Straw residue to control furrow erosion on sloping, irrigated cropland

Robert D. Berg

ABSTRACT: Small amounts of straw placed uniformly in steeply sloping portions of irrigation furrows reduced soil erosion and sedimentation on three fields with an erodible silt loam soil. Erosion was eliminated during the first irrigation on two fields in the straw-treated plots and markedly reduced during subsequent irrigations on these plots and on the third field. The reduction ranged from 30% to 100% in straw-treated furrows compared to furrows without straw. Straw treatment also increased infiltration and lateral water movement significantly, and crop yields rose 7% to 16%.

FURROW erosion on steep farmland remains a major problem for irrigated agriculture. The problem has existed for more than 40 years. Soil losses of 50.9 metric tons per hectare (22.6 tons/acre) were reported on a 7 percent slope during a 24-hour irrigation of corn on Sagemoor fine sandy loam (*4*). Extensive work on the effects of slope on irrigation furrow erosion showed that erosion will occur on most row-cropped soils when slopes exceed 1% (*4*). Erosion can be controlled on slopes up to 2% if stream size is carefully regulated.

In an Idaho study, a sugarbeet field with a 4% slope lost 141 mt/ha of soil in one season (*2*). This is equivalent to a depth of 8 to 9 millimeters of soil over the entire field. Erosion and soil loss were most severe on fields in row crops, for example, corn, dry beans, and sugarbeets. The relationship between slope and soil loss also held with cereal grain, but soil loss was only about one-tenth that for row crops. No soil loss was measured from alfalfa fields. In fact, alfalfa removed sediment from the irrigation water.

Many fields in southern Idaho have a relatively flat slope at the upper end and a steep slope toward the middle or lower end of the field. A fairly large stream size is set at the head ditch to ensure that water will reach the lower end of the furrows quickly, allowing reasonably uniform water distribution (*3*). When the furrow stream reaches the steeper sloping sections of furrows, flow velocity increases and soil erosion increases greatly. If stream size is reduced at the head ditch, flow may decline on the upper, flat-slope section and no longer reach the furrow end. Irrigation requirements are thus not satisfied.

Robert D. Berg is a soil technician at the Snake River Conservation Research Center, Route 1, Box 186, Kimberly, Idaho 83341. This article is a contribution from the Snake River Conservation Research Center, Agricultural Research Service, U.S. Department of Agriculture.

Applying plant residue to irrigated cropland reduces soil erosion. In one study, soil erosion was essentially eliminated when furrows contained 2.2 mt/ha of straw along the furrow. This was equivalent to about 0.4 mt/ha on a total area basis. Even smaller amounts, down to 60 kilograms of straw per hectare, effectively reduced furrow erosion.

Reported here are the results of placing straw uniformly in furrows on the steeper sections of fields to reduce soil erosion and to increase infiltration. Straw is an inexpensive, readily available resource in most irrigated areas.

Study procedures

Four studies were conducted on Portneuf silt loam (Durixerollic Calciorthid) during the 1982 irrigation season in southern Idaho. The studies took place on three fields owned by two cooperators.

Plots in study 1 were arranged in a randomized block design with four treatments and three replications. The plots were 30.5 meters (100 feet) long and three rows wide, each 76 centimeters (30 inches) apart. The plots were located on the steepest part of the field, which had a 4% slope beginning about 100 m below the head ditch. Corn was planted by the cooperators. After the final cultivation, straw was placed by hand uniformly in the furrows on the plots. The straw treatments were as follows: check, no straw; S1, 0.6 mt/ha; S2, 1.2 mt/ha; and S3, 2.2 mt/ha. The field was irrigated with gated aluminum pipe. Inflow to all plot furrows was set at 9.5 liters per minute at the gated pipe. Water samples for sediment analysis were collected during as many irrigations as possible. One-liter samples (0.9 quart) were collected at the top and bottom of the plots, beginning after the furrow flows had run long enough for the stream size to stabilize. Samples were collected at intervals during each irrigation. Infiltration was determined by measuring inflows and outflows on the furrow plots. Lateral wetting was determined by measuring the width of the surface-wetted band along the furrow after each irrigation. The flows were measured with small, trapezoidal, 60-degree flumes.

Samples were filtered, oven dried, and weighed to determine sediment concentration. Furrow erosion was calculated from sediment concentrations and flows for the duration of each irrigation and totalled for the season.

