DEMONSTRATION OF IRRIGATION RETURN FLOW SALINITY CONTROL IN THE UPPER RIO GRANDE*

The general objective of this demonstration project funded by EPA through the New Mexico Water Resources Research Institute is to show the feasibility of alternative water management practices on the quantity and quality of drainage return flow and soil salinity in the Upper Rio Grande basin (Figure 1). The project consists of a 450-acre demonstration site in the Mesilla Valley, a four-acre test site on the New Mexico State University Plant Science Farm, and a hydrosalinity model. On the 450-acre demonstration site, a combination of present-day irrigation techniques is being used to show how, through modern water management, the irrigation return-flow quality and quantity can be improved (Figure 2). The feasibility of irrigating at or near 100 percent efficiency with water of medium salinity (1,200 ppm), while maintaining optimum crop yields over a period of years is being demonstrated on the four-acre test site. A third major effort involves preliminary testing in the Mesilla Valley of a hydrosalinity model developed

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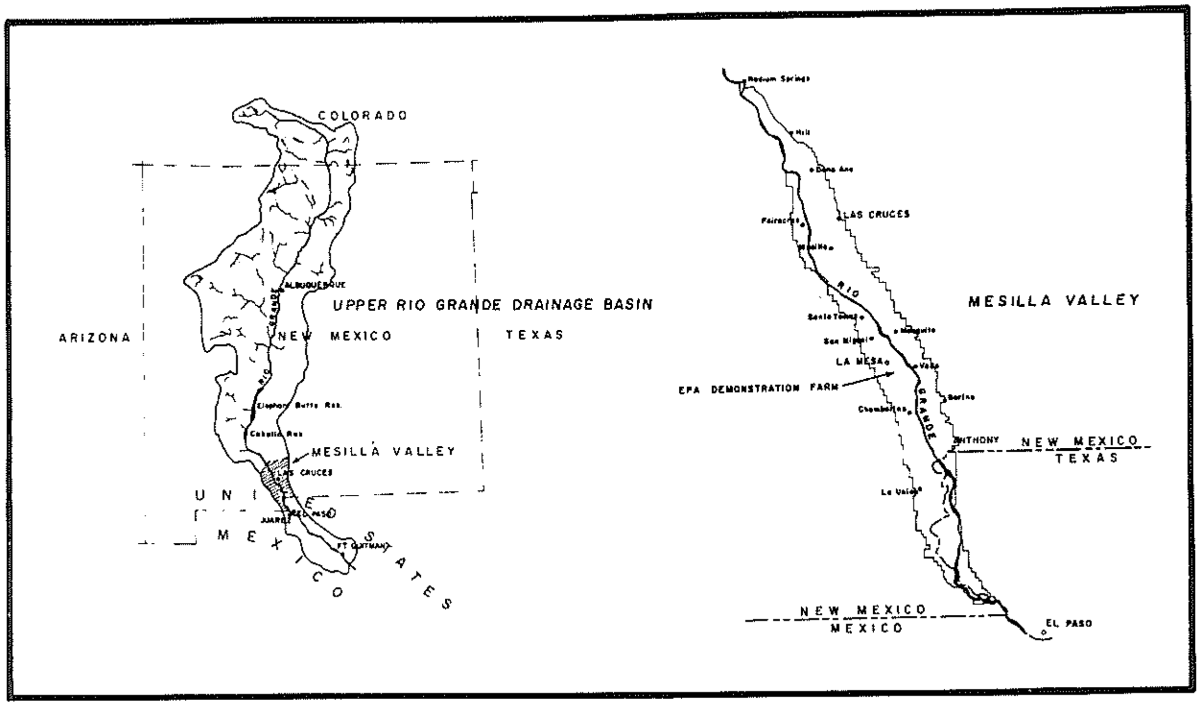
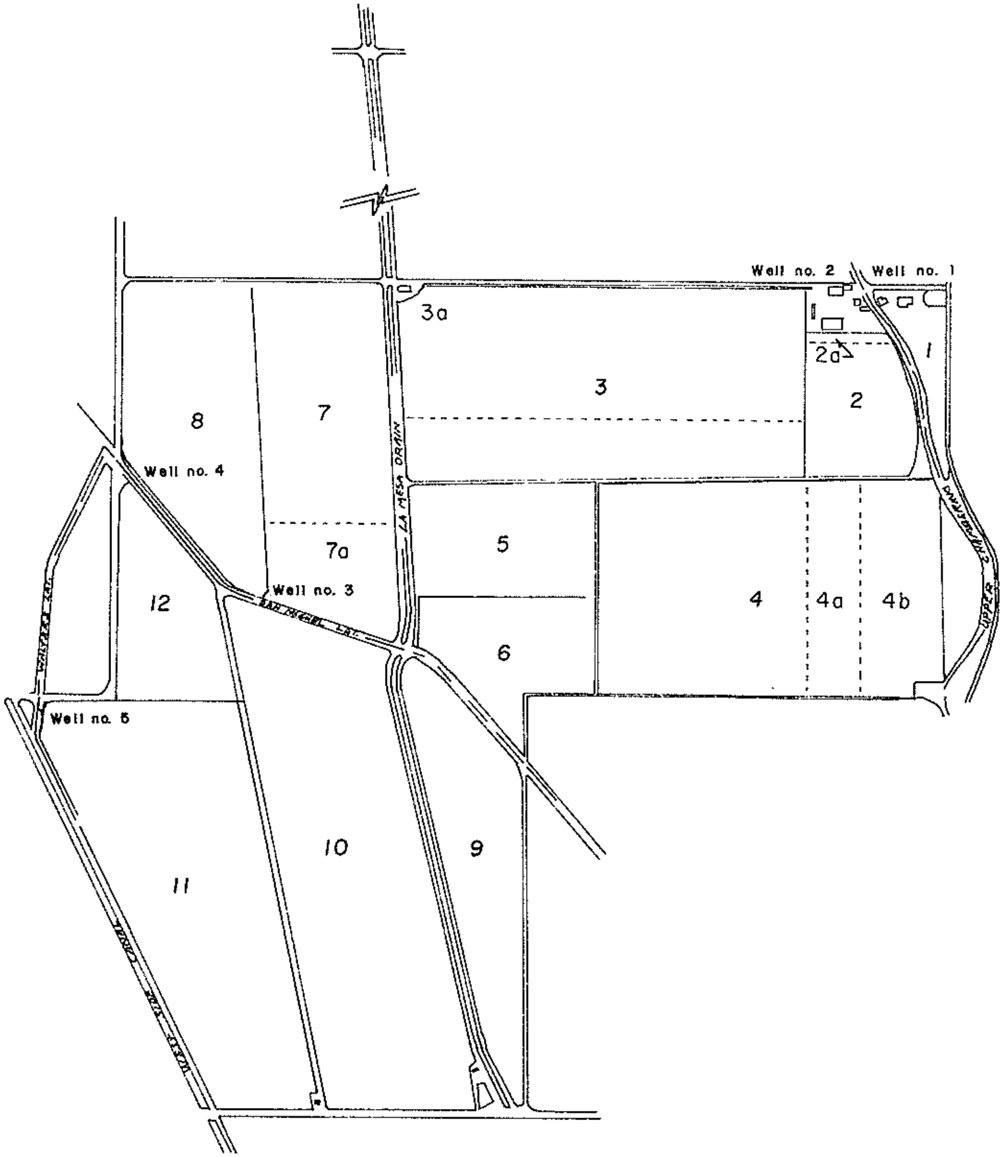


Figure 1. Location of irrigation return flow salinity control demonstration farm in the Mesilla Valley and Upper Rio Grande drainage basin, New Mexico



