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## EC68-771 Furrow Irrigation of Nebraska Soils

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John Davis

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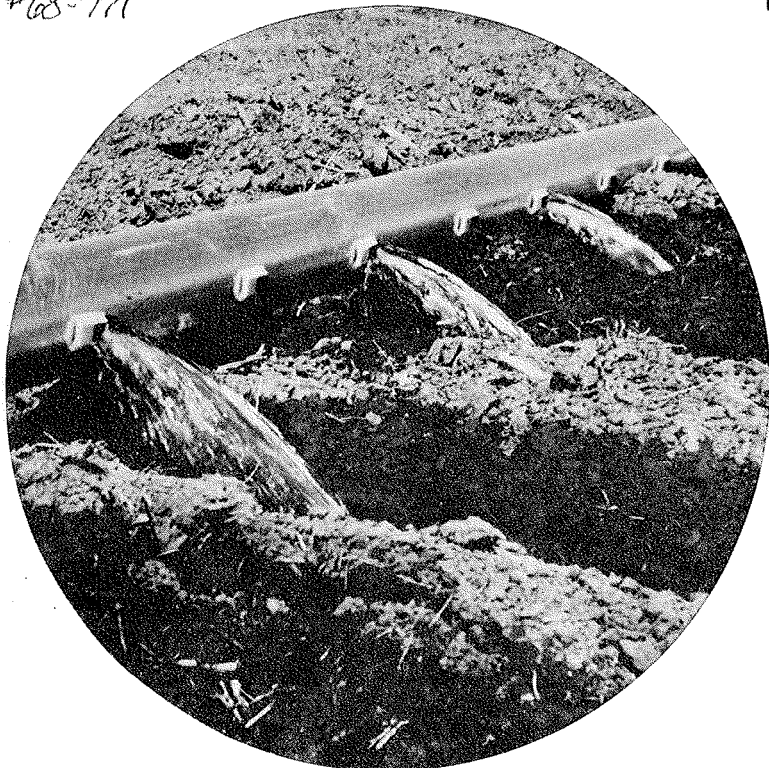
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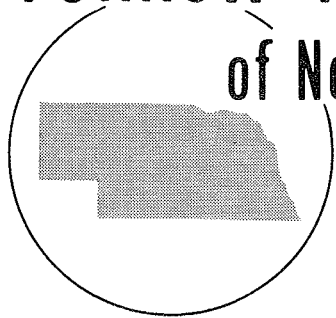
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# FURROW IRRIGATION of Nebraska Soils



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# Furrow Irrigation Of Nebraska Soils

Paul E. Fischbach 1/ & John R. Davis 2/

Proper irrigation practices usually reduce irrigation costs and result in higher crop yields. These practices involve:

1. Applying the right amount of water.
2. Obtaining uniform water application over the field.
3. Applying water at the proper time.

This publication will serve as a general guide for the first two practices.

## How Much Water To Apply

Applying proper amounts of water provides the best opportunity for high crop quality and yields.

The amount of water to apply at each irrigation depends on the amount of soil water used by the plants between irrigations, the water-holding capacity of the soil, and the depth of crop rooting.

In general, apply water when about one-half or less of the total available water in the root zone has been used by the crop. One of the most common irrigation practice failings is to apply too much water too late, especially at the first irrigation.

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Apply nearly enough water to replace the moisture extracted by the active roots and no more. Applying too much (1) raises the water table; (2) leaches plant nutrients, especially nitrogen; (3) wastes water and (4) increases costs.

Corn is ditched for irrigation when it is about 30 inches high. At this stage of growth roots have penetrated about 18 to 24 inches into the soil, so irrigation water should be applied to a soil depth of 18 inches. Applying water deeper than 18 inches wastes water and leaches nitrogen below the active root zone.

Two to four inches of water will replace water used by the plant at this stage of growth in most soils.

Both corn and sorghum have a critical need for water and nitrogen shortly after ditching for irrigation. Recent research shows that corn yields were reduced from 144 to 110 bushels per acre (over 30 bushels per acre loss) when irrigation or rain was delayed 8 to 10 days during this stage of growth. Too much water applied at this time will also reduce yields because nitrogen may be leached below the active roots or soil air may be displaced from the root zone.

