IMPROVED IRRIGATION EFFICIENCY AND REDUCTION IN SEDIMENT LOSS BY MECHANICAL FURROW MULCHING WHEAT

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Abstract

Treasure spring wheat was grown on sloping ground with and without mechanically applied furrow mulching. Furrow mulching used 800 lb/ac of wheat straw. Mulched and non-mulched furrows were irrigated five times during the season receiving 483 and 19.0 and 40.9 ac-in of irrigation water, respectively. For non-mulched furrows, infiltration totaled 13.0 ac-in, while runoff constituted 27.9 ac-in or 68.1 percent of applied water. For mulched furrows, infiltration totaled 13.2 ac-in, while runoff constituted 5.8 ac-in or 30.5 percent. Average sediment yield was reduced from 49.4 tons/ac to 2.2 tons/ac with furrow mulching. Grain yield increased by 15.7 bu/ac with furrow mulching, from 96.0 to 111.7 bu/ac.

Introduction

The use of surface irrigation on sloping ground has resulted in substantial loss of topsoil in Malheur County over the last 50 years. Wheat straw can be used to mulch irrigation furrows, with potential short term and long term benefits. Often the potential economic advantages of a change in crop management practices is evaluated on a one-year basis. In the present study, irrigation furrows in field plots have received 0 or 800 lbs/ac of wheat straw each of four successive years. While furrow mulching led to increased potato quality in 1990, there was no yield improvement. Repeated furrow mulching led to increased yields of onions in 1991 and sugar beets in 1992. Would yield advantages continue with spring wheat in 1993?

Consistently, furrow mulching has provided reduced sediment loss and improved irrigation efficiency for the row crops. Would sediment losses and improvements in irrigation efficiency and sediment loss be less with wheat that is planted perpendicular to the direction of the irrigation furrows and covers much more of the soil surface?

Procedures

A 1.3 acre field of Nyssa silt loam with 3 percent slope was planted April 24, 1993, to Treasure spring wheat at 115 lb/ac. Planting was delayed by late snow melt (March 17) and wet spring soil conditions. Planting followed fall chisel plowing and fall planting of winter wheat. Winter wheat stands failed due to carry-over residual herbicide damage from herbicide applications to the preceding sugar beet crop.

Irrigation furrows were bedded out at 27 inch spacing and the field was divided into 27 plots, each 235 feet long, arranged lengthwise down the field. At random, 12 of the plots were designated in 1990 as non-mulched plots and 12 were designated as furrow-mulched plots. The other three plots have been planted as borders. Potatoes, onions, sugar beets, and spring wheat have been planted in successive years (1990, 1991, 1992, and 1993) with and without mechanical furrow mulching of wheat straw at 800 lb/ac each year (Hobson Mulching System, Hobson Manufacturing Inc., Ontario, OR). Gated pipe was arranged so that all 24 plots were irrigated during the same irrigation set but the duration of irrigation in the non-mulched furrows was longer due to slower water infiltration rate.

Regardless of furrow treatment, only every other furrow was irrigated at about 2 gallons/min during each irrigation. During successive irrigations, only the previously irrigated furrows were irrigated, a pattern which we have called "alternate" furrow irrigation.

On June 10 Bronate was applied using a tractor mounted spray boom at 1 qt/ac to control broadleaf weeds. On July 9 DiSyston EC was applied at 0.5 lb ai/ac by air to control aphids.

Water and Sediment Measurement

Onset of water inflow and water outflow, and measurements of water inflow rate, water outflow rate, and sediment yield were recorded during each irrigation. Water inflow rates were recorded and outflow rates were recorded for one of the two irrigated furrows in each plot. For each water outflow rate reading, a one-liter sample was placed in an Imhoff cone and allowed to settle for 15 minutes. Sediment content in the water, y in g/l, was found to be related to the Imhoff cone reading after 15 minutes (x) by the equation:
$y = 1.015x$
$r^2 = 0.98$
$p < 0.0001$.

Composite water samples were collected in 5-gallon buckets to obtain sediment samples for nutrient analysis during each irrigation. Sediment will be analyzed for nitrate-N, ammonium-N, total N, phosphate-P, and total P.

Total inflow, outflow, infiltration, and sediment loss were integrated from field measurements using a Lotus Improv program "InfilCal 5.0" (Shock and Shock, 1993).

During all five irrigations, inflow water samples and outflow water samples were collected from every plot. The collection time of the water was recorded and composite water samples were made in proportion to the water inflow or outflow volume calculated by InfilCal 5.0. Composite water samples will be analyzed for nitrate-N, ammonium-N, and phosphate-P. Net nutrient losses are to be calculated.