1976 Crop Year

Field Number	Crop
1	Pecans
2	Cayenne Chile
2a	Trickle vegetables
3	Wheat
3a	Wheat/Lettuce
4	Cotton
4a	Chile 6-4
4b	Floral Gem Chile
5	Wheat
6	Wheat
7	Cayenne Chile
7a	Grain Sorghum
8	Tomatoes
9	Cotton
10	Alfalfa
11	Tomatoes
12	Cotton

1975 Crop Year

Field Number	Crop
1	Pecans
2	Wheat
3	Tomatoes
4	Cotton
5	Floral Gem Chile
6	Chile 6-4/Corn
7	Lettuce
8	Cotton
9	Chile 6-4
10	Alfalfa
11	Chile 6-4
12	Chile 6-4

Figure 2. Crops and well locations on demonstration farm, 1975 and 1976 crop years.

by the Bureau of Reclamation for the Environmental Protection Agency. This model permits prediction of the quantity and quality of irrigation return flow from a drainage basin.

At lunch today, you will have an opportunity to briefly visit the four-acre test site at the Plant Science Farm, and after lunch you will be able to see first-hand and ask questions about the 450-acre demonstration farm located near La Mesa, New Mexico. The farm operator is Orlando Cervantes.

Demonstration Farm

The research on the demonstration farm consists primarily of monitoring the operations of the farm. Two alternative water management practices are being evaluated to reduce the quantity and hopefully improve the quality of irrigation return flows. The first practice is irrigation scheduling where the correct amount of water at the right time is applied. The second alternative management practice is trickle irrigation on pecans and chile. All irrigation water applied on the farm is measured either by parshall flumes for surface water deliveries or meters on the irrigation wells.

Trickle Irrigation Well

An irrigation well for the trickle system was developed utilizing data developed by Clyde Wilson of the USGS. The trickle well supplies water for the chile and pecans. During the 1976 crop year, .71 acre-feet per acre was applied which is considerably below the typical three to four acre-feet per acre for trees of the same size of those on the demonstration farm.

Observation Wells and Piezometers

A nest of three observation wells was developed to test groundwater at 25 feet, 50 feet, and 75 feet, respectively. In addition, piezometers were installed to measure the water table changes during the growing season.

Drains

The flow of the La Mesa Drain is monitored as it enters the demonstration farm and as it leaves the farm in an attempt to determine the affect of the farm on the flow and quality of the drain. The data indicate that our instruments are not sensitive enough to measure either additional flow resulting from the demonstration farm or the quality of return flows resulting from the farm.

Seepage Test

Seepage tests have been conducted on a section of a farm irrigation ditch and on a section of the Upper Chamberino lateral. In the case of the on-farm irrigation ditch, the transmission losses per hundred meters of length was approximately 2.7 cubic meters per hour. On the Upper Chamberino lateral, the infiltration rate in the lateral was considerably less than in the irrigation distribution ditch amounting to a loss of .4 cubic meters per hour/100 meters of canal.

Hydrosalinity Modeling

The objective of this section of the study is to implement, test and modify the USBR mathematical model for predicting changes in water quality due to irrigation activities in the Mesilla Valley. The sensitivity analysis indicates that the initial chemistry of the aquifer and the consumptive use estimates play an important role in the predicted TDS output. The simulation results also demonstrated the importance of the manner in which water is transferred from the aquifer to the river or vice versa.

The initial simulation of the model is encouraging as Figure 3 and Table 1 indicate, however, the results of the sensitivity analyses indicate a need to improve the input data and model structure (see McLin and Gelhar, 1976).

Economic Analysis

The objective of this portion of the project is to project the changes in the quantity of irrigation return flows as a result of alternative water management practices that could be adopted by farmers in the Mesilla Valley. They are (1) irrigation management scheduling, (2) trickle irrigation on tree crops, and (3) sprinkle irrigation for vegetable crop emergence. The effects of these practices will be simulated for the approximately 100,000-acre Mesilla Valley.

