FUNDAMENTALS OF SURGE IRRIGATION

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Furrow irrigation is currently used on over half of the irrigated acres in Nebraska. This is likely to remain the situation for sometime because of lower energy and equipment costs for furrow as compared to sprinkler irrigation and because farmers are accustomed to managing this type of irrigation system. Some farmers are switching from furrow to center pivot irrigation to reduce labor and improve irrigation performance. Surge irrigation gives furrow irrigators a possibility of gaining these same advantages without an additional major equipment investment.

Surge irrigation or surge flow is the process of intermittently applying water in an irrigation furrow. Continuous flow is the normal process of applying water for the entire irrigation set time. Surge irrigation was first studied as a method of reducing the amount of runoff that occurred during irrigation. It was discovered that the time required for water to move to the end of the field was reduced using an intermittent application of water, surge, as compared to the continuous flow system.

The intermittent application of water is accomplished by cycling irrigation water between two irrigation sets. In years past, the idea of cycling irrigation water was used when water was not getting to the end of a field. The irrigator would move on to subsequent sets and return in one or two days to finish irrigating the partially watered sets. The second time, the irrigation water could be moved all the way to the end of the field because the soil surface had sealed and more water was available at that point where flow had previously stopped. This same thing occurs when using surge irrigation, except three to six cycles are used and the cycling is done automatically at short durations, 20 minutes to 2 hours.

HOW SURGE IRRIGATION WORKS

When water first makes contact with the soil in an irrigation furrow, the rate of infiltration is high. As the water continues to run, the infiltration rate at that point in the furrow is reduced to a near constant rate. If water is shut off to the furrow and the furrow is allowed to dry for a short period of time, the surface soil particles consolidate and form a seal in the furrow. When water is reintroduced to the furrow the intake rate is reduced due to this sealing action. The result is more water being carried down the furrow rather than infiltrating the soil. High infiltration rates can lead to poor irrigation system performance due to deep percolation and poor water distribution across the field. Thus, surge flow can increase irrigation performance by

providing a more uniform application. In Figure 1, the infiltration pattern of surge and continuous flow are shown to demonstrate the difference in uniformity of water application between the two systems.

Rather than shut the water off to achieve an on-off cycle, an irrigation surge valve is used to alternate flow between two irrigation sets. Figure 2 shows one method of using a surge valve. Cycle times used with surge irrigation vary with soil texture and slope. Fine textured soils respond less to surge irrigation than do coarse textured soils that have higher initial intake rates. If field slope is so steep that it causes a rapid rate of advance, the effects of surge irrigation will be reduced. If intake rate of a soil is low due to soil texture, tight soils or compacted layers, surge irrigation is likely to be ineffective in reducing the irrigation advance times below those for continuous flow.

Surge flow has been used to reduce irrigation runoff, in some cases, by using short duration cycles after the water has reached the end of a field. This helps maintain high uniformity of water application and improve overall irrigation performance. Another advantage to surge, unrelated to the improvements in irrigation system performance, is that the surge irrigation valve can be used to improve irrigation system management without a large increase in labor requirements. The surge controller provides a two-set automated furrow irrigation system.

There are two concerns when using surge flow. First, surge flow will not always be effective in reducing the advance time of water down the furrow. When this occurs, there may still be benefits of labor savings and runoff reduction. Because of lower infiltration rates often seen with surge flow, a second concern is with total water application. With lower infiltration rates associated with surge, less water may be applied to the soil during an irrigation set. If this occurs, the irrigator must compensate by irrigating more frequently or increasing set time to avoid under watering.

SURGE IRRIGATION FIELD TESTS

The University of Nebraska has tested and evaluated surge irrigation since 1983. The tests have compared continuous flow irrigation to surge irrigation. Tests have been conducted on a variety of soil types in the Central Platte Valley, the Blue River Basin and the Panhandle of Nebraska.

