Proceedings of the 30th Annual Central Plains Irrigation Conference, Colby, Kansas, Feb. 20-21, 2018
Available from CPIA, 760 N. Thompson, Colby, Kansas

ADDRESSING THE BASIC DESIGN ISSUES OF SUBSURFACE DRIP IRRIGATION (SDI)

Freddie R. Lamm
Research Agricultural Engineer
Northwest Research-Extension Center
Colby, Kansas
Voice: 785-462-6281
Email: flamm@ksu.edu

Danny H. Rogers
Extension Agricultural Engineer
Biological and Agricultural Engineering
Manhattan, Kansas
Voice: 785-532-2933
Email: drogers@ksu.edu

Jonathan P. Aguilar
Extension Irrigation Specialist
Southwest Research-Extension Center
Garden City, Kansas
Voice: 620-275-9164
Email: jaguilar@ksu.edu

Kansas State Research and Extension

SUMMARY

Successful SDI systems require careful attention to design and selection of components. Source water quality can seriously affect design, operation, and maintenance and no SDI system should be developed without first assessing source water quality. Fundamental SDI design characteristics include aspects about dripline selection and system installation and these aspects often interact with each other. In addition to the water distribution components, all SDI systems should include a number of components that essentially protect the system from premature failure. Subsurface drip irrigation remains as an emerging technology in the U.S. Great Plains and the network of industry support continues to evolve. Producers still have the responsibility to carefully evaluate the viability of this irrigation system for their own farming operation.

INTRODUCTION

Overall, SDI systems have been successful in the Great Plains region despite minor technical difficulties during the adoption process. In a 2005 survey of SDI users, nearly 80% of Kansas producers indicated they were at least satisfied with the performance of their SDI system, and less than 4% indicated they were unsatisfied (Alam & Rogers, 2005). A few systems had failed or been abandoned after limited use due to inadequate design.

Although design and management are closely linked in successful SDI system, this paper will focus on the basic design aspects. A system that is improperly designed and installed is difficult to operate and maintain and most likely will not achieve high irrigation water application uniformity and efficiency goals. Proper design and installation alone do not ensure high SDI efficiency and long system life, though. A successful SDI system also must be operated according to design specifications while utilizing appropriate irrigation water management techniques. SDI systems also are well-suited to automation and other advanced irrigation scheduling and management techniques.

WATER QUALITY ANALYSIS, THE STARTING POINT FOR ALL SUCCESSFUL SDI SYSTEMS

Because most SDI systems are planned for multiple-year use, water quality is an extremely important consideration. Clogging prevention is crucial to SDI system longevity and requires understanding of the potential hazards associated with a particular water source. Remediation or replacement of clogged driplines can be expensive, difficult, and time-consuming. Although nearly all water is potentially usable for SDI, the added cost of complex water filtration and chemical treatment of marginal-quality water might further reduce the feasibility of SDI use on lesser-value crops. Therefore, no SDI system should be designed and installed without first assessing the quality of the proposed irrigation water supply. In some cases, poor water quality can also cause crop growth and/or long-term soil problems. However, with proper treatment and management, many waters high in minerals, nutrient enrichment, or salinity can be used successfully in SDI systems. A good water quality test (Table 1) provides information to growers and designers in the early stages of the planning process so that suitable water treatment, management, maintenance plans, and system components can be selected.

Although a complete water quality test may cost a few hundred dollars, the absence of it may result in an unwise investment in an SDI system that is difficult and expensive to manage and maintain. There is some variation among laboratories in terms of the parameters provided in an SDI water quality test. Table 1 lists items that are generally provided or that can be easily calculated from the provided parameters. The table also includes levels of concern for the different parameters but it should be noted that a parameter having a value of concern does not always result in emitter clogging. Additionally, the clogging criteria for the various parameters are not fully interrelated. For example, a water source could have a TDS less than 500 suggesting little chemical precipitation hazard, but still have Calcium (Ca) and Bicarbonate (HCO_3) levels sufficient to trigger calcium carbonate precipitation.

Additional information on assessing water quality and developing water treatment plans are available from a number of sources (Rogers et al., 2003a; Burt and Styles, 2007; Schwankl, et al., 2008).