The analytical system consists of two specific models sequentially linked to simulate the agricultural production and hydrological adjust-

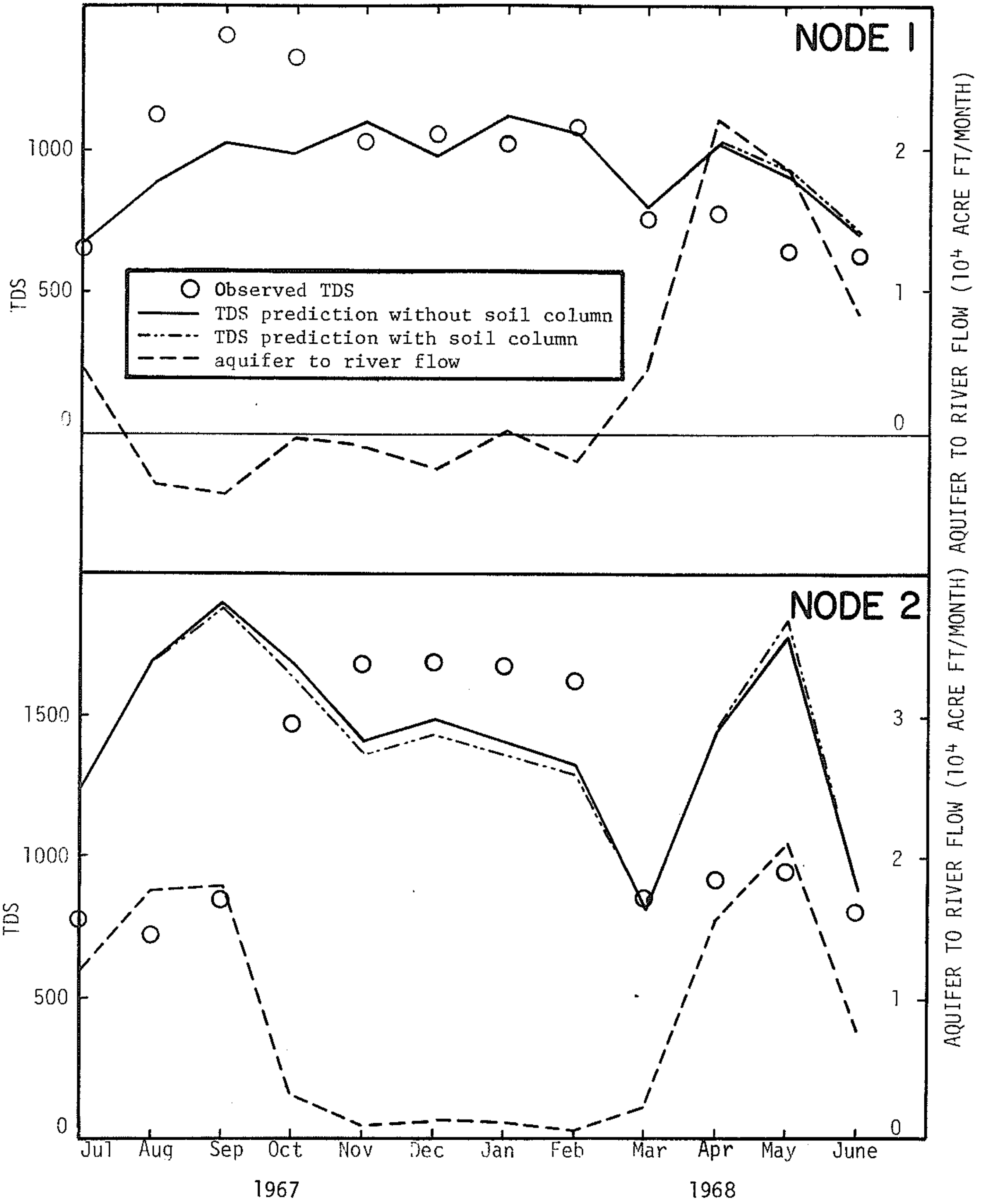


Figure 3. Model predictions for July 1967 to June 1968.