Determining how much water to apply during each irrigation set is important for maximum crop returns. This can be done fairly simply if you know or measure three factors:

1. Area (in acres) irrigated in each irrigation set. You can determine this by knowing the length of furrows, number of furrows and distance between furrows (Table 1).

2. Rate of irrigation water flow, which in most cases is given in gallons per minute pumped. The rate of flow can also be supplied by the irrigation district.

3. Time that water is applied to each irrigation set (Table 2).

Example: A field being irrigated is  $1/4$  mile long (1320 feet). There are 40 furrows in each set, with 30-inch furrow spacing. What is the area irrigated per set?

See Table 1. For furrows on 40" rows, the area would be 4.0 acres. For 30" rows, multiply 4.0 acres times 0.75. The answer is 3.0 acres irrigated per set.

Table 1. Acres Irrigated Per Set.

Length of Furrow		Number of Furrows Per Set (40" rows)					
rds.	ft.	10	20	30	40	50	100
		Acres in Each Set					
20	330	.25	.5	.75	1.0	1.25	2.5
40	660	.50	1.0	1.50	2.0	2.50	5.0
80	1320	1.0	2.0	3.0	4.0	5.0	10.0

To Determine Number of Acres for Various Furrow Widths

30 inch furrow	multiply by 0.75
28 inch furrow	multiply by 0.7
24 inch furrow	multiply by 0.6
20 inch furrow	multiply by 0.5

Table 2. Hours Required to Apply Three Inches of Water.

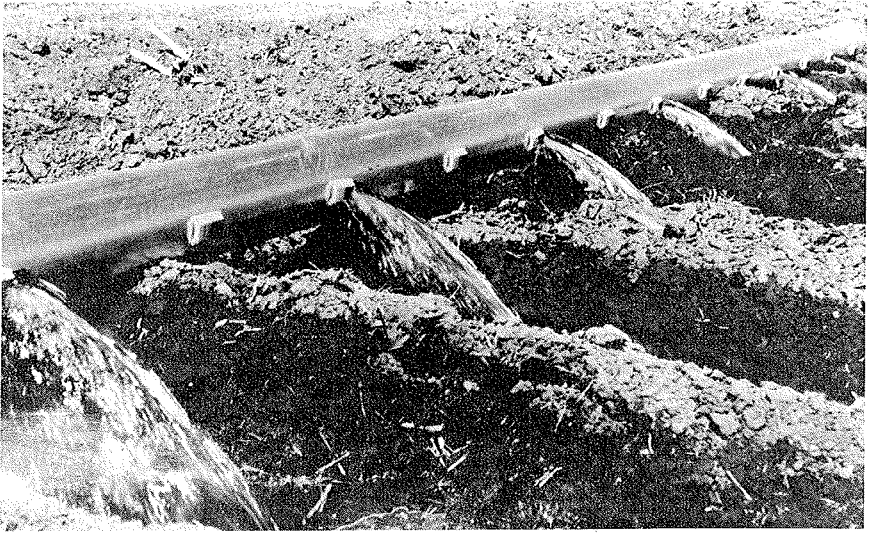
gpm <u>1/</u>	cfs <u>2/</u>	ac.	ac.	ac.	ac.	ac.	ac.	ac.
		.5	1.0	2.0	3.0	4.0	5.0	10.0
		hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
225	0.5	3.0	6.0	12.0	18.0	24.0	30.0	60.0
450	1.0	1.5	3.0	6.0	9.0	12.0	15.0	30.0
675	1.5	1.0	2.0	4.0	6.0	8.0	10.0	20.0
900	2.0	0.75	1.5	3.0	4.5	6.0	7.5	15.0
1125	2.5	0.6	1.2	2.4	3.6	4.8	6.0	12.0
1350	3.0	0.5	1.0	2.0	3.0	4.0	5.0	10.0

1/ gpm - gallons per minute

2/ cfs - cubic feet per second

Tables 1 and 2 can help you determine how many hours you should irrigate each set to apply 3 inches of water.