Of the 26 tests that have been conducted, Table 1, surge was never less effective than continuous flow irrigation. The average reduction in advance times across a field using surge irrigation compared to continuous flow is approximately 17 percent with a range of 0 to 52 percent. The majority of these tests were conducted during the first irrigation.

Of the 26 test cases, 12 resulted in no difference in advance between surge and continuous flow. Four tests were conducted during the second irrigation and two of

those resulted in a 17 percent decrease in time of advance using surge irrigation. Tests conducted on the hard furrows resulted in only one of the four cases having a reduction in advance time.

Through observation during these tests, soil texture and structure play an important role in the ability of surge to reduce the time required to advance water through a field. Soils that have acceptable advance times with conventional irrigation practices, may not benefit from surge irrigation. On the other hand, soils with high intake rates may show substantial benefits from surge irrigation. With any soil, benefits are more likely to occur when infiltration rates are highest. This is often with coarse textured soils and during the first irrigation of the season.

As with conventional irrigation practices any difference in soil preparation, soil compaction and soil moisture during field operations or during irrigation can impact the results of using surge irrigation.

COMMON QUESTIONS ABOUT SURGE IRRIGATION

Is There Research to Support the Benefits of Surge Irrigation?

Yes. Research has been conducted in Nebraska since 1983. There has been additional research done by nearly all of the Land Grant Universities in the Western United States. Their results are similar to those found in Nebraska.

Does the Surge Valve Require Pressure in Order to Operate?

No. The valve can operate under open discharge or gravity flow conditions. The only requirement is the valve and pipe diameter must be large enough to accommodate the flow requirements.

What if I Don't Use Gated Pipe?

Surge is not easily adapted to open ditch irrigation. However, the use of plastic or lay flat tubing can work as well as gated pipe. If using a plastic tube conveyance system, locate the valve so flow is always downhill in the tubing regardless of flow direction in the valve.

I Don't Have Enough Gated Pipe to Get to the Middle of the Field, What Do I Do? Is There an Alternative?

Using a surge valve often requires that somewhere in the system, pipe is used to convey water to the desired location of the valve. Try using some of the lay flat plastic tubing as a low cost alternative.

Should I Reduce My Furrow Stream Size and Go To Larger Sets Because of Improved Irrigation Efficiency?

No. You should start with the same stream size and set size that you use under continuous flow conditions. Adjustments can be made to match stream size and the distance the stream moves down the furrow later.

What Should I Do When the Water Reaches the End of the Field?

Use the valve to reduce the on-time to 65 percent of the last on-time to keep water on the field. Some controllers do this automatically using a cutback phase. On-times during cutback should move water nearly to the end of the field and then switch to the other set. The water remaining in the furrow should continue to flow to the end of the field with some runoff. Remember, runoff alone does not insure adequate irrigation.

What Kind of Improvements Can I Expect?

Field tests have shown reductions in irrigation advance times of 50 percent are possible during the first irrigation. During later irrigations you can expect surge irrigation to be nearly the same as continuous flow.

If Surge Effects are Reduced as the Season Progresses, What Advantages Do I Get from the Valve Later On?

The valve allows you to make two sets before you need to reset the valve and open and close gates. In short, a form of automation. This may mean that you can operate shorter set times and still apply enough water to fill the profile. Runoff may also be reduced by use of cutback cycle times. The ability to apply less water yet provide adequate water for crop growth means deep percolation and pumping costs can be reduced.

Are All Soils the Same When Using Surge Irrigation?

No. The ability of a soil to seal itself after water has been introduced to the furrow is critical to obtain a reduction in the furrow advance rate. A tight soil with a low infiltration rate may not achieve the reduction in advance times as would a sandy soil that has a high initial infiltration rate.

Do All My Rows Have to Come Through At the Same Time To Make Surge Work?

No. But like continuous flow systems, management is needed to adjust stream size and number of furrows. Results of field tests indicate that the variability among rows tend to be less when using surge irrigation.

What Equipment Do I Need to Get Started?