Table 1. Results of model sensitivity analysis

	(1)	(2)*	(3)*	(4)
Physical Feature	25% reduction in initial aquifer pore volume	50% reduction in chemical concentration of aquifer waters	Consumptive use; 2 ft/yr Irrigation efficiency, 50%	50% increase in initial chemical concentration in the soil
Effect	No appreciable difference from original predicted TDS output (i.e. identical to Figure 3).	Large systematic differences of several ppm were noticed as compared to the original predicted TDS output.	Produced systematic differences in predicted TDS output. The transfer of water from the aquifer to the river remained practically unchanged.	Produced only minor differences in TDS from that originally predicted for node 1. Node 2 differences are somewhat larger.

*Soil chemistry subroutine was omitted for clarity.

ments that would occur as a result of implementation of the alternative water management practices. The first is a linear programming model to estimate the economic impact and the irrigation water requirements. The solution is constrained by the usual physical, institutional, and market restrictions. The results of the LP model serve as inputs to the physical hydrosalinity model.

The linear programming model derives a cropping pattern that maximizes returns to water in each of the nodes, subject to the amount of surface and groundwater available and the crop rotation and marketing requirements of the area. The locations of crops were specified in the base year, with the location of additional acreages of crops only being constrained by market characteristics. Water use in the base year approximated actual water use reported by the area irrigation districts. Average commodity prices for 1967-76 are justified by constraining the LP crop production.

Alternative crop production activities and coefficients will be developed by utilizing a submodel budget generator to derive engineering cost approach crop enterprise budgets. The base year budgets are being designed to simulate the cost and returns and input requirements for typical farming operations in the Mesilla Valley. Alternative crop production budgets incorporating irrigation water management practices are being developed by modification of the base year budgets, thus providing a series of levels of irrigation water management practices in the Mesilla Valley.

Field Plot Demonstration

The field plot design described in the first Annual Report (Lansford, et al., 1976) was employed during the second year also, except that a previously bare area next to each plot was also planted. As a result, the total planted area was doubled in size. The irrigation treatments applied to previously planted plots were also used for the new plots. By merely extending the size of the plots, we were able to get yield and salinity date from "new" (B) plots which had undergone no treatments, as opposed to the "old" (A) plots which had been irrigated at various efficiencies and depletion rates for four years. The final plot layout and the numbering of the plots are presented in Figure 4.