Study 2, conducted on the same field as study 1, was located on a 1.5% slope below the steeper (4%) slope. There were three treatments, with omission of the highest straw rate (2.2 mt/ha), and three replications. The high straw rate was not used because it was thought the large amount of sediment carried down from the

Table 1. Furrow erosion rates, study 1.

Treatment	Soil Loss (mt/ha)	Soil Retained (mt/ha)
Study 1 (corn), 4% slope, 12-hour irrigations		
First irrigation		
Check	32.5	
S1		2.7
S2		7.8
S3		5.6
Second irrigation		
Check	25.8	
S1	17.9	
S2	4.7	
S3	4.5	
Third irrigation		
Check	60.5	
S1	21.3	
S2	15.1	
S3	6.2	

Table 2. Furrow erosion rates, study 2-4.

Treatment	Soil Loss (mt/ha)	Soil Retained (mt/ha)
Study 2 (corn), 1.5% slope, 12-hour irrigations		
Check		45.9
S1		55.5
S2		59.9
Study 3 (beans), 5.0% slope		
Check	3.3	
S1	0.1	
S2	0.05	
S3	0.5	
Study 4 (beans), convex ends, 10% slope		
Check	311	
S1	39.2	
S2	65.0	
S3		11.0

Reprinted from the Journal of Soil and Water Conservation
January-February 1984, Volume 39, Number 1

Figure 1. Straw placed in irrigation furrows increased lateral wetting.

steeper slope would fill up the lower plot furrows. This was also found to be true on the two lower straw rates that were used. Sediment samples were collected, and measurements were made during the first irrigation after cultivation. Thereafter, all the straw furrows were completely filled with sediment, and representative samples could not be obtained.

Study 3 was located in a bean field along a portion of the length where the slope was 7%. The three straw rates tested previously, plus a control plot, were used, comprising four treatments with three replications.

Study 4 was on a bean field where the tailwater ditch had eroded below the ends of the furrows. The result was a steep slope at the end of the field, called a convex end, which causes severe erosion along the lower 10 to 30 m of the furrows. Three straw rates were placed in these furrows. Plots were 7.6 m (25 ft) long and four furrows wide. There were four treatments and two replications. Sediment samples were taken and furrow flows were measured during the first irrigation. Lateral furrow wetting and depth of furrow erosion was determined after the irrigation was completed.

Results and discussion

In study 1, during the first irrigation, furrow erosion was eliminated on all straw treatments, and 10% to 30% of the soil eroded from the portions of the furrows above the plots was retained in the straw-treated furrows within the plots (Table 1). After the first irrigation, the straw had a tendency to settle and become more dispersed in the furrows, allowing water to channel around it. This reduced the straw's effectiveness. As a result, there was some soil loss during the second irrigation.

The soil loss and infiltration rate were higher during the third irrigation (Table 1) than during the earlier irrigations (Tables 1 and 3). This resulted from increased furrow stream size, which was three times that in the earlier irrigations.

The two highest straw rates were the most effective in reducing erosion during the three irrigations (Table 1).

Corn silage yields on the straw plots were 8% to 16% higher than those with no straw treatments (Table 4). This yield increase resulted from greater water infiltration and better lateral water movement from straw-treated furrows. The increased yield added to net returns from the crop and produced more crop residue that will have subsequent beneficial effects upon the severely eroded soil.

Data were collected from study 2 during the first irrigation only. During the following irrigations, the large amounts of soil that were eroded from the steeper, upper slopes completely filled all straw-treated furrows, making any further measurements impractical. The heaviest straw rate (S-3) was not used because it was thought that it would increase sedimentation in the furrows too much. The two straw rates retained 7% to 23% more sediment than untreated furrows (Table 2). These results indicate that furrow residue plots should not be located below highly erodible steep slopes.

Infiltration rates on the straw plots were 50% higher than on those with no straw treatments (Table 3). Measurements of lateral furrow wetting and furrow erosion depth were not made because of heavy soil deposition in the furrows (Figure 1).

