SURGE IRRIGATION OF WHEAT, TO INCREASE IRRIGATION EFFICIENCY AND REDUCE SEDIMENT LOSS, 1993

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Abstract

Treasure spring wheat was grown using conventional furrow irrigation and surge irrigation on 12 one-half-acre plots. Both systems were operated simultaneously five times during the season. Conventional irrigation applied 24.7 ac-in of water with runoff of 5.6 ac-in and infiltration of 19.1 ac-in. Surge irrigation applied 12.0 ac-in with 1.7 ac- in of runoff and 10.3 ac-in of infiltration. Average grain yield under both systems was 128 bu/ac with no significant difference in grain quality. Surge irrigation reduced the loss of sediment in the runoff by 70 percent.

Introduction

Surge irrigation is a process where water is applied to an irrigation furrow intermittently, whereas in continuous-flow (or conventional) irrigation, water is applied to the furrow during the entire irrigation set. With surge irrigation, a switch valve, commonly referred to as a surge valve, is used to cycle water during an irrigation set from one half of the field to the other half.

Preliminary side by side trials comparing surge irrigation with conventional irrigation demonstrated the feasibility of using surge irrigation on silt loam soils in the Treasure Valley. In the 1991 side by side observation trial, spring grain yields were similar between the two systems with substantial water savings on surge irrigation plots. Surge irrigation used 12.9 ac-in of water compared with 28.2 ac-in of water used by conventional irrigation. In 1992, surge irrigation of onions was compared with furrow irrigation of onions for water use, onion yield and grade, and nitrate leaching. Substantial water savings and reduced nitrate leaching were observed, while onion yields were roughly equivalent; however, onion yield and grade diminished down the length of the irrigation row in the surge irrigation plots.

The 1993 surge irrigation trial was designed to compare the effects of surge irrigation with the effects of conventional irrigation on spring wheat yield and quality; water use, infiltration, and runoff; nitrate leaching; and sediment lost in the runoff. In the 1993 surge irrigation trial, a randomized experimental design was used providing replicated plots and resulting in greater certainty of treatment effects.

Procedures

A 6-acre field of silt loam soil was planted April 23, 1993, to Treasure spring wheat at 113 lb/ac. Planting was delayed by late snow melt (March 17) and wet soil conditions. Planting followed fall moldboard plowing and fertilization with 20 lb N, 100 lb P_2O_5, and 10 lbs Zn broadcast to frozen ground in the winter. Previous crops were onions and sugar beets.

Irrigation furrows were bedded out at 30-inch spacing, and the field was divided into 12 one-half-acre plots each 600 feet long, arranged lengthwise down the field. At random, six of the plots were designated as conventional furrow irrigation plots and six were designated as surge irrigation plots. Gated pipe was arranged so that all 12 plots could be irrigated during the same irrigation set. A Waterman Model LVC-5 surge valve automatically oscillated the water from three of the surge irrigation plots to the other three surge irrigation plots. Surges were programmed to range from 39 minutes to one hour long before switching to the other side of the field.

Regardless of irrigation system, only every other furrow was irrigated at about 6.5 gallons/min during any given irrigation. During successive irrigations, the previous dry furrows were irrigated, a pattern that we have called "alternating" furrow irrigation, as opposed to "alternate" furrow irrigation.

On June 6, 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. The west half of the field, the head end of the furrows, received 25 lb N/ac two times as spring broadcast urea. The east half of the field received no fertilizer.

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 for every furrow and outflow rates were recorded for every 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 $y = 1.015x$ with $r^2 = 0.98$ and $p < 0.0001$.

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.

Distribution of water infiltrating into the soil along the length of the furrows was determined using a neutron probe to 6 feet deep in one-foot increments. During each irrigation, water flow and infiltration down the length of several furrows were determined by making timed flow measurements at weirs at various distances for each treatment.

