FACTORS AFFECTING FARM IRRIGATION EFFICIENCY IN THE MIDDLE RIO GRANDE VALLEY

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How much progress have we made in improving farm irrigation efficiency in the Middle Rio Grande Valley?

First, we think of land leveling. Approximately 60 percent of the land has been leveled under the technical guidance of the Soil Conservation Service. Let us look at the irrigation trial in Figure 1. Note the 4.8 inches unfilled storage in the upper third of this unleveled border of alfalfa on Gila clay loam. We failed to fill this part because we were forced to stop irrigation too soon. The uneven cross slope forced us to use a flow of 1.5 cubic feet per second (c.f.s.) in order to cover. When 780 feet of the border was covered, we cut off the water at the ditch. In a few minutes more, the entire 939-foot border was covered. If we had run water longer, the border ridges would have broken. Such an irrigation results in either low crop yields or frequent irrigation since we filled less than half of the capacity to store readily available moisture in the upper third of the border. Since we had no waste water and no deep percolation, this irrigation was highly efficient--over 90 percent. But, it failed to give the farmer a satisfactory refill.

So, we level land with little or no cross slope. Figure 2 shows a trial also in alfalfa on land leveled to a uniform 0.1-foot fall per 100 feet near Socorro. The soil was Vinton clay moderately deep over sand. We examined the soil before irrigation and estimated a 3-inch irrigation would fill it. Actually, we normally would have waited until a 4-inch refill was needed. But, some farmers irrigate too soon.

First of all, we had trouble to hold the small stream of 1.2 c.f.s. on the border. We lost about 12 percent on the adjacent borders due to the low border ridges. Even cutting the water off 130 feet from the end, we still lost an inch of water to deep percolation below the root zone. You can see that by leveling, we easily filled the root zone. Unfortunately, the field irrigation efficiency was only 64 percent. If we had had higher border ridges and could have used a larger stream, we could have applied less water and increased our efficiency. If we had waited another week to irrigate, our efficiency would have increased since we were not able to apply the small amount needed when moderately wet.

What field irrigation efficiency should one expect under good management? Note I said good, not the best. To answer this