Because of an unreliable water supply, measurements were made only during the first irrigation after cultivation in study 3. Furrow inflow was quite low, resulting in a small amount of soil erosion. The straw plots reduced soil erosion 96% to 98% compared with check furrows (Table 2). Infiltration on the straw plots was 50% more than on the plots with no straw treatment. Lateral furrow wetting on the straw plots increased 17% to 41% more than on those with no straw. In contrast, furrows without straw eroded into narrow, deep channels with a small wetting parameter, and the water source was often 15 cm below the soil surface. Increased lateral wetting resulted because furrows with straw did not erode into narrow channels cut deep into the soil. Instead, they become wide, shallow furrows with a greater wetting parameter. The water source remained near the soil surface and thereby moved better laterally. Depth of furrow erosion declined significantly on the straw plots (Table 3).

High furrow inflows washed out most of the straw treatments after the first irrigation in study 4. Erosion measurements were taken during the first irrigation only. The two lower straw rates reduced erosion 79% to 87% compared with the control furrows. The highest straw rate (S-3) eliminated all soil erosion and retained some sediment from upstream in the furrow. No measurable infiltration differences could be detected because of the short plot length.

Table 3. Furrow infiltration rates, width of lateral wetting, and depth of furrow erosion after a 12-hour irrigation.

Treatment	*Infiltration (l/min)*	*Furrow Wetting Width (cm)*	*Depth of Furrow Erosion (cm)*
Study 1 (corn)			
First irrigation			
Check	1.2	38	10-15
S1	1.8	50	2.5-5.0
S2	1.7	66	0-2.5
S3	3.2	71	0-2.5
Second irrigation			
Check	1.1	38	8-10
S1	1.5	50	2.5-5.0
S2	2.3	71	0-2.5
S3	3.0	72	0-2.5
Third irrigation			
Check	2.6	38	8-10
S1	4.3	50	2.5-5.0
S2	4.3	71	0-2.5
S3	7.2	72	0-2.5
Study 2 (corn)			
First irrigation			
Check	1.1	-	-
S1	2.3	-	-
S2	2.3	-	-
Study 3 (beans)			
First irrigation			
Check	1.1	25-30	7-10
S1	2.2	30-36	2.5-5.0
S2	1.9	41-46	0-2.5
S3	2.6	46-51	0-2.5
Study 4 (beans), convex ends, no infiltration differences			
First irrigation			
Check		20-25	10-15
S1		25-30	2.5-5.0
S2		38-51	0-2.5
S3		46-51	0-2.5

Table 4. Crop yields from study 1.

Treatment	*Corn Silage (mt/ha)*
Check	63.0
S1	68.0
S2	71.0
S3	75.0

Lateral furrow wetting increased and depth of furrow erosion declined on all straw treatments.

Straw length proved important in reducing furrow erosion. Short straw had a tendency to float down the furrows and bunch up when the water was first applied. Longer straw tended to stick into the sides of the furrows and become imbedded when the water was applied. The straw residue may stay in place better if it were pressed lightly into the furrow after application.

High stream flows (over 7.5 l/min) on steep slopes will wash out straw residue placed in the furrows. Therefore, stream size control is a factor in the success of straw treatment for erosion control on steep slopes.

Erosion can be controlled on critical-slope portions of furrow-irrigated fields by placing straw in the furrows along the critical slopes. Not only is erosion reduced, but infiltration and lateral wetting are increased. Improving these parameters increased crop yields on those critical-slope portions of the fields. Placing straw in the furrows below the critical-slope areas traps too much sediment. Furrows fill with sediment, which results in inadequate irrigation of downslope portions of the field.

Use of straw to control erosion on critical-slope portions of furrow-irrigated fields is an inexpensive management alternative to protect an important resource, the soil.

REFERENCES CITED

1. Aarstad, J. S., and D. E. Miller. 1981. *Effect of small amounts of residue on furrow erosion*. Soil Sci. Soc. Am. J. 45: 116-118.
2. Berg, R. D., and D. L. Carter 1980. *Furrow erosion and sediment losses on irrigated cropland*. J. Soil and Water Cons. 35(6): 267-270.
3. Carter, D. L. 1976. *Guidelines for sediment control in irrigation return flow*. J. Environ. Quality 5(2): 119-124.
4. Mech, S. J. 1959. *Soil erosion and its control under furrow irrigation in the arid West*. Info. Bull. 184. Agr. Res. Serv., U.S. Dept. Agr., Washington, D.C. 6 pp. □