Results and Discussion

The crop developed slowly and did not need irrigation until May 11. The crop was irrigated again on June 15, July 1, July 14, and July 29. Irrigation durations were 28, 28, 24, 24, and 24 hours for both irrigation methods. The long delays between irrigations and late crop maturity were caused by weather that was cooler and wetter than normal. Spring wheat evapotranspiration or consumptive use was only 19.6 ac-in for the season.

The conventional irrigation system delivered an average season total of 24.7 ac-in of water, of which 5.6 ac-in was runoff and 19.1 ac-in was infiltration (Table 1). In comparison, surge irrigation applied only 12.0 ac-in of water with 1.7 ac-in of runoff and 10.3 ac-in of infiltration. The distribution of water along the length of the furrows was uniform in the surge plots. Infiltration plus rainfall was less than the crop evapotranspiration in the surge irrigation plots, and the irrigation deficit was made up by the spring wheat extracting residual soil moisture left over from the wet winter and spring (Table 2).

Surge irrigation resulted in a lower percent runoff than conventional furrow irrigation, 13.7 percent vs 22.7 percent (Table 3). In addition, total estimated sediment loss was reduced from 1,383 lbs per acre to 406 lbs per acre (Table 4).

Grain yield and quality were not significantly different between conventional furrow and surge irrigation (Table 5). Surge irrigation is an efficient way to conserve water while sustaining yields. Growers interested in surge irrigation systems should consult their local SCS office for engineering advice, since surge systems are only appropriate for certain fields.

Table 1. Total water applied, runoff, and infiltration during five furrow irrigations of spring wheat using surge and conventional systems. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

	By irrigation					
	1	2	3	4	5	Total
Conventional irrigation	- - - - - - - - - - - - ac-in - - - - - - - - - - - -					
Water applied	5.5	5.4	4.4	4.6	4.8	24.7
Runoff	1.3	1.1	1	0.8	1.4	5.6
Infiltration	4.2	4.3	3.4	3.8	3.4	19.1
Surge irrigation						

Water applied	2.4	2.6	2.3	2.3	2.4	12
Runoff	0.4	0.5	0.1	0.2	0.5	1.7
Infiltration	2	2.1	2.2	2.1	1.9	10.3
Comparison						
LSD(0.05) Water applied	0.4	0.1	0.2	0.4	0.2	0.8
LSD(0.05) Runoff	0.7	0.5	0.2	0.3	0.3	1
LSD(0.05) Infiltration	0.4	0.5	0.4	0.3	0.2	1.2

Table 2. Water budget for conventional and surge irrigated spring wheat using alternating furrow irrigation. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

	Irrigation method	
	Conventional	Surge
	ac-in	
Infiltration of applied water	19.1	10.3
Rainfall (planting to harvest)	3.2	3.2
Total supply for crop	22.3	13.5
Consumptive use (ET_c)	19.6	19.6
Estimated deep percolation	2.7	0
Estimated net extraction	0	6.1

Table 3. Percent runoff of applied water during five furrow irrigations of spring wheat using surge and conventional systems. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

	Percent runoff by irrigation					
	1	2	3	4	5	Total
	- - - - - - - - - - % - - - - - - -					
Conventional	22.8	19.6	22.8	18.4	30	22.7
Surge	17.6	18.4	6.1	6.9	19.6	13.7
LSD(0.05)	ns	ns	4.5	7.1	8	5.8

Table 4. Sediment yield in runoff water during five furrow irrigations of spring wheat using surge and conventional systems. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

	Sediment yield by irrigation					
	1	2	3	4	5	Total
	- - - - - - - - - lb/ac - - - - - - - - -					
Conventional irrigation	477	460	74	127	245	1383
Surge irrigation	30	166	29	123	58	406
LSD(0.05)	196	ns	ns	ns	102	647

Table 5. Yield, grain weight, and harvest index of soft white spring wheat grown with furrow irrigation and surge irrigation. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

	Grain yield	Bushel weight	Harvest index
	bu/ac	lb/bu	0 to 1
Conventional	128.3	61.5	.515

furrow irrigation			
Surge irrigation	128.2	61.7	0.529
LSD(0.05)	ns	ns	ns§

§ different at $P < 0.086$