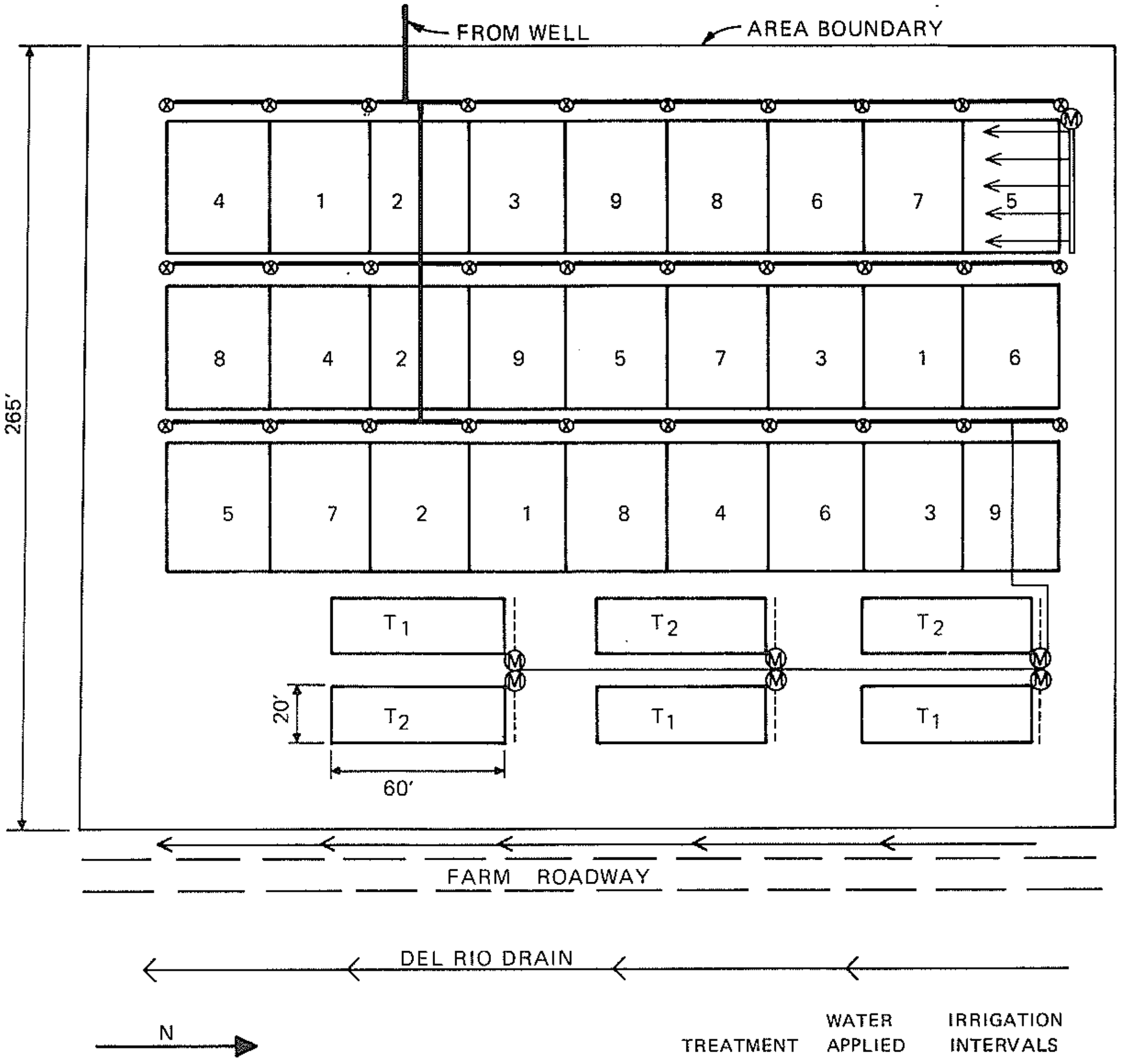
Data on consumptive use of cotton at the experimental site indicate that about 60 cm of water would be required for a crop of cotton. On this basis, total irrigations of 50 cm, 60 cm, and 70 cm (20, 24, and 28 inches, respectively) were planned for 1976. These amounts were applied over the irrigation season, according to a previously developed curve relating consumptive use and days after emergence. Irrigations were scheduled at one-week, two-week, and three-week intervals, resulting in nine treatments (3 efficiencies and 3 depletions).

The "wet" trickle plots were irrigated when the soil water tension at eight inches below the trickle line reached a value of 0.2 bars. The "dry" treatment received 70 percent of the water applied to the "wet" treatment. Irrigation of the field plots was terminated on August 20, 1976.

The amounts of water applied during the 1976 growing season (May 6 to August 20) are listed in Table 2 for the surface irrigated plots, and in Table 3 for the trickle irrigated plots.

Figure 4.

