



*Infiltration and Its Relation to Soil and Water
Conservation Under Irrigation*

STEPHEN J. MECH
*Division of Irrigation and Water Conservation
Soil Conservation Service**

IRRIGATION HAS BEEN PRACTICED in many parts of the world for centuries, but it was not until about the beginning of the present century that any systematic study of it was made. Interest in soil and water conservation is even more recent. Compared to many agricultural sciences, irrigation is a very young science indeed.

The Research Division of the Soil Conservation Service has conducted experiments on soil and water conservation at the Irrigation Experiment Station at Prosser since 1939. The ultimate objective of these studies is to find out how to get sufficient moisture into the soil for maximum crop production with the least amount of erosion and water loss.

Current work deals with the irrigation and erosion characteristics of furrow or rill irrigation. It is primarily a critical evaluation of stream size, furrow grade, length of run, tillage, crop, and crop sequence as these influence soil and water conservation. Basic data for the evaluation of these factors consist of information on rates and total amounts of erosion; amounts, frequency, and duration of irrigation; and infiltration rates. Comprehensive soil moisture determinations before and after each irrigation furnish information on the moisture consumption between irrigations as well as on the efficiency of different irrigation practices. Yield records are obtained for all experimental areas.

Alfalfa is by far the most extensively grown crop in the irrigated areas of the Northwest. Since alfalfa has a profound influence on the soil, both dur-

*Washington Agricultural Experiment Station cooperating.

ing the time it is being grown and for some time after it is plowed under, all current studies are being made on crops as they occur in a seven-year rotation. The seven-year rotation of wheat, alfalfa (three years), potatoes, sugar beets, and corn is a commonly recommended practice. Data are now available through the alfalfa or soil-building phase of the rotation.

INFILTRATION RATE DETERMINING FACTOR

A CHARACTERISTIC of furrow irrigation is that the irrigating head applied to a furrow cannot be reduced to less than its infiltration rate without sacrificing irrigation at the lower end of the field. For example, if a 400-ft. furrow can take up water at the rate of 20 gal/min and a stream of 15 gal/min is turned in, only the first 300 ft. will be irrigated. The 100 ft. at the far end will remain dry. The rate at which the entire furrow takes up water represents, therefore, the minimum below which the practicable irrigating head cannot be reduced.

A given length of run can be irrigated with a smaller head when its infiltration is low than when its infiltration is high. It is an accepted fact that reducing the irrigating head will reduce erosion. Conversely, increasing the head will increase the erosion hazard, regardless of why the head is raised. This is an unfortunate combination of circumstances because the usual good farming practices such as rotation, contouring, adding of organic matter, and other soil improving practices generally increase infiltration.

Table 1 shows something of the influence that crop and crop sequence exert on infiltration. It shows that the same field cropped to corn, potatoes, alfalfa, and alfalfa on successive years had a wide range of irrigation characteristics. First-year alfalfa, although it produced more than 5 tons of hay in three cuttings, had an infiltration rate not much higher than that found for row crops. Beginning with the second year the infiltration rate doubled and the necessary duration of irrigation was cut in half. This shows that the irrigation characteristics of first-year alfalfa are quite different from those of the older stand.

Reducing the furrow grade from 7 per cent to 2 per cent by directing the furrows across the slope has practically doubled the infiltration rate. This increase in infiltration is attributed not to any soil difference, but to the fact that the wetted area in the furrow on the 2 per cent grade is about twice that

Table 1.—Influence of crop and crop sequence on infiltration and duration of irrigation for two furrow grades

Crop sequence	Infiltration		Duration*	
	Fur. gr. 7%	Fur. gr. 2%	Fur. gr. 7%	Fur. gr. 2%
	<i>in/br</i>	<i>in/br</i>	<i>br.</i>	<i>br.</i>
Corn (10 years after alfalfa)	0.16	0.28	25.0	14.3
Potatoes (following corn)	0.14	0.25	28.6	16.0
Alfalfa (first cutting year)	0.18	0.32	22.2	12.5
Alfalfa (second cutting year)	0.39	0.62	10.2	6.4

*For 4-in. irrigation.

on the 7 per cent slope. There is more surface in contact with the water, thus increasing the area through which the water can enter the soil.

