

Surge Irrigation

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Figure 1. Surge irrigation uses a valve to oscillate water from one side of the field to the other. Advantages include reductions in water use, nitrogen leaching, and sediment loss.

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Funding to help prepare this publication was provided by an Oregon Watershed Enhancement Board grant.

Cite as C.C. Shock and T. Welch. 2011. Surge Irrigation, Sustainable Agriculture Techniques, Oregon State University, Department of Crop and Soil Science Ext/CrS 135.

In surge irrigation, a butterfly valve is placed in the center of the top of the field. Gated pipe leads out of the valve and goes in both directions along the top of the field. The valve oscillates water from one side to the other at predetermined intervals. (In conventional surface irrigation systems, the water flows continuously during the irrigation set.) The alternating flow of water on each side of the valve causes an intermittent wetting and soaking cycle in the irrigated furrows.

The alternating wetting and soaking cycle causes soil particles to settle to the bottom of the furrow. As these soil particles partially seal the soil surface, the water intake rate is reduced. As a result, less water is lost to deep percolation at the beginning of the row and the water can advance down the furrow faster. Precise timing shuts off the water flow before much of it flows off the field at the end of the rows. By reducing deep percolation at the beginning of the row and tailwater runoff at the end, the result is more uniform water application, less total water applied, and much lower water runoff.

The surge valve is operated by a solar-powered battery and is relatively maintenance free. A controller on the surge valve allows the grower to choose the durations of the oscillations from one side of the field to the other.

Why use surge irrigation?

Excessive runoff and deep percolation in surface-irrigated fields wastes water and can cause high levels of dissolved salts and fertilizer residues to enter groundwater and surface water. Growers are increasingly concerned with how to stretch limited supplies of water, while maintaining yield. At the same time, growers face more stringent standards regarding water quality. Irrigation management practices that reduce deep percolation and runoff will address both of these concerns.

Studies done at the Malheur Experiment Station and elsewhere have shown significant benefits to surge irrigation:

- More uniform application of irrigation water
- Reduced water use through reductions in deep percolation and runoff
- Reduced costs through reductions in water use and labor

- Reduced nitrogen leaching
- Reduced sediment loss
- Reduced surface water contamination

Several of these studies are briefly summarized on pages 4–5.

What fields are suitable for surge irrigation?

Surge irrigation works well on sandy and silt loam soils. In cracked or compacted clay soils, poor penetration can thwart surges. A simple test by manual control of irrigation oscillations will show whether a soil is suitable for surge irrigation.

How much does this practice cost?

For many fields currently using gated pipe, the main costs are the surge valve, controller, and any extra distribution pipe required to connect to the surge valve. The cost of surge valves depends on the manufacturer, the size of the pipe, and the complexity of the controller used. Valves for 8- to 10-inch pipe cost \$755 to \$895, and the cost of a controller may run from \$545 to \$1,015. These costs are relatively low compared to the savings in labor and water achievable with surge irrigation.

A study in Kansas compared the costs and returns of various types of center-pivot, furrow flood, surge, and subsurface drip irrigation systems for corn and grain sorghum. Of the seven systems studied, the surge system had the highest economic return.

In the Kansas study, surge was one of the least expensive systems to acquire and also had relatively low maintenance costs. Its low operating pressure, low horsepower requirement, and 75 percent application efficiency resulted in relatively low fuel and lubrication costs per acre-inch. Although the surge system had the next-to-lowest yields for both crops, the relatively large number of acres irrigated and the low ownership and operation costs resulted in the highest net value.

How do I change an irrigation system to surge?

If a gated pipe system is already in place, changing your current system to surge could be relatively easy and low-cost. If there is minimal side fall in the field, you would simply need to add a surge control valve and additional pipe to connect to the valve.

In fields with substantial side fall, you can place the valve at the corner of the field where water enters. Use a transmission pipe parallel to the gated pipe down the first half of the field.

How do I manage irrigation with a surge system?

When installing a surge system, there is a certain amount of trial and error involved in establishing the duration of the wetting and soaking schedule. The number and length of alternating wetting cycles depends on the soil type, length of irrigation run, and the amount of water available. In Malheur County research with spring wheat growing on a silt loam soil, we have used surges (wetting cycles) ranging from 39 minutes to 1 hour. Once you have established a cycle to use in a particular field, the surge controller memory can be used to repeat or modify slightly the sequence for future irrigations, greatly saving operator time.

The initial alternating cycles are used to wet the field through to the end. The first cycle



Figure 2. A controller on the surge valve allows the grower to manage the duration of the wetting and soaking cycles.

should not wet the field beyond 30 or 40 percent of the field length. During these cycles, it's important to watch the bottom end of the furrows carefully to minimize runoff.