The equipment needed to convert to surge irrigation includes the surge valve and possibly enough mainline pipe to locate the valve at the desired location in the field.

What Do Surge Valves Cost?

Normally, valves will cost between $800 and $2,000 depending on the size of the valve and controller options. Keep in mind, getting over the field during the first irrigation in half or three quarters of the time it normally takes may more than pay for a valve in a single year. Because of the inability to automate and the inherent efficiency of furrow irrigation, some furrow irrigation farmers apply more than twice the amount of water that a crop can use. By realizing a water savings, pumping costs can be reduced. For each

inch of water saved, pumping costs savings could be in excess of $150 for a quarter section field. Estimate the savings you could expect and the valve may well pay for itself in just a few years.

Is the Equipment Reliable?

Like any new technology, equipment improves with time. Surge valves have been in operation for over 5 years and the reliability of the valves has become quite good.

Are There Other Advantages to Using Surge Irrigation?

Water quality is becoming a major concern in all irrigated areas. Irrigation efficiency is often low in furrow irrigated fields and surge irrigation can improve irrigation uniformity and the efficiency of irrigation by reducing runoff and deep percolation. The end result can be less water applied and less deep percolation which can carry chemicals into the ground water and cause water quality problems.

How Do I know After Reading All This if Surge Irrigation Will Work for Me?

You don't. Run your own test and compare two rows of continuous flow to two rows that you manually surge. Compare the total time that it takes water to get to the end of the furrow. Only count the time when water is running in the furrow. If water advances to the end of the field in a shorter period of time compared to the continuous flow furrows, improvement in uniformity of water application will likely result from using surge irrigation. For example, if the water reaches the end of the field on the second of two surge sets at the same clock time as for a continuous set, surge reduced advance time by 50 percent. This means with the same volume of water you were able to irrigate two rows where normally you only irrigated one.

If the advance times are the same, make sure there wasn't an outside factor affecting water advance and that continuous irrigation performed as you normally expect it to. In addition, keep in mind the advantages to automation and the ability to control runoff using surge irrigation.

SUMMARY

Surge irrigation provides farmers that use furrow irrigation an opportunity to improve their management of irrigation water. By reducing infiltration rates, surge irrigation allows lighter applications which can improve irrigation performance. In addition, reducing deep percolation by using surge means major steps can be taken to reduce the potential for chemical flow to the ground water.

The effects of surge irrigation are most prevalent during the first irrigation when the soils intake rate is high. Although intake rate reduces as the season progresses the advantages of surge continue in the ability to manage water supplies by keeping water on the field and minimizing the amount of runoff leaving the field.

Surge irrigation does not apply to everyone but past success suggests that furrow irrigators should at least consider this new technology.

Table 1. Surge irrigation test results.

Year	Row Identity Soft/Hard	Soil Type	Irrigation Number	Advance Time Reduction (%)
1983	soft	Hastings Silt Loam	1st	0
1985	soft	Hord silt loam	1st	0
1985	soft	"	2nd	0
1986	hard	"	1st	0
1986	soft	"	1st	52
1986	hard	Keith silt loam	1st	0
1986	soft	"	1st	29
1987	hard	Hord silt loam	1st	0
1987	soft	"	1st	0
1987	hard	Keith silt loam	1st	20
1987	soft	"	1st	36
1988	soft	Hastings silt loam	1st	23
1988	soft	Tripp very fine sandy loam	1st	0
1988	soft	"	1st	40
1988	soft	"	2nd	20
1989	soft	"	1st	25
1989	soft	"	2nd - reditched	0
1989	soft	"	3rd	0
1989	soft	"	1st	50
1989	soft	"	1st	35
1989	soft	"	2nd - reditched	38
1989	soft	"	3rd	14
1989	soft	Hastings silt loam	1st	0
1989	soft	"	2nd	0
1989	soft	Holdredge silt loam and Butler silty clay loam	1st	21
1989	soft	"	2nd	19