Another field taken out of alfalfa and cropped to potatoes for three consecutive years gave the results shown in Table 2.

Table 2.—Residual influence of alfalfa on infiltration and irrigation of potatoes

Potatoes	Infiltration	Duration*
	<i>in/br</i>	<i>br.</i>
Following alfalfa	0.33	12.2
Second year after alfalfa	0.16	25.0
Third year after alfalfa with rye as green manure	0.20	20.0

*For 4-in. irrigation.

Table 2 shows that potatoes the first year following alfalfa and potatoes two years after alfalfa have entirely different irrigation characteristics. Since the differences are not due to any apparent differences in vegetation during the two years, it must be attributed to the residual effect of the alfalfa on the soil. This influence is greatly reduced during one year of row cropping.

Disturbing the irrigation furrow by reditching decreases the rate at which the water enters the soil. Infiltration for alfalfa averages 0.37 in/hr for the irrigations preceding reditching and where the furrows were not disturbed since the last irrigation, but infiltration dropped to 0.26 in/hr for those irrigations following reditching. On this basis it would require 15.4 hr. for a 4-in. irrigation after reditching, while only 10.5 hr. were sufficient to add 4 in. of water before reditching.

The effect of soil management and soil disturbance on rate of infiltration is further illustrated by a case in which irrigation was made in an established apple orchard. Here the infiltration rate was 0.66 and 0.72 in/hr for two successive years ditched only once—in the spring. Because the alfalfa stand was running out it was plowed and seeded to rye the third year.

The infiltration rate during that season averaged only 0.26 in/hr. It required 15.4 hr. to add 4 in. of water to the soil. The same amount was added to the soil in about 6 hr. before the plowing of the old cover crop.

EROSION IN IRRIGATION FURROWS

IN FURROW IRRIGATION, as in rainfall, the greatest erosion is at the point of greatest water flow. In furrow irrigation, however, the greatest flow is at the upper end of the run, and it is there that the greatest soil movement takes place. Heavy erosion can take place on the upper parts of an irrigated field with no appreciable runoff or soil loss at the bottom. That severe erosion occurs even under good irrigation practices may be illustrated by the data in Table 3. The data show flow and erosion conditions at three points along a furrow laid out on a 2 per cent grade. Since the 7.03 gal/min application rate

Table 3.—Characteristics along an irrigation furrow having a 2 per cent grade

Distance from bottom of furrow	Flow per furrow	Soil loss per furrow	Runoff	Infiltration	Travel time	
					From point of application	For 300 ft. distance
ft.	gal/min	lb.	%	in.	hr.-min.	hr.-min.
7.03 gal/min per furrow applied 900 ft. from bottom						
600	4.49	116	61	3.8	0 - 48	0 - 48
300	1.94	13	21	3.9	3 - 31	2 - 43
0	0.67	1	2	1.9	11 - 22	8 - 51
8.08 gal/min per furrow applied 900 ft. from bottom						
600	5.46	137	66	3.9	0 - 24	0 - 24
300	3.14	38	35	3.7	1 - 38	1 - 14
0	1.42	2	8	3.5	7 - 16	5 - 38

required too much time to reach the end of the furrow, the head was raised to 8.08 gal/min for the second test. This, too, required a longer time than is practical, as can be seen by the travel time. Soil and runoff measurements were made 300, 600, and 900 ft. down from the point of application.

It is interesting to note that considering the 900-ft. run as a whole, both the runoff and the soil losses are negligible and the over-all irrigation is very good on both counts. Yet when consideration is given to what is occurring along selected portions of the furrow it becomes evident that parts of it are subjected to severe runoff and erosion.