Example: An irrigator with a pumping plant producing 900 gallons per minute is set on 40 (40 inch wide) furrows, 1320 feet long.



Off-Season Irrigation with Gated Pipe Spacing the gates at 20 inch intervals assures the irrigator with 30 inch spaced furrow a gate will always be available for every furrow without shovel work even though all the furrows are not equally spaced at 30 inch intervals.

See Table 1. Find the number of furrows per set (40). Follow down the column to the figure opposite 1320 ft. (4.0 acres). Go to Table 2 and locate the column headed by 4.0 acres, follow down this column to the number of hours opposite 900 gallons per minute (6.0 hours).

Therefore, it would require six hours to apply 3 inches of water on 4.0 acres when pumping at the rate of 900 gallons per minute. If you use a 12 hour set, 6 inches of water would be applied, which is too much.

### Distributing Water Uniformly

Applying the right amount of water to your irrigation set is not enough. Water must be uniformly applied from one end of the irrigation run (field) to the other. Crop yields may be reduced on both ends of the field if one end receives too much water and the other end too little water.

Perfect water distribution is seldom obtained with any method of irrigation, but knowledge of the factors involved and the use of the guides in this publication will help you achieve good water distribution.

Those factors are: length of run, intake rate of the soil, furrow stream size, and furrow slope.

### Furrow Slope

The more uniform the slope from one end of the irrigation run to the other the more uniform the water distribution. It is almost impossible to construct and maintain a completely uniform slope from one end of the field to the other. Changes in slope up to 0.1 foot per 100 feet are usually satisfactory on an average slope of 0.2 foot per 100 feet.

### Length of Run

In general, the length of irrigation runs should not exceed 600 feet on sandy soils and about 1300 feet on clay soils. The length of run will be less than the suggested distance because of fixed boundaries on some fields. In other fields the length of run will be more than the recommended distance.

For example, if a field with a silty clay loam soil had fixed boundaries at a distance of 1500 feet, the operator probably would irrigate the entire length in one irrigation run, to save labor in operating the system.

However, running the water too far causes deep percolation on the upper end. If the length of run is too long, divide the field in half by adding another irrigation lateral or by setting gated pipe half-way in the field.

### Intake Rates

The rate at which water goes into the soil varies from season to season and from one irrigation to the next during the season. This means that you can't use the same furrow stream size or irrigation time every time you irrigate. You must observe and adjust the system each irrigation to achieve highest yields.

Soils compacted by tillage operations when the soil was too wet will have a lower intake rate than soils tilled at optimum soil moisture content.

Low soil moisture content during winter months reduces the freezing and thawing action in Nebraska soils and results in lower intake rates. You should consider supplying clay soils with moisture before the winter months, with a fall irrigation if necessary.

### Furrow Stream Size

Select a stream size appropriate for the slope, intake rate, and length of run. Using too large a stream down each furrow may cause serious erosion. Using too small a stream down each furrow will cause poor distribution of water within the field, because it takes too much time for the water to reach the lower end of the field.



Irrigating Corn With Gated Pipe

All the water can be delivered from the water source to the furrows when using gated pipe. The gates are adjustable from 0 to 50 gallons per minute.



A small furrow stream causes deep percolation on the upper end of the run, and in turn carries with it valuable nutrients, especially nitrogen. Also, a small furrow stream will not supply enough water for the lower end of the run (field) without causing the deep percolation on the upper end of the run. Maximum furrow stream sizes for various slopes are given in Table 3.

Table 3. Approximate Maximum Furrow Stream Size For Various Slopes

Percent Slope	Gallons Per Minute Per Furrow
1.0	10.0
0.5	20.0
0.3	30.0
0.2	50.0

The best approach is to use as large an irrigation stream down each furrow as possible without causing serious erosion. Approximate values of this stream size are shown in Table 3.

Water should reach the far end of the furrow in the recommended time or less than the recommended time for the various soil textures (Table 4). If more time than is shown in Table 4 is required for water to reach the far end of the run when using the maximum allowable stream size, shorten the length of run.