Results and Discussion

The crop developed slowly and did not need irrigation until May. The crop was irrigated on May 17, June 17, July 2, July 15, and July 28. Irrigation durations were shorter for the plots with furrow mulching. The long delays between irrigations and late crop maturity were caused by cooler and wetter than normal weather. Crop evapotranspiration or consumptive use was only 19.6 ac-in for the season.

The duration of irrigation with and without furrow mulching was managed to provide the crop about the same amount of water infiltration (19.4, 24.5, 12.7, 12.3, and 12 hours, respectively, with straw compared to 48, 47, 28, 24.3, and 25.5 hours, respectively, without straw). The irrigation duration in the non-mulched plots was prolonged so that water infiltration, 13.2 ac-in, closely matched the infiltration in the plots with furrow mulching, 13.0 ac-in, (Table 1). To match infiltration in the furrow mulched plots required that more than twice as much water be applied to the non- mulched plots. Irrigation water infiltration plus rainfall was less than crop consumptive use in both strawed and non-strawed plots (Table 2).

Without straw mulch, on average, 68.1 percent of the applied water was lost as runoff; whereas, with straw mulch the loss was 30.5 percent (Table 3). Water lost was not wasted, since it entered the feeder ditch for irrigating the next successive field down hill.

Sediment loss averaged 20 times higher in the non-strawed furrows than in the mulched furrows (Table 4). The high rate of sediment loss without straw mulch 49.4 t/ac was surprising given the soil cover provided by wheat.

Furrow mulching increased wheat yields from 96.0 to 111.7 bu/ac (Table 5). Since the increase in wheat yield was not directly related to relative water stress, increased yield may be due to cumulative improved soil conditions resulting from four years of continuous furrow mulching. Grain bushel weight and harvest index were not significantly changed by furrow mulching.

Table 1. Total water applied, runoff, and infiltration during five furrow irrigations with and without furrow mulching on spring wheat. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

	By irrigation					
	1	2	3	4	5	Total
No straw mulch	- - - - - - - ac-in§ - - - - - -					
Water applied	12.3	10.8	6.4	5.5	5.9	40.9
Runoff	9	7.6	3.6	3.6	4.1	27.9
Infiltration	3.3	3.2	2.8	1.9	1.8	13
Furrow mulching						
Water applied	4.4	5.8	3	3.1	2.7	19
Runoff	1.5	1.6	0.9	1	0.8	5.8
Infiltration	2.9	4.2	2.1	2.1	1.9	13.2
Comparison by mulching						
LSD(0.05) Water applied	0.3	0.4	0.1	0.4	0.1	0.7
LSD(0.05) Runoff	0.7	0.5	0.6	0.4	0.5	1.6
LSD(0.05) Infiltration	ns	0.5	0.8	0.2	ns	ns
§1 ac-in = 25.4 mm						

Table 2. Water budget for furrow irrigated spring wheat with and without furrow mulching. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

	No mulch	Furrow mulch
	ac-in	
Infiltration of applied water	13	13.2
Rainfall (planting to harvest)	3.2	3.2
Total supply for crop	16.2	16.4
Consumptive use (ET_c)	19.6	19.6
Estimated deep percolation	0	0
Estimated net extraction	3.4	3.2

Table 3. Percent runoff of applied water during five furrow irrigations with furrow mulching of spring wheat. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

	Percent runoff by irrigation					
	1	2	3	4	5	Total
	- - - - - - - - - - % - - - - - - -					
No straw mulch	74.8	72.3	56.4	64.4	69.8	68.1
Furrow mulching	32.7	28.5	30.3	30.8	31.5	30.5
LSD(0.05)	11.4	7	11.7	7.2	12.6	6.4

Table 4. Sediment yield in runoff water during five furrow irrigations with and without furrow mulching of spring wheat. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

	Sediment yield by irrigation					
	1	2	3	4	5	Total
	- - - - - - - t/ac§ - - - - - - - -					
No straw mulch	15.1	12.7	10	4.7	6.9	49.4
Furrow mulching	0.5	0.04	1.3	0.07	0.3	2.2
LSD(0.05)	3	1.5	6.3	1.1	2.9	15
§1 t/ac = 2.24 Mg/ha						

Table 5. Yield, grain weight, and harvest index of soft white spring wheat grown with and without furrow mulching. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

	Grain yield	Bushel weight	Harvest index
	bu/ac	lb/bu	0 to 1
No straw mulch	96	60.5	0.518
Furrow mulching	111.7	60.7	0.506
LSD(0.05)	8.1	ns	ns