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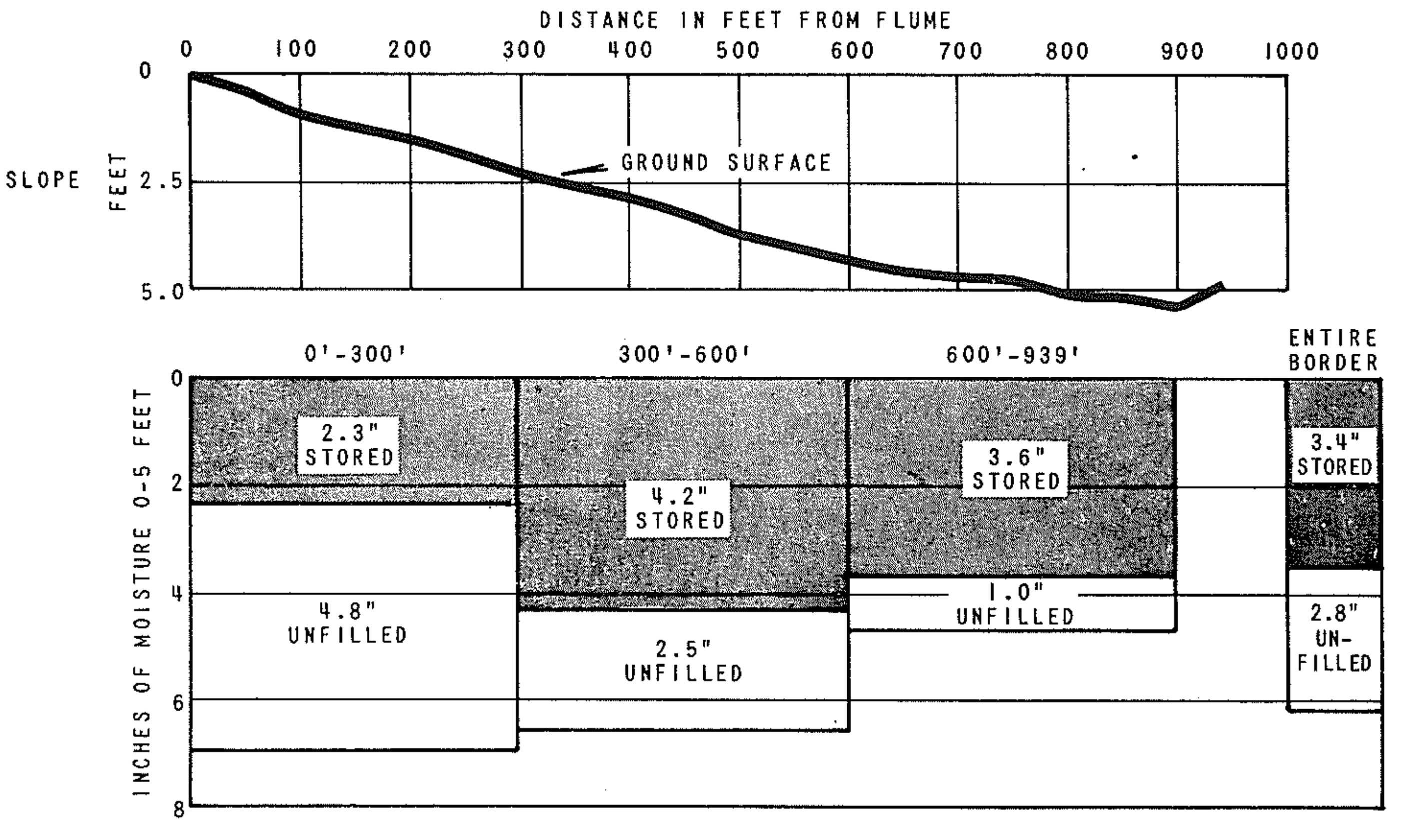


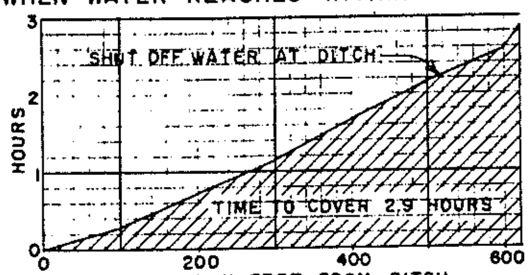
LARGE AMOUNT OF UNFILLED STORAGE DUE TO UNEVEN CROSS SLOPE REQUIRING FLOW OF 1.5 CFS TO COVER STEEP BORDER OF ALFALFA, 35x939 FEET, GILA CLAY LOAM, BERNALILLO, N. M.
WATER CUT OFF 160 FEET FROM END TO AVOID SPILL INTO NEXT BORDER.