Table 1. Water Quality Guidelines To Prevent Or Reduce SDI Emitter Clogging

Parameter	Definition or Comments	Level of Concern		
		Low	Moderate	High
1. pH	A measure of acidity, where 1 is very acidic, 14 is very alkaline, and 7 is neutral.	<7.0	7.0 to 8.0	>8.0
2. $\mathrm{pH_c}$	A calculated pH useful in comparisons with the measured pH.	See LSI below		
3. LSI	Langelier Saturation Index (LSI) is equal to pH minus pHc.	<0	>0	-
4. TDS	Total dissolved solids (TDS) is an equivalent dry measure of the total inorganic salts and the small amounts of dissolved organic materials in solution expressed in mg/L or ppm. TDS values in excess of 500 may present a chemical precipitation hazard.	<500	500 to 2000	>2000
5. Insoluble Scale-Forming Cations	Calcium (Ca^{2+}) expressed in meq/L	< 2	2 to 3	>3
	Total Iron (Fe) expressed in ppm or mg/L	<0.2	0.2 to 1.5	>1.5
	Magnesium (Mg^{2+}) expressed in meq/L	<2	2.5	>2.5
	Manganese (Mn^{2+}) expressed in ppm or mg/L	<0.1	0.1 to 1.5	>1.5
6. Insoluble Scale-Forming Anions	Carbonate (CO_3^{2-}), expressed in meq/L	These individual anions, as well as the hydroxide, oxide, and phosphate anions, may under some circumstances combine with chemically equivalent levels of the scale-forming cations to form precipitates.		
	Bicarbonate (HCO_3^-), expressed in meq/L			
	Sulfate, (SO_4^{2-}), expressed in meq/L			
7. Hydrogen Sulfide (H_2S)	Expressed in ppm or mg/L. *This compound is typically not tested for in the Central Great Plains.* If the odor of rotten eggs is detected in the water sample, more accurate testing can be pursued to determine the potential for precipitates.	<.2	0.2 to 2.0	>2.0
8. TSS	Total suspended solids (TSS) is an equivalent dry measure of the particles that would be trapped in normal SDI filtration expressed in mg/L or ppm. *This is not typically tested for in groundwater samples.*	<50	50 to 2,000	>2,000
9. Bacteria Count	Expressed in #/mL. *This is not typically tested for in groundwater samples.*	<10,000	10,000 to 50,000	>50,000
10. Presence of Oil	Oil that can be mixed with groundwater through well surging or other contamination processes can foul filtration systems or clog emitters. *This is not typically provided in standard SDI water quality tests but may be a useful determination.*			

Most standard SDI water quality tests in the Central Great Plains region will provide additional parameters that do not directly influence emitter clogging. These include Electrical Conductivity (EC), SAR, and adjusted SAR, which are all salinity terms, along with some of the soluble cations [Sodium (Na^+) and Potassium (K^+)] and soluble anions [Nitrate-N (NO_3^--N) and Chloride (Cl^-)] and Boron (B), which has plant toxicity. The usefulness of these parameters are discussed in other publications.

The ratio of the total cations (soluble and insoluble) and total anions (soluble and insoluble) can be used as an informal test of data reliability. A ratio of less than one would be suspect for naturally occurring waters and a second test is recommended. A ratio greater than one suggests the data quality is good. A ratio exactly equal to one may be the result of one of the chemical constituents being mathematically determined, rather than being measured. Please check with your lab.

Adapted from Bucks et al., 1979; Nakayama and Bucks, 1991; Hanson et al., 1997; Hassan, 1998, and Rogers et al., 2003a

FUNDAMENTAL SDI DESIGN CHARACTERISTICS

Fundamental SDI design characteristics need to be addressed early in the design process, namely dripline selection and dripline installation aspects. Interactions exist between these two and with other design aspects that occur later in the design process. A complete discussion of these characteristics is beyond the scope of this paper, so the reader is referred to Lamm and Camp (2007) for further discussion. However, some brief discussion is necessary since the characteristics are so fundamental to SDI design.

Dripline Selection

The selection of a dripline involves consideration of dripline diameter and wall thickness, emitter type, discharge rate and emitter spacing.

Dripline inside diameter

Larger diameter driplines allow long lengths of run and large zone sizes without sacrificing water distribution uniformity. Although larger diameter driplines cost more per unit length, their selection may result in a less expensive SDI system because of reduction of trenching and system controls. Dripline diameters up to 1.375 or 1 $^3/_8$ inches are now available and often used in large fields to decrease the number of required zones and field obstructions posed by additional valve boxes. Each SDI system design is different, however, and the grower should not automatically choose the larger dripline diameter. Larger driplines require longer fill and drain times which can adversely affect water and chemical application uniformity and redistribution within the soil. Overall, the most popular dripline diameter currently is 0.875 or 7/8 inches (Lamm, 2016).

Dripline wall thickness

The wall thickness of SDI driplines is often greater than surface drip irrigation (DI) because of the additional risk of dripline damage during installation and because the SDI system is intended to have an extended, multiple-year life. Thin-walled, collapsible polyethylene (PE) driplines with wall thicknesses of 12 to15 mil are used primarily for SDI installations in the Great Plains. In situations where soil compaction or soil overburden may cause dripline deformation, thick-walled PE tubing (hard hose) can be selected, although it is considerably more expensive. Thicker-walled products allow greater maximum dripline pressures that can be used to open partly-collapsed driplines caused by soil compaction or overburden, or to increase flow of chemically treated water through partly-clogged emitters. In addition, anecdotal reports highlight less insect damage to hard hose driplines.

Emitter type

Subsurface drip irrigation emitters are fully contained within the dripline to avoid significant protrusions that may become damaged during the SDI system installation process. These internal emitters are typically formed using one of three different methods: 1) long, tortuous passageway is formed through an indention process within the seam of the dripline as it is formed; 2) integral short tortuous path emitter is fusion-welded to the internal wall of the PE tubing; and 3) continuous narrow strip containing the turbulent emitter passageway is fusion-welded to the internal dripline wall. Integral short path emitters sometimes have a smaller manufacturer's coefficient of variation (CV) than those of the other processes, but all processes provide acceptable CV values with the modern manufacturing processes currently available. All three of these emitter types are used in SