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An economic analysis of factors affecting water loss in irrigation channels in the Yazoo-Mississippi Delta

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An Economic Analysis of Factors Affecting

Water Loss In Irrigation Channels In The Yazoo-Mississippi Delta

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Summary

It has been found that evaporation and seepage of irrigation water in some areas can increase the cost of irrigation water delivered to the field.

To determine if evaporation and seepage were important factors in water cost in the Mississippi Delta, water losses were measured in irrigation channels in sandy, loam, and clay soils.

Due to peculiarities in these soil types it was found that the greatest losses were in clay soils and the smallest losses were in sandy soils. Extreme cracking in the clay soils caused higher losses, while a high percentage of silt in sandy soils causes a sealing which reduces water seepage in these soils.

Evaporation from irrigation channels was found to be of little significance.

When the low cost of pumping water in the area is taken into consideration, it becomes apparent that transportation systems which would reduce or eliminate the high water losses found in clay soils cost more on an annual basis than the value of the water lost during an irrigation season.

Pumping costs would need to increase considerably before it would pay to install distribution systems to prevent these losses.

AN ECONOMIC ANALYSIS OF FACTORS AFFECTING WATER LOSS IN IRRIGATION CHANNELS IN THE YAZOO-MISSISSIPPI DELTA

By FRED T. COOKE, JR.[1]

One of the most important costs associated with irrigation is that of pumping and transporting water. The cost of irrigation water which reaches the field is increased due to evaporation and seepage. This study was undertaken to determine the extent of these losses in various soil types and to determine if they are great enough to justify replacing open unlined channels with lined channels or pipe.

Portable Parshall flumes were constructed to measure water in irrigation channels. The flumes were able to measure volumes of water ranging from 150 to 4,018 gallons per minute with a fairly high degree of accuracy. Flumes were used because it is possible to accurately measure the wide range of water volumes which are encountered on Delta farms. Also, most water channels in the area have little head or slope and flumes can be used under these conditions much better than weirs.

Three Soil Groups Studied

Three general soil groups were considered in the study—sandy soils, loam soils, and clay soils. The soil classifications were made from Soil Conservation Service maps.

The clay soils consist of clay and silty clays and other soils that have similar characteristics. These soils include Sharkey Clay, Alligator Clay, and Dowling Clay. The clay soils in the area are composed of montmorillonite clay which expands greatly when wet. When these clays dry out cracks are formed and water passes through them readily. These cracks close very slowly in irrigation channels due to exposure to air and sunlight. On soils of this type, observations made in channels that had been wet for several weeks showed losses about the same as in channels that had been wet only a few days.

The loam soils are made up of silt loams, silty clay loams and other similar soil types and include Forrestdale silt loam, Forrestdale silt clays, and Dundee silty clay loams. Usually they have poor to fair internal drainage and generally have a silt loam top soil with a clay or silt loam subsoil. These soils also tend to crack like the clay soils but not to such a great extent due to a high percentage of silt present. Water losses in these soils are greater than that in sandy soils but not as great as in the clay soils.

The sandy soils consist of fine sandy loams, loams and silt loams. Some of t more common soil series included in this group are Boskett silt loam, Boskett loam, Boskett fine sandy loam, Pearson silt loam, Dundee silt loam, and Dundee fine sandy loam. These soils are well drained, medium to course textured, lend themselves well to high levels of inputs, and are extremely well adapted to row cro production. These soils should probably be called fine sandy loams because they have less sand and more silt in them than sandy soils in other areas. The silt in these soils causes a sealing or crusting effect when they become wet. This sealing results in a very small amount of seepage.

Two Kinds of Channels Tested

The channels used to transport water were of two kinds — ditches and flumes. For the purpose of this study a ditch is

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defined as a channel which transports water below the surface of the ground and a flume is defined as a channel which transports the head of water above the ground surface.

The great majority of the ditches were "V" shaped while the flumes were about evenly divided between "V" and rectangular shape. Only channels with a surface width of 4 to 6 feet were measured due to limitations of the flume. To measure the flow of water in the irrigation channel Parshall flumes were spaced 1,000 feet apart. The water loss is reported as percent of volume lost per 1,000 feet of channel. Table 1 presents the water loss due to evaporation and seepage associated with the various soil groups included in the study.

It had been felt that the flumes would show greater losses due to seepage than ditches. The study indicated that there was no significant difference in losses in either type channel. Shape or type of construction had no apparent affect on water loss in the channels studied.

Evaporation

Studies of evaporation in the Mississippi Delta have been carried on by the U. S. Weather Bureau at Stoneville, Mississippi.[2] This work indicates that the evaporation from a 4-foot wide irrigation channel would constitute 0.6 percent of the volume flowing during the most common irrigation period, July 15 to August 15.

It is evident from this that evaporation accounts for a large part of the water loss in sandy soils but constitutes only a small proportion of the total loss in loam and clay soils.

Cost of Water

To determine the value of the water which is lost in irrigation channels a cost must be assigned to water which is used for irrigation. The cost of pumping water from wells with electric motors, the most common source of power, in the Mississippi Delta was $0.47 per acre inch for wells of the capacity found in this study[3]. Table 2 presents the value of the water lost from a well delivering 904 gallons per minute or 2 acre inches per hour if the well were operated 512 hours, the average number of hours operated annually[4], and one mile of channel was used.

To analyze the feasibility of reducing or eliminating water loss the clay soil situation will be used as water losses are the greatest in these soils. If the alternative transport systems do not prove to be economical in clay soils, then these systems cannot be economical in soils which have less seepage. Three alternative methods of transporting water are compared. These three examples are for illustrative purposes only. The three systems of transportation compared are an unlined channel, aluminum pipe, and a concrete lined irrigation channel. The costs of these systems are presented in table 3.

The first transportation system considered is an unlined irrigation channel. For this example it is assumed that the ditch is constructed with a motor patrol. A charge for land rent is included. However, this charge would not be applicable if the channel were constructed in the field turn-row. It has been found that 12 feet of right-of-way is needed for a ditch 4 feet wide, therefore 1.45 acres of land would be required for a ditch one mile long.

Aluminum Pipe

One way to eliminate the loss of water

[2]"Climate of the Delta Area of Mississippi," Riley, J. A. Mississippi Agricultural Experiment Station Bulletin 605, September 1960.

[3]"Investment and Operating Costs of Irrigation in the Delta Area of Mississippi." A progress report by Thomas E. Tramel, Grady B. Crowe, and J. F. Able, Jr., Mississippi Agricultural Experiment Station Bulletin 559. 1958.

[4]Ibid.

in the channel would be the use of portable aluminum pipe. It is assumed that only one-half mile of aluminum pipe would be required to replace one mile of channel. The pipe could be run one-half mile from the source of water in one direction and one-half mile in the other. This cannot be done with open ditches because of topography.

The smallest practical size aluminum pipe which could carry a volume of 904 gallons of water per minute is 8 inches in diameter and would cost $2.02 per foot. When water is moved through pipe the volume of flow is reduced because of friction. In this example a relift pump which can deliver a pressure of 39 pounds per square inch is necessary to force the required volume through the pipe. When tractor power is used it costs about $0.66 per acre inch to pump water with a relift pump of this size.

A six-foot lane is usually required to lay this pipe and thus a land charge of 0.73 acres must be made. The cost of the pipe is depreciated over 10 years in this example. The cost of laying and moving the pipe has been omitted from the example as this varies from season to season but should be taken into consideration when comparing systems.

Concrete Lining

Another possible method of reducing water loss is lining channels with concrete. Very little of this has been done in the Mississippi Delta and information is limited. These channels cost $1.25 per foot to build. No maintenance costs are included in the example because there is little or no information on this subject. It is known that a certain amount of patching and filling of cracks is necessary every year. This would add to the yearly cost of this type distribution system. The expected life of these channels is unknown in clay soils but would probably be somewhat less than concrete lined channels in sandy or mixed soils due to cracking and heaving of the soil.

These channels are permanent and could interfere with the use of equipment in the fields. A charge for land rent is much more applicable for the permanent channels. The temporary channel may be constructed on the turnrow and would not necessarily require additional land as would the permanent concrete channel. A life of 20 years is assumed for this channel but this may be too long in clay soils

Costs Exceed Returns

These three examples indicate that the cost of preventing water losses in irrigation channels in clay soils exceeds the cost of the water loss. The depreciation on investment for aluminum pipe or concrete lined channels would go on in years in which no irrigation would be needed, and this would increase the cost of the systems for the years used. With temporary ditches there would be no cost in years when irrigation was not needed because no ditches would be constructed.

The cost of pumping water would have to increase substantially before the installation of a system to reduce these losses would be economically sound. It should be emphasized that if the concrete ditch should have a shorter life than 20 years then the cost of this system would go up considerably.

Most irrigation channels in the Mississippi Delta are found in sandy and mixed soils because most irrigated row crops are grown on these soils. The water losses in these soils are less than in clay soils and the need to reduce this loss is correspondingly less. Most rice production is on clay soils and these losses could become significant.

Other Water Losses

With irrigation, water is also lost when channels overflow or break. These losses seldom amount to a great deal of water in terms of dollars and cents but greatly add to labor cost. With pipe or lined ditches these losses are negligible. It has been found that these losses can be greatly reduced in unlined channels if care is taken in their construction.

The most common cause of breaking and overflowing channels is poor engineering in locating the channel. Care must be taken to follow the natural slope in laying out the channel. All low or high points should be marked so appropriate cuts and fills can be made. Little of this is necessary in most instances in the Delta.

When flumes are used, trash and sticks in the banks often cause breaks. This can usually be eliminated by thorough disking before the ditch is constructed.

Few farmers in the area prime their ditches before they are used but this would greatly reduce overflowing and breaks. Priming helps seal the ditch and if an overflow or break occurs the well can be cut off and the break fixed before the actual irrigation work begins.

Table 1. Average water loss in unlined irrigation channels by soil groups.

Soil group	Number of observations	Average percent of volume lost per 1000 feet	Range of losses per 1000 feet (percent of volume)
Sandy	34	1.3	0.6 — 5.0
Loam	17	6.8	3.7 — 8.8
Clay	23	9.8	5.1 — 19.5

Table 2. Amount and value of water lost in one mile of irrigation in sand, loam, and clay soils.

Item	Unit	Sand	Loam	Clay
Discharge at well	GPM	904	904	904
Percent loss per 1000 feet	Pct.	1.3	6.8	9.8
Volume of water pumped in 512 hours	Acre in.	1024	1024	1024
Value of water pumped in 512 hours	Dol.	481.28	481.28	421.28
Discharge at end of one mile of unlined channel	GPM	841.81	623.89	524.95
Volume lost in 512 hours	Acre in.	71.68	317.44	430.08
Value of water lost	Dol.	33.69	149.20	202.14

Table 3. Annual cost of transporting irrigation water one mile by selected methods.

Item	Transportation method		
	Temporary channel on clay soils	8-inch aluminum pipe[1]	Concrete-lined irrigation channel[1]
	Dollars	**Dollars**	**Dollars**
Construction and maintenance	66.04	----	—
Closing ditch	30.00	----	----
Value of water loss	202.14	----	----
Land rent @ \$7.00 per acre[2]	10.15	5.11	10.15
Maintenance and depreciation	----	533.23*	330.00**
Relift cost	----	675.84	----
Value of water loss due to evaporation	----	----	15.15
Total	308.33	1,214.23	355.25

[1]1.45 acres of land is required for one mile of temporary or concrete-lined irrigation channel.

[2]Land rent charge of \$7.00 per acre is an arbitrary one and should be varied under different circumstances.

*Original costs and life. **Original costs and life.

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