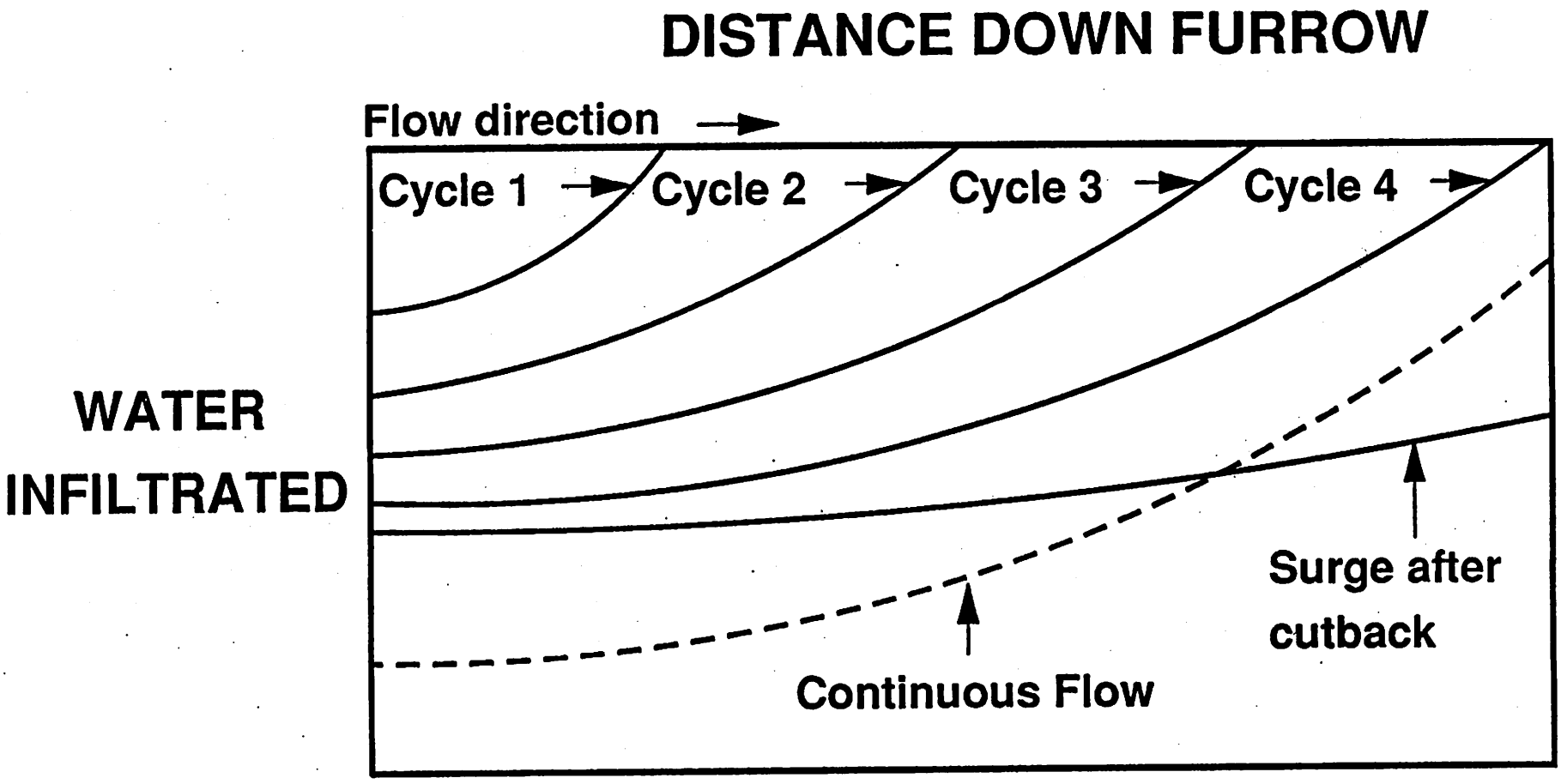

Figure 1. Infiltration pattern for surge and continuous flow irrigation.