After the initial cycles, the field should be wet through to the end and excess water runoff (tailwater) should be minimal. At this time, decrease the duration of the wetting cycles. These shorter surge cycles are known as soaking, or cutback, times.

Keep in mind that if the total irrigation duration is the same as with conventional irrigation, each half of the field will receive only half as much water. As discussed above, the total amount of water required in surge-irrigated fields is reduced, due to reduced losses to deep percolation and runoff. Nonetheless, in some research, infiltration plus rainfall was less than crop evapotranspiration in surge-irrigated plots. In most cases, the irrigation deficit was made up by the crop extracting residual soil moisture left over from winter precipitation. In one case, however, yield/grade was lower at the bottom of the field, indicating a water deficit. Thus, it is important to monitor the system to ensure that sufficient water is applied.

The timing between the right and left sides of the surge valve is set on a solar battery-powered controller mounted on the valve itself. After a suitable schedule is developed, it can be programmed into the controller, making irrigation almost completely automatic. The computerized



Figure 3. The initial alternating cycles are used to wet the field through to the end.

controller allows the grower to enter the total irrigation time and let the computer determine the irrigation sequence for each half of the field.

If field shape or soil characteristics require control of flow down individual furrows, the grower can adjust individual gates as needed.

Can I fertilize through surge irrigation?

Fertilizer can be added to the irrigation water in front of the surge valve, either by allowing it to flow by gravity or by using an injector system.

Advantages of this method include:

- Less nitrogen fertilizer lost to deep percolation
- Minimal gaseous losses of nitrogen
- No need to use power equipment for fertilizer application
- Lower cost
- Ability to apply fertilizer when it is needed by the crop

Disadvantages include:

- Presence of fertilizer in surface runoff
- Potential pitting of aluminum gated pipe and surge valve
- Need to calibrate injection equipment

The timing of fertilizer addition is important. If fertilizer is added too soon in the surge cycles, application may be concentrated at the top of the furrow and/or be moved too deeply into the root zone. If fertilizer is applied during the latter cutback cycles, distribution is uniform and fertilizer remains in the upper part of the soil profile, thereby minimizing loss to deep percolation.

One approach is to add fertilizer during the next-to-last cutback cycle. At this time, the entire length of run should have been wetted, so water (and fertilizer) will soak in evenly. Use the last cycle to move the fertilizer down into the soil and flush the solution out of the system, thereby reducing the likelihood of corrosion or pitting of pipes. Fertigation software is available that

enables growers to automatically fertilize and flush.

Phosphorus fertilizers do not move readily in the soil. For these fertilizers, add the material at the beginning of the cutback irrigations or at each cutback cycle so the phosphorus moves into the profile as much as possible. Use the last cutback cycle to flush the system.

To determine the gallons per acre needed to achieve a desired fertilizer application rate, and to calculate the required flow rate, see “Fertigation through surge valves” (<http://www.prsurge.com/research/csufert.html>).

The injection method must provide enough pressure to inject the fertilizer at the desired rate, which will depend on the irrigation flow rate and on the concentration needed to inject the fertilizer during the on-time of the runoff cycle. The pressure will be low, since surging is a low-head irrigation method. To calculate the injection rate, see “Fertigation” (<http://www.prsurge.com/research/sieof.html>).

If the calculated flow rate of the liquid fertilizer is too great for the capacity of the application system, the fertigation application may be split between two or more cutback cycles, as long as the last cycle is reserved for flushing the system and moving the fertilizer into the soil.

Research related to surge irrigation in the western U.S.

Oregon—More uniform application and reduced deep percolation

A 1990 trial with ‘Bliss’ spring wheat showed that surge-irrigated furrows finished more uniformly than furrows irrigated solely with gated pipe. One-third of a field was irrigated using conventional furrow irrigation with gated pipe. The remaining two-thirds were irrigated using a surge valve in the center of the gated pipe to oscillate water between the two thirds.

During the first irrigation, water in 22 out of 56 conventionally irrigated furrows (39 percent) failed to reach the end of the furrows. In the

surge-irrigated portions of the field, water in only 18 out of 112 surge-irrigated furrows (16 percent) failed to reach the end of the furrow.

Conventionally irrigated and surge-irrigated fields had equivalent yields, but surge used half the amount of water over the entire irrigation season (12.9 ac-in versus 28.2 ac-in). Water losses under conventional irrigation in this trial can be attributed to deep percolation. The extra water was of no benefit to the crop.

Reference: “Surge irrigation of ‘Bliss’ spring wheat” (<http://www.cropinfo.net/AnnualReports/Old/surgeirrigation1992.html>)

Washington—Improved application efficiency

Surge boosts some surface irrigation application efficiencies by as much as 40 percent. Washington State University research compared surge to drip for light, frequent irrigations, and found similar efficiencies of 85 percent for both systems.

Reference: “Surge—The cutting edge of irrigation technology” (<http://www.prsurge.com/research/ijisrg.html>)

Oregon—Reduced runoff, total water application, and nitrogen leaching

A 1991 study on a grower’s field showed that 71 percent of the water applied with surge irrigation soaked into the soil, while only 50 percent of the water soaked in with conventional irrigation. Thus, runoff from the conventionally irrigated field represented 50 percent of water applied, while only 29 percent of the water applied to the surge-irrigated field was lost to runoff.

Based on the hours of water application and the flow rate, surge irrigation required only 57 percent of the water volume needed for conventional furrow irrigation over the entire irrigation season.

After harvest, residual soil nitrate was higher in the surge plots than in the conventionally irrigated plots. In fact, twice as much nitrogen was lost from the soil during the season in the conventionally irrigated plots (373 lb/ac) than in

the surge plots (187 lb/ac). Nitrogen loss under both irrigation systems was probably due to leaching during and following irrigation.

Reference: “The effect of surge irrigation on onion yield and quality, irrigation efficiency, and soil nitrogen losses” (<http://www.cropinfo.net/AnnualReports/Old/surgeirriion1992.html>)

Colorado—Reduced surface water contamination, water loss, and fertilizer cost

The Colorado State University Cooperative Extension Service began a study in 1990 of the potential for surge irrigation to reduce the salt load in return flows to the Colorado River. Surge systems were installed on almost 1,000 acres, representing a broad range of field and crop conditions. In the first year, deep percolation was reduced by nearly an acre-foot per acre. Surge irrigators stopped 790 tons of salt from entering the river. By 1994, the cumulative salt-load reduction to the Colorado River was 3,430 tons.

The study compared surge with conventional flood for water applied, runoff, and deep percolation. Surge cut the conventional numbers in half. In fields using fertigation with surge irrigation, growers saved up to 25 percent in fertilizer costs.

Reference: “Report to the United States Department of the Interior, Bureau of Reclamation, Cooperative Agreement for Surge Irrigation Research and Development Program, Grand Valley Unit” (<http://www.pr surge.com/works/reclam.html>)

Table 1. Water application and runoff with conventional furrow and surge irrigation, Malheur County, OR.

	Conventional (ac-in/ac) (%)		Surge (ac-in/ac) (%)	
Water applied	24.7	100	12.0	100
Runoff	5.6	22.7	1.7	14.1
Infiltration	19.1	77.3	10.3	85.8

Oregon—Reduced runoff and sediment loss

‘Treasure’ spring wheat was grown in Malheur County using conventional furrow irrigation and surge irrigation on 12 half-acre plots. Both systems were operated simultaneously five times during the season. Conventional irrigation applied more water, with greater amounts lost to runoff (Table 1). Season-long sediment losses averaged 1,383 lb/ac with conventional irrigation and 406 lb/ac with surge irrigation, a reduction of 70 percent.

Average yield under both systems was 128 bu/ac, with no significant difference in grain quality.

Reference: “Surge irrigation of wheat to increase irrigation efficiency and reduce sediment loss, 1993” (<http://www.cropinfo.net/AnnualReports/Old/surgeirriwheat1993.html>)

Oregon—Reduced sediment loss

In a 1994 trial, ‘Stephens’ winter wheat was grown using conventional furrow irrigation and surge irrigation on 12 half-acre plots. Both systems were operated simultaneously four times during the season. Runoff was low under both systems (Table 2).

Nonetheless, season-long sediment losses were less than half as much with surge irrigation. Sediment loss averaged 131 lb/ac with conventional irrigation and 51 lb/ac with surge irrigation, a reduction of 60 percent. There was no significant difference in grain yield or quality.

Reference: “Water savings through surge irrigation” (<http://www.cropinfo.net/AnnualReports/Old/surgesavings1994.html>)

Table 2. Water application and runoff with conventional furrow and surge irrigation, Malheur County, OR.

	Conventional (ac-in/ac) (%)		Surge (ac-in/ac) (%)	
Water applied	26.4	100	13.7	100
Runoff	0.8	3.0	0.5	3.6
Infiltration	25.7	97.3	13.1	95.6