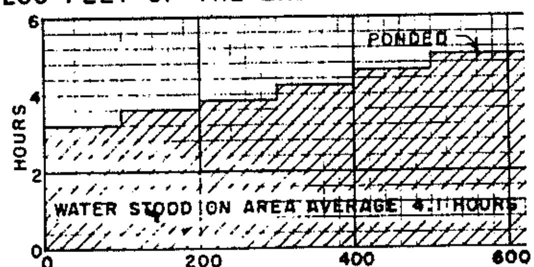
BORDER IRRIGATION TRIAL ON CLAY SURFACE SOIL
SAND AT TWO FEET

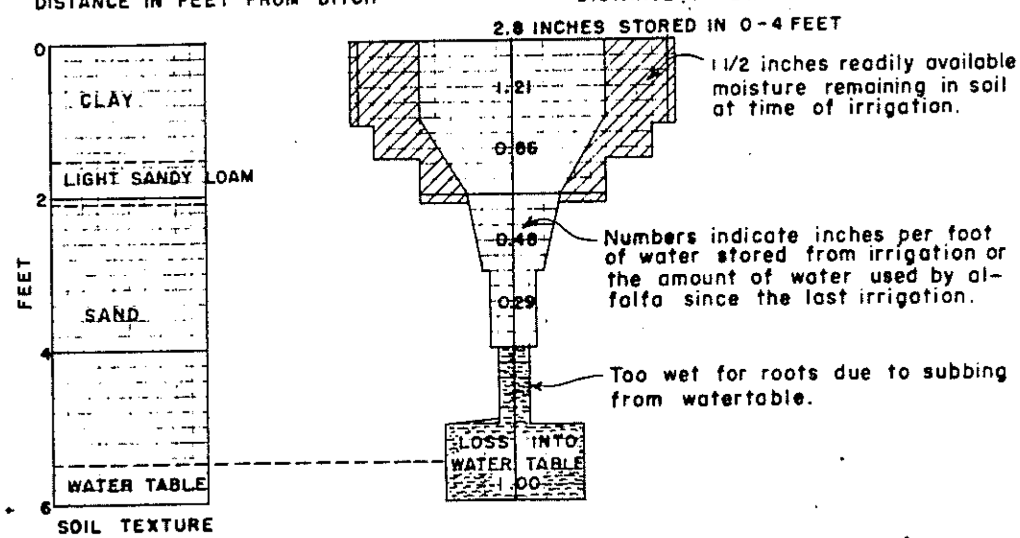
Crop	Alfalfa
Height	16 inches
Soil unit	14P2
Moisture needed 0-4 feet	3 inches
Surface foot	
Readily available	
Moisture prior irrigation	1/2
Compaction class	Mod. compact
Effective pores per sq. ft.	3
Grade, fall per 100 feet	0.1
Time since last irrigation	2 weeks

Date	July 25, 1952
Size of border	42' x 640'
Average flow	1.20 c.f.s.
Time applied	2.22 hours
Depth applied	4.35 inches
Average irrigation intake rate	0.92 in/hr.
Surface waste water	0.00
Estimated evaporation	0.1
Loss into adjacent borders owing to low borders	0.5
Loss into watertable below 4 feet	1.0

SPEED UP YOUR IRRIGATION ON CLAY SOILS BY SHUTTING OFF THE FLOW WHEN WATER REACHES WITHIN 100 TO 200 FEET OF THE END OF THE BORDER







Border irrigation trial on clay surface soil, soil unit 14P2, grade 0.1% in alfalfa, and the moisture stored two days after irrigation, Socorro Soil Conservation District.

question in part, we took soil moisture samples before irrigation and 2 days after irrigation from about 75 trials where we carefully measured the water. In Table 1, we estimate that on deep soils of medium to moderately fine texture on slopes of 0.0 to 0.3 percent, we should expect 80 percent irrigation efficiency by good irrigators. This means 80 percent of the water applied would be used by crops. These soils normally require a 5-inch refill irrigation about every 3 weeks to keep a crop such as alfalfa growing rapidly. For shallow soils of similar texture but underlain by sand, refill 3 inches, we would expect 70 percent field irrigation efficiency.

Under good management, the major loss is deep percolation. You can expect to lose 15 percent of your water on deep medium textured soils by deep percolation. On shallow medium textured soils it may be 25 percent. Under average management these figures are estimated at 30 percent for the deep soils and 40 percent for the shallow soils in the Middle Rio Grande Valley.

What can be done to reduce deep percolation losses? Let's first assume that your border size has already been designed by us for efficient irrigation for a given stream size.

Farmers need to use the design stream size, but unfortunately, most farmers have not installed measuring devices. One of the cheapest devices is a 2-foot rectangular weir, cost $20.00. Note Figure 3 shows a staff gage mounted on a board with numbers painted in cubic feet per second. In Figure 4 we show a one-foot Parshall flume also marked in cubic feet per second. The metal flume costs $80.00. It will measure accurately muddy flows of water whereas the weir tends to silt up and under-read the flow of water. These devices are often used to measure water for 30 to 50 acres; their cost is about that of leveling one or two acres.

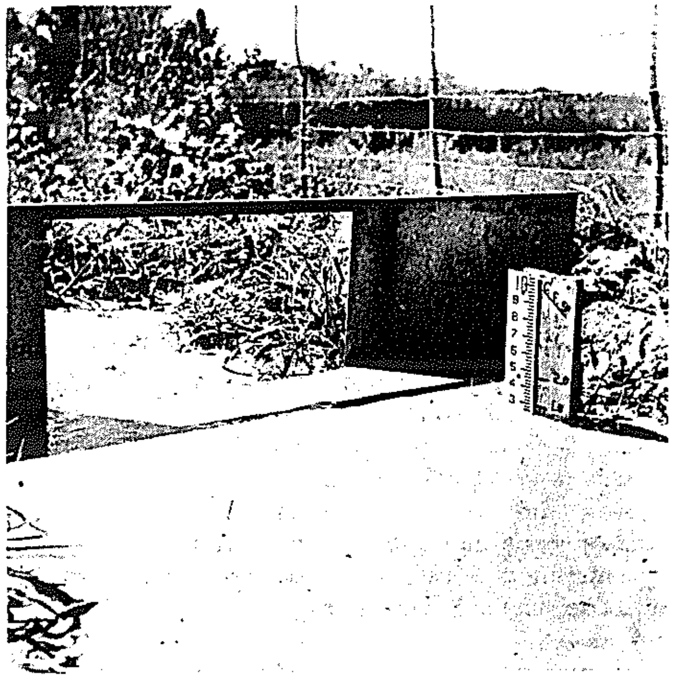
Why measure water? The kind of soil you have, how fast it takes water, how much water it holds, the grade, the size of border are all considered for a design stream size. This is the stream size that saves the most water. We want that stream to cover as fast as possible but slow enough to refill the root zone with little deep percolation, without waste water.

You say the water in the canal fluctuates. Another reason you should measure water, so your irrigator can quickly change the flow to the design flow. Have you enough water to irrigate 1, 2, or 3 borders? Measuring water takes out the guess work just as a feeler gage takes the guess work out of valve grinding. If you measure water and use the same design stream, there is a place in each border where you can cut off the water at the ditch so that it will just nicely cover. Cutting the water off 100 to 200 feet from the end may save 1 to 2 inches of deep percolation loss.

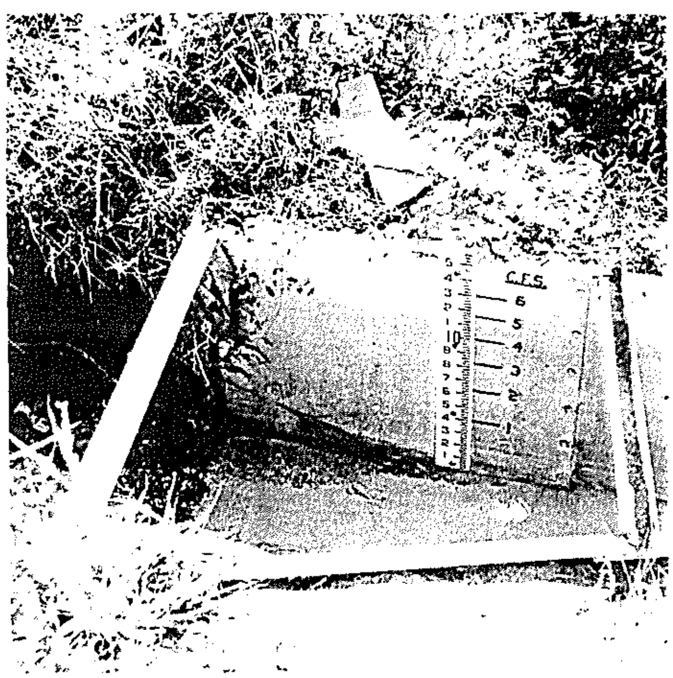
How much of an effort should one make to eliminate high spots of .1 to .2 in flat leveled borders? We found it took 0.5 to 1.0

TABLE 1. Relation Between Design Refill Capacity, Field Irrigation Efficiency and Losses, Grades 0.0 to 0.3 Foot Per 100 Feet

Refill Inches	Surface Texture	Field Irrigation Efficiency	Deep Percolation	Waste Water	Evaporation
5	Fine to Mod. Fine	80	15	0	5
	Medium	80	15	0	5
4	Fine to Mod. Fine	75	20	0	5
	Medium	80	15	0	5
	Sandy	75	20	0	5
3	Fine to Mod. Fine	70	25	0	5
	Medium	70	25	0	5
	Sandy	65	30	0	5



One-Foot Parshall Flume



Two-Foot Rectangular Weir

inch more water to cover these high spots. Usually these high spots were the first to show stress at our Albuquerque Soil Conservation Service Nursery.

How much do concrete pipe lines and concrete ditches save water? A hard question to answer. In the Albuquerque Area about 40 percent of the field ditches are lined; at Socorro about 10 percent. For example, on clays and clay loams, Table 2 indicates a small loss of .02 c.f.s. per 1,000 feet of ditch. For deep sandy soils the loss may be as high as .25 c.f.s. per 1,000 feet.

Ditch losses are usually small percentagewise where streams of 2 to 5 c.f.s. are used. For example, Table 3 shows that Gila loam, a deep medium textured soil would have a ditch loss of 0.3 inch for a gross application of 6.0 inches when using a flow of 2.5 c.f.s. on a border 42 feet wide and 800 feet long. The farm ditch is assumed to be 1,000 feet long and to have a loss of 0.12 c.f.s. per 1,000 feet of ditch. If we were to double the flow to 5.0 c.f.s. and irrigate 2 borders at the same time, we could cut this small ditch loss about one-half or less than 5 percent.

Suppose we let the water run on this same border 0.3 hour or 18 minutes longer than necessary--irrigation efficiency drops 12 percent or over twice the ditch loss. If we went off and let the water run 54 minutes too long our irrigation efficiency drops from 83 to 55 percent; in this 54 minues, we lost 1.9 inches more water by deep percolation.

On the other hand, if you were irrigating with a weak well or a small stream of 1 c.f.s., ditch loss could be more important than deep percolation, Table 3.

On sandy soils ditch loss can also be important, Table 4. But if you irrigated a sandy soil like Vinton loamy fine sand 21 minutes longer than necessary, deep percolation loss would be 3 times that of the ditch loss for a flow of 2.5 c.f.s. on a border 42 X 500 feet.

How often do you need to irrigate? Years ago I wrote an article on the ball test for Crops and Soils which was reprinted in 15 different publications. It is still the cheapest and simplest method I know. Just dig down with a spade to 6-12 inches, if the ball of soil breaks with less than 5 tosses, it is time to irrigate in the next 2 or 3 days.

In Table 5 we are fortunate to summarize the number of irrigations for alfalfa and the field yields by a cooperator in the East Valencia Soil Conservation District, who measures water, who uses design flows, who cuts off the water as far as possible from the end and still have it all get wet.

On the Glendale loamy for 6 years there was an average of 7 6-inch irrigations and a yield of 6.9 tons per acre. Note that the

TABLE 2. Ditch Loss in Cubic Feet Per Second Per 1,000 Feet by Surface Texture and Subsoil Permeability, Tentative

Surface Texture	Permeability Very Slow to Slow	Moderate	Rapid
Fine to Mod. Fine	.02	.08	.08
Medium		.12	.20
Sandy		.15	.25

TABLE 3. Relation Between Size of Stream, Hours Applied, and Farm Irrigation Efficiency for a Border 42 Feet Wide, 800 Feet Long, Factor 1.3, Gila Loam

Flow cfs	Depth Applied Per Hour Inches	Hours Applied	Depth Inches	Refill Needed	Farm Irrigation Efficiency %	Ditch Loss[a/] Inches	Deep Percolation Inches
2.5	3.2	1.9	6.0	5.0	83	0.3	0.5
		2.2	7.0	5.0	71	0.3	1.5
		2.5	8.0	5.0	62	0.4	2.4
		2.8	9.0	5.0	55	0.4	3.4
1.0	1.3	4.6	6.0	5.0	83	0.7	0.1
		5.4	7.0	5.0	71	0.9	0.9
		6.2	8.0	5.0	62	1.0	1.8

a/ Assumes 1,000 Feet of Ditch

TABLE 4. Relation Between Size of Stream, Hours Applied, Depth Applied, and Farm Irrigation Efficiency for a Border 42 Feet Wide, 500 Feet Long, Factor 2.1, Vinton Loamy Fine Sand

Flow cfs	Depth Applied Per Hour Inches	Time Applied Hrs-Min		Depth Inches	Refill Needed	Farm Irrigation Efficiency %	Ditch Loss[a/] Inches	Deep Percolation Inches
2.5	4.2	1	4	4.5	3.0	67	0.5	0.8
		1	25	6.0	3.0	50	0.7	2.1
		1	40	7.0	3.0	43	.8	3.0

a/ Assumes 1,000 Feet of Ditch

TABLE 5. Field Yields of Fall Planted Ranger Alfalfa as Related to Annual Number of Irrigations - Scale Weights, Four Cuttings

SOIL	GLENDALE LOAM		GILA LOAM and CLAY LOAM		GLENDALE CLAY LOAM and GILA CLAY LOAM	
Size:	42 X 740		42 X 700		42 X 900	
Grade:	0.1 %		1.0 %		0.0 %	
Stream:	2.0 c.f.s.		0.5 c.f.s.		2.7 c.f.s.	
Year	6-Inch Irrig.	Yield Tons/Acre	4-Inch Irrig.	Yield Tons/Acre	7-Inch Irrig.	Yield Tons/Acre
1958	9	6.2			7	6.2
1959	7	6.9	11	6.1		
1960	7	7.2	8	7.7	5	5.4
1961	7	7.9	9	7.3	6	6.7
1962	8	7.1	10	7.6	6	6.3
1963	5	6.3	7	6.8	5	6.7
Average	7	6.9	9	7.1	6	6.2

highest yield was made in 1961 on 7 irrigations. The following year, one more irrigation produced 0.8 tons less per acre. Even in the dry year of 1963, 5 irrigations produced 6.3 tons per acre for this 7-year old stand.

Now some people like light frequent irrigations. In Table 3, data are shown for a 1 percent slope on a deep soil, Gila, which has a medium textured permeable subsoil. Ten irrigations of about 4 inches gave a yield of 7.6 tons in 1962, but 8 irrigations produced as much alfalfa in 1960 and 7 irrigations produced 6.8 tons per acre in dry 1963. Light irrigations were used on this relatively steep field to avoid waste water. An average of 9 irrigations produced 7.1 tons per acre over a 6-year period. The least amount of water annually was used on this field.

Some people like flat grades on heavy soils that take water slowly. This field was found to yield alfalfa better with only one heavy 7-inch irrigation between cuttings. On this Glendale clay loam and Gila clay loam, an average of 6 7-inch irrigations produced 6.2 tons per acre.

The most important part in automobile driving is the nut behind the wheel. So, the farmer is the most important factor in improved water management. You can increase irrigation efficiency and refill the root zone:

1. Level your land to flat cross slope, uniform grade lengthwise.
2. Install a designed irrigation system.
3. Use the ball test at the 6-to 12-inch depth to determine when to irrigate.
4. Measure and use the design flow for each irrigation.
5. Cut off the water as far as possible from the end and still have the entire area covered and refilled.
6. Record each date of irrigation by fields.
7. Line ditches where ditch losses are significant.
8. Build and maintain good border ridges 6 to 10 inches above the average level of each border.