LAYOUT OF EXPERIMENTAL SITE ON THE NMSU PLANT SCIENCE FARM WITH TREATMENTS



TREATMENT	WATER APPLIED	IRRIGATION INTERVALS
1	20″	1 Week
2	20″	2 Weeks
3	20″	3 Weeks
4	24″	1 Week
5	24″	2 Weeks
6	24″	3 Weeks
7	28″	1 Week
8	28″	2 Weeks
9	28″	3 Weeks
T_1	Irrigated at 0.2 Bar	
T_2	Irrigated at 0.6 Bar	

⊗ ALFALFA VALVE

Ⓜ WATER METER

━━━ 4″ PIPELINE

─── 1″ PIPELINE

------- TRICKLE HEADERS

═══ GATED PIPE

Table 2. Water applied to surface irrigated plots from May 6 to August 20, 1976*

	Planned Irrigation Efficiency					
	100%		90%		80%	
Irrigation Interval	Plot No	Water Applied (in)	Plot No	Water Applied (in)	Plot No	Water Applied (in)
1 week	8	18.2	9	22.1	2	25.9
	12	18.2	18	22.1	14	26.1
	26	18.2	24	22.1	28	26.2
2 weeks	7	18.4	1	22.1	4	26.1
	17	18.2	15	22.0	19	26.1
	27	18.2	29	21.6	25	26.1
3 weeks	6	18.3	3	21.3	5	24.2
	13	18.3	11	21.3	16	24.5
	22	18.2	23	21.2	21	24.1

*The amounts of water listed do not include rainfall of 3.5 inches over this period.

Table 3. Water applied to the trickle plots from May 6 to August 20, 1976*

Irrigation Treatment			
0.2 BAR		0.7 of Amount at 0.2 BAR	
Plot No	Inches	Plot No	Inches
3	19.15	1	16.87
4	19.72	2	16.89
5	19.04	6	16.60

*Not including rainfall of 3.5 inches over this period.

The plots were not pre-irrigated, but it is quite possible that residual water was present in the soil from irrigation of the barley during the preceding winter.

Note from the data that the average amount of water applied to the trickle plots (19.3 inches) is only one inch or 5.6 percent higher than the average amount of water applied to the 100 percent surface treatment. This indicates that the 100 percent treatment was indeed close to the planned irrigation efficiency of 100 percent. It also suggests that trickle irrigation management based on tensiometer readings is an efficient method of applying water.

The effects of irrigation efficiency and irrigation interval on cotton yield are presented in Table 4. Table 4 shows the considerably higher yields for the B plots than for the A plots, possibly because the B plots had been bare before planting for several years. This was the first year that irrigation treatments had a significant effect on yield. The 100 percent efficiency treatment on the A plots resulted in a significantly higher yield, possibly as a result of less leaching of nutrients from the plots in this treatment over the past four years. Irrigation of the B plots at three-week intervals resulted in reduced yields. This indicates that if the total water applied is nearly equal to the consumptive use, more frequent irrigation will produce an increased yield.

The yield and quality of the cotton from the trickle plots are presented in Table 5. There were no significant effects due to irrigation treatment on either cotton yield or quality.

Table 4. Effects of irrigation efficiency and irrigation interval on the total fiber yields of cotton for the surface irrigated plots A and B, 1976

Irrigation Interval	Irrigation Efficiency			
	80	90	100	Average
(weeks)	(Kg/ha)			(units)
		A Plots		
1	1,084	1,082	1,434	1,200
2	1,071	1,286	1,480	1,279
3	1,342	1,318	1,354	1,338
Average	1,166a	1,229a	1,423b	1,272
		B Plots		
1	1,557	1,459	1,528	1,515a
2	1,562	1,618	1,514	1,565a
3	1,424	1,326	1,318	1,356b
Average	1,514a	1,468a	1,453a	1,478

Yield means followed by the same letter are not significantly different at the five percent or less level of probability.

Table 5. Yield and quality of cotton for the trickle irrigated plots 1-6, 1976

Treatment	Yield	Lint	2.5% Span	Uniformity Ratio	Mil	Strength	Elongation
	(kg/ha)	(%)					
.2 bar	1,280	38.61	1.167	46.60	3.93	23.17	6.93
70% of .2 bar treatment	1,308	38.66	1.197	44.57	3.53	22.77	6.53

No significant differences.

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