It becomes apparent that erosion measurements at the bottom furnish very little information on what is occurring up the slope. The upper third of this run, for example, is irrigated with an average runoff of 61 per cent and 66 per cent. The soil losses at the bottom end of this 300-ft. section are 116 lb. and 137 lb. The upper end of this run has a considerably greater flow and, no doubt, is subjected to an even greater soil loss.

The middle third receives a much less severe treatment. Yet here, too, the soil and runoff are quite high. The erosion at the upper part of this section is 116 lb. and 137 lb. while that at its lower end is 13 lb. and 38 lb. The lower third is subjected to a very small head and though the soil movement over its length is small, the effectiveness of the irrigation is considerably reduced by this reduction in irrigating head.

There is no satisfactory way of avoiding greater flow on the upper ends of irrigating furrows. Whether the 7.03 gal/min application is used to irrigate a 900-ft. run or is all taken up in a shorter run and greater infiltration, there will still be a soil loss of 137 lb. at the point where the flow is 5.46 gal/min. It is inherent in furrow irrigation that the upper part of the furrow must act as a channel to supply the water required by the rest of the run. Whether this demand is due to length of run or increased infiltration, or both, is immaterial. The water must be delivered at a rate high enough to satisfy the total infiltration demand. This last consideration makes infiltration rate the limiting factor below which the irrigating head cannot be satisfactorily reduced.

EROSION CONTROL RECOMMENDATIONS

THOUGH THE APPLICATION RATE cannot be reduced to less than the infiltration rate of a furrow, considerable saving of soil and water can be accomplished by positive means of controlling the irrigation head. Measurements on various farms have shown that in many cases as much as 70 per cent of the applied water is wasted from the field. This tail water contributes

practically nothing towards more effective irrigation. It merely moves more soil out of the furrow.

Erosion takes place early in the irrigation. On slopes of approximately 7 per cent practically all of the erosion takes place within 3-4 hr. after runoff begins. To illustrate, corn had a total soil loss of 22.7 tons per acre during a 24-hr. irrigation; 17.3 tons of soil eroded during the first 32 min. of flow, and all of the loss took place within 4 hr. Irrigation after the fourth hour added practically nothing to the total erosion though the furrow flow continued at the same or greater rate.

The use of a large head at the beginning of an irrigation to get the water through and then make the final setting may have some justification from the irrigation convenience standpoint. From the erosion standpoint, however, the surge of this large stream will cause excessive erosion. If this large stream flows for 3-4 hr. it will cause in that time practically all the erosion damage it will do during the entire irrigation. Letting this stream on for even 2 days more would add very little to the total erosion damage.

Steep slopes are more vulnerable to erosion than the more gradual ones. Under average irrigating conditions where the runoff from the end of the furrow is from 20 to 50 per cent, reducing the furrow grade causes a distinct reduction in erosion. It also permits better distribution of moisture and increases the infiltration.

Cultivation and other means of stirring the soil are by far the greatest single causes of erosion. First-year alfalfa, on a 7 per cent slope irrigated immediately after reditching, lost 477 lb. of soil per furrow. The next irrigation, using approximately the same head, without disturbing the furrow, lost only 52 lb. Third-year alfalfa on the same slope lost 250 lb. and 24 lb. for the disturbed and undisturbed furrows respectively.

That the same thing is true in row crops may be illustrated by the following: Corn lost 450 lb. of soil during the irrigation just after the last cultivation, but the next irrigation, with the same furrows in a laid-by condition, lost only 77 lb. The possible use of chemicals and flame for weed control has much potential value in erosion control.

Vegetation in the furrow itself will hold the soil and reduce soil movement. For most effective control the irrigating furrow should remain undisturbed for as long a time as possible. It is in the furrow, where the soil and flowing water are in contact with each other, that the protection is necessary.