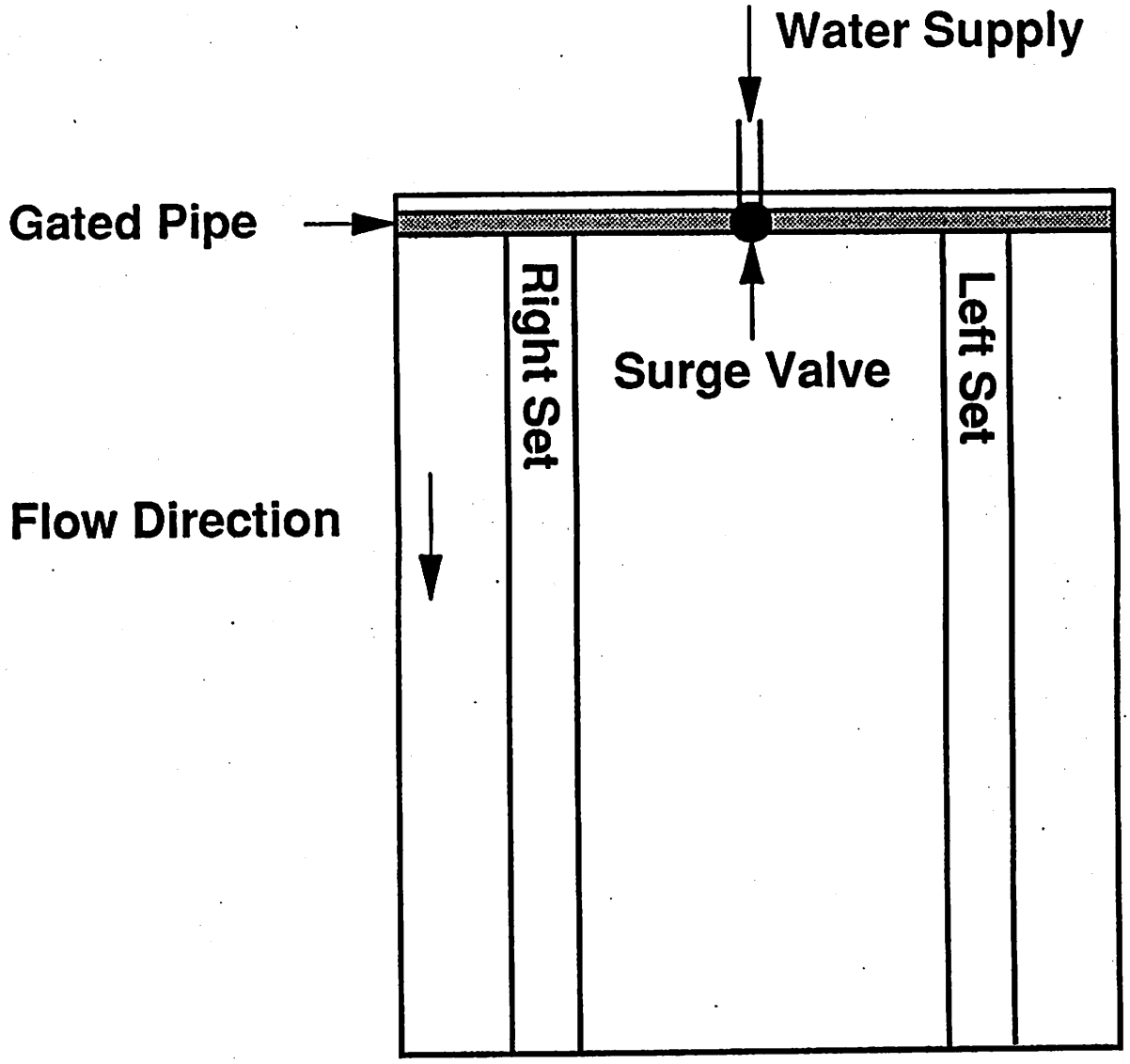

Figure 2. Field installation of surge valve.