entire irrigated area (Bagley and Criddle, 1956; Hansen, 1960). Thus equation [1] would be expressed as:

$$E_r \approx \frac{q}{E_a\ E_d}\ h \qquad \text{Eq. [2]}$$

where q is the net application desired, E_a is the application efficiency, and E_d is distribution efficiency.

The LEPA system offers excellent potential to decrease irrigation energy consumption in each area represented by equation [2]. These are: (1) lower net irrigation requirement (q) through greater rainfall retention in supplemental irrigated areas; (2) high application efficiency (E_a); (3) high distribution efficiency (E_d); and (4) low operating head requirements (h).

The actual energy required for pumping water by the various methods in 1980 and 1981 are given in Tables I and II, and combined in Table III. It is then presented as an energy ratio representing the energy consumed for pumping for each bushel of soybeans produced. Next, the pumping cost per bushel is given assuming an energy cost of $0.05 per kw-hr.

SUMMARY

Perhaps the best summary of data taken to date would be in terms of net return realized by each treatment over the irrigation energy expense. This data is shown in Table IV. The average price received for soybeans in 1980 was about $8.00/bu and about $5.00/bu in 1981. Energy expense was assumed to be $0.05 per kw-hr for both years.

LEPA irrigation demonstrated a distinct advantage over all other treatments in the dry year of 1980 where irrigation had a greater

TABLE IV

NET RETURN OVER IRRIGATION

ENERGY EXPENSE* ($/ACRE)

	BASIN TILLAGE			CONVENTIONAL TILLAGE		
YEAR	LEPA	SPRINKLER	FURROW	LEPA	SPRINKLER	FURROW
1980	236.20	192.20	143.70	150.95	146.60	164.50
1981	206.20	163.10	231.00	209.75	160.60	228.50
Two-Year Total	442.40	355.30	374.70	360.70	307.20	393.00

* 1980 Soybean Price ∿ $8.00/bu
1981 Soybean Price ∿ $5.00/bu
Energy Cost ∿ $0.05/kw-hr

influence on yield response. Excess rainfall in 1981 caused some indication of negative yield response to retained water and therefore favored furrow irrigation. Furrow diking or basin tillage is considered an integral part of the LEPA irrigation concept and the data supports the importance of its inclusion in the system.

REFERENCES

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