WATER SAVINGS THROUGH SURGE IRRIGATION, 1994

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Abstract

Stephens winter wheat was grown using conventional furrow irrigation and surge irrigation on 12 one-half-acre plots. Both systems were operated simultaneously four times during the season. Conventional irrigation applied 26.5 ac-in/ac of water with runoff of 0.8 ac-in/ac and infiltration of 25.7 ac-in/ac. Surge irrigation applied 13.7 ac-in/ac with 0.5 ac-in/ac of runoff and 13.1 ac-in/ac of infiltration. Average grain yield was 95.0 bu/ac with conventional furrow irrigation and 98.7 bu/ac with surge irrigation with no significant difference in grain yield or quality.

Introduction

In surge irrigation, water is applied to an irrigation furrow intermittently, whereas incontinuous-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 byside 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/ac of water compared with 28.2 ac-in/ac 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 and 1994 surge irrigation trials were designed to compare the effects of surge irrigation with the effects of conventional irrigation on wheat yield and quality: water use, infiltration, and runoff; nitrate leaching; and sediment lost in the runoff. In both these surge irrigation trials, a randomized experimental design was used providing replicated plots and resulting in greater certainty of treatment effects. The 1993 trial demonstrated reduced water use, reduced sediment yield, and equivalent grain yield (128 bu/ac). In 1993 irrigation water was reduced from 24.7 ac-in/ac under conventional furrow irrigation to 12.0 ac-in/ac under surge irrigation.

Procedures

A 6-acre field of silt loam soil was planted to Stephens winter wheat at 123 lb/ac on November 18, 1993. Planting followed spring wheat harvest, stubble disking and soil ripping, disking, and ground hogging. The field was fertilized with 20 lb/ac N, 100 lb/ac P205, and 10 lb/ac Zn broadcast before ripping.

Irrigation furrows were bedded out at 30-inch spacing on November 18, 1993, and the field was divided into 12 one-half-acre plots each 600 feet long, arranged lengthwise down the field. For the 1993 season, six of the plots had been designated at random as surge irrigation plots, and the same layout was maintained in 1994. 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 gal/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 April 14, Bronate was applied using a tractor-mounted spray boom at 1 qt/ac to control broadleaf weeds. The field received 90 lb N/ac as urea broadcast on April 4 and 30 lb N/ac as urea broadcast on April 27. No insecticide was used during the 1994 season.

Water and Sediment Measurement

Onset of water inflow and water outflow were recorded during each irrigation. Measurements of water inflow rate, water outflow rate, and sediment yield were recorded hourly if possible 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 it = 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 was analyzed for nitrate-N, ammonium-N, total N, phosphate-P, and total P. Nutrient losses are not reported here.

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 four 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 were 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 early, but had symptoms of "take all" fungus. The poorer crop health in 1994 is reflected in the lower harvest index and yield in 1994 compared with 1993 (Table 5). The crop was irrigated on April 4, April 26, June 6, and June 21. Substantial rainfall in May delayed the third irrigation until June. Irrigation durations were 48,26,27, and 24 hours for both irrigation methods. Desired irrigation durations were 24 hours but were increased to try to complete irrigations. Seasonal total wheat evapotranspiration or consumptive water use was estimated to be 21.3 ac-in/ac for the season.

The conventional irrigation system delivered an average season total of 26.5 ac-in/ac of water, of which 0.8 ac-in/ac was runoff and 25.7 ac-in/ac was infiltration (Table 1). In comparison, surge irrigation applied only 13.7 ac-in/ac of water with 0.7 ac-in/ac of runoff and 13.0 ac-in/ac of infiltration. The distribution of water along the length of the furrows was uniform in the surge plots, except during the first irrigation when water from neither the surge or conventional irrigation exited the field. Infiltration plus rainfall was less than the crop evapotranspiration in the surge-irrigation plots, and the irrigation deficit was made up by the wheat extracting residual soil moisture left over from winter precipitation and residual soil water (Table 2).

Surge irrigation and conventional irrigation resulted in similar low water runoff tosses (Table 3). In addition, total estimated sediment loss was much less than the 1,383 pounds per acre and 406 pounds per acre measured in 1993 for conventional and surge irrigation respectively (Table 4). The soil texture was very mellow after freezing and thawing during the winter of 1993-1994. Consequently, the field was very hard to irrigate, with high rates of water intake and low rates of water runoff and sediment yield.

Grain yield and quality were not significantly different between conventional furrow and surge irrigation (Table 5).

Conclusions

Surge irrigation is an efficient way to conserve water while sustaining yields. Growers interested in surge irrigation systems should consult their local NRCS or SWCD office or pipe supply company for engineering advice.

Table 1. Total water applied, runoff, and infiltration during four furrow irrigations of winter wheat using surge and conventional systems. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1994.

	By irrigation				
	1	2	3	4	Total
Conventional irrigation	ac-in/ac				
Water applied	9.0	4.8	8.3	4.4	26.5
Runoff	0.0	0.5	0.2	0.1	0.8
Infiltration	9.0	4.3	8.1	4.3	25.7
Surge irrigation					
Water applied	4.7	2.5	4.1	2.4	13.7
Runoff	0.0	0.5	0.1	0.1	0.7
Infiltration	4.7	2.0	4.0	2.3	13.0
Comparison					
Water applied	0.7	0.5	0.6	0.4	0.7
Runoff	1.5	ns	ns	ns	ns
Infiltration	0.7	0.5	0.7	0.4	2.1

Table 2. Water budget for conventional and surge irrigated winter wheat using alternating furrow irrigation. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1994.

	Irrigation method	
	Conventional	Surge
	ac-in/ac	
Infiltration of applied water	25.7	13.0
Rainfall (planting to harvest)	+3.0	+3.0
Total supply for crop	28.7	16.0
Consumptive use (ET_c)	-21.3	-21.3
Estimated deep percolation	7.4	0
Estimated net extraction	0	-5.3

Table 3. Percent runoff of applied water during four furrow irrigations of winter wheat using surge and conventional systems. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1994.

	Percent runoff by irrigation				
	1	2	3	4	Total
	%				
Conventional	0	10.8	2.6	1.4	3.1
Surge	0	19.1	1.8	2.3	4.5
LSD (0.05)	ns	6.7	ns	ns	ns

Table 4. Sediment yield in runoff water during four furrow irrigations of winter wheat using surge and conventional systems. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1994.

	Sediment yield by irrigation				
	1	2	3	4	Total
	lb/ac				
Conventional	0	80	48	3	131
Surge	0	35	12	4	51
LSD (0.05)	ns	6.7	ns	ns	ns

Table 5. Yield, grain weight, and harvest index of soft white wheat grown with conventional furrow irrigation and surge irrigation. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1994.

	Grain yield		Bushel weight		Harvest index	
	1993	1994	1993	1994	1993	1994
	bu/ac		bu/ac		0 to 1	
Conventional	128.3	95.1	61.5	59.7	0.515	0.427
Surge irrigation	128.2	98.7	61.7	60.4	0.529	0.448
LSD (0.05)	ns	ns	ns	ns	ns*	ns

* different at P < 0.086