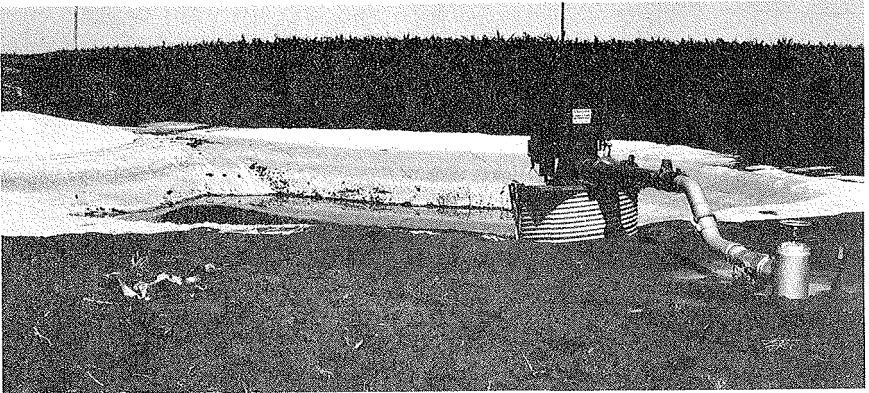
Table 4. Maximum Number of Hours for Water to Flow from One End of Field to Other for Various Soil Textures.

Soil Texture	Hours
Loamy sands	2-3
Sandy loams & some clay soils (Albaton)	3-4
Fine sandy loams	4-5
Silt loams	5-6
Silty clay loams	6-7

If the water flows through the field in less than the recommended time, the water distribution within the field will be better.

As soon as the water reaches the lower end of the field, the furrow stream can be reduced, so as to maintain a flow that will just barely produce runoff on the lower end.

To avoid making furrow stream adjustments, a reuse (tail water) system can be used to pick up the runoff water. Continue running water down the furrow until it has penetrated the desired soil depth. Determine depth of penetration by sampling the soil with a soil tube or auger.



Reuse (tailwater) System

A reuse system picks up the runoff water to put it back into the same irrigation set or another field. It saves labor by eliminating the need for furrow stream adjustment. It makes it easier to do a good job of irrigating without wasting water. Efficiencies of 87 to 92 percent can be obtained with Surface Irrigation using gated pipe and a reuse system.

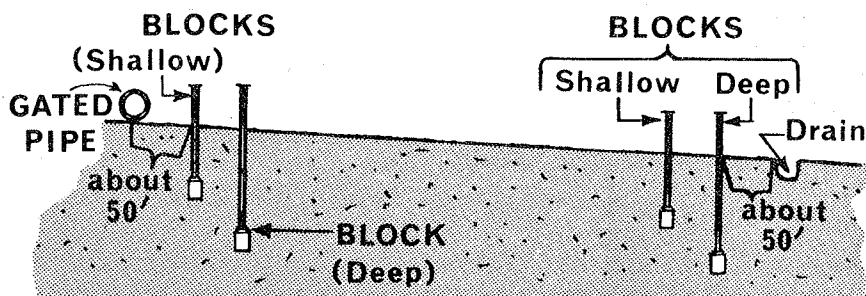
Another good method of selecting the correct furrow stream size is to install tensiometers or electrical resistance blocks in the first irrigation set.

One station (at least 2 tensiometers or electrical resistance blocks placed at various depths) can be installed about 50 to 100 feet from the upper end of the irrigation

run and another station about the same distance from the lower end of the irrigation run.

Select a furrow stream size appropriate for the slope, soil texture and length of run (Table 3), for a trial irrigation set. Then irrigate the set.

After the irrigation has been completed or even while the set is still being irrigated the soil moisture sensing devices can be read. If gauge readings show that water has penetrated beyond the deep soil moisture sensing device on the upper end of the run, but has not yet penetrated to the shallow soil moisture sensing device on the lower end of the run, then increase the furrow stream size in the next irrigation set.



Electrical resistance block, and/or tensiometer stations can be installed at strategic locations in the field to evaluate water penetration between the upper and lower end of the field.



How much the furrow stream size is increased or reduced is determined by trial and error; consequently, additional adjustments may be necessary. Increase or reduce the stream size by opening or closing gates in gated pipe or by setting more siphon tubes per row or by using larger or smaller diameter siphon tubes.

### Alternate Furrow Irrigation

To produce high yields on all acres served by one water source, it is important to irrigate every acre as quickly as possible during the critical stages of growth. Irrigating every other furrow results in getting water to more acres faster than irrigating every furrow, and still provides irrigation water to at least one side of the row.

Some irrigators with 40-inch spaced furrows have used this practice for many years. However, there is a question of the effect of irrigating every other furrow on the yield per acre.

It appears that the ditching operation (making the irrigation furrows) may damage some of the root system. However, research shows that if adequate water and nutrients are available almost immediately, the plant will respond for high yields. On the other hand, if the soil is left dry, yields are reduced.

Another factor which may influence the response of the corn plant is the amount of soil air. Plant roots need oxygen as well as water and nutrients. On clay pan soils if every furrow is irrigated excessively, the soil air may be reduced to a point where it is the limiting factor of production. Consequently, irrigating every other furrow may help reduce this problem.

On shallow sandy soils and on some clay (albaton) soils which have rapid intake rates, there is a problem of applying too much water each irrigation. Irrigating every other furrow would help reduce this problem.

On the other hand, shallow sandy soils have limited water holding capacity per foot of depth and may need more frequent irrigations when only irrigating every other furrow.

It appears this practice has many merits but furrows should be alternated every other irrigation to maintain the soil moisture level in all the root zones at an optimum level.

### How to Use Tables 1, 2 and 3

A well delivers 900 gpm, slope is 0.3 percent (0.3 ft. per 100 feet), field is 1320 ft. long. What is recommended furrow stream, time to irrigate, number of furrows per set?

a. Using Table 3, find that 30 gallons per minute per furrow should be used.

b. Then 900 divided by 30 = 30 furrows per set.

c. From Table 1, if the field is 1320 feet long, and rows are 40" apart, the area irrigated is 3.0 acres per set.

d. From Table 2, read across from 900 gpm to 3.0 acres per set, find that 4.5 hours is required to apply 3 inches of water.

e. If water does not reach the lower end of the furrows in this 4.5 hours, either the furrow stream must be increased or the length of the furrows decreased. (See Table 4). Usually a larger flow is used to "get the water through." Then the flow is reduced and additional furrows opened.

### Do It Yourself

You can understand any irrigation by knowing and applying a simple relation: one cubic foot per second (450 gallons per minute) flowing for one hour applies one inch of water on one acre. Expressed a little differently:

$$\frac{\text{Gallons per minute pumped} \times \text{hours}}{450} = \text{acre - inches applied}$$

Here are several examples to illustrate the use of this relationship:

1. An irrigator has a 900 gpm well, and wishes to apply 3 inches of water on 160 acres. How many hours should he operate the well?

$$\frac{900 \text{ gpm} \times \text{hours}}{450} = 160 \text{ acres} \times 3 \text{ inches}$$

$$2 \times \text{hours} = 480 \text{ acre inches}$$

$$\text{hours} = 240$$

or 20 hours each day for 12 days.

2. The above example does not provide consideration for water losses which occur even in well-designed and properly operating systems. For a good system, the water to be applied can be increased by 20%. Instead of 3 inches, use 3 inches + 20%, or 3.6 inches. The number of hours to operate also increases by 20 percent, from 240 hours to 288 hours.

3. A man pumps 1000 gallons per minute for 12 hours into gated pipe. He uses 40 gates per set, in 30" wide furrow spacing, and his rows are a quarter-mile long. How good is his irrigation system?

First, determine the area irrigated (Table 1), which shows that for 40 furrows, 30-inch spacing, 1320 feet long, the area irrigated is 3.0 acres.

Then, from the relationship:

$$\frac{1000 \text{ gpm}}{450} \times 12 \text{ hours} = 3.0 \text{ acres} \times ? \text{ inches}$$

$$2.22 \times 12 = 3 \times ? \text{ inches}$$

$$\frac{2.22 \times 12}{3} = ? \text{ inches} = 8.88 \text{ inches}$$

In this case, 8.88 may be an excessive application of water, suggesting that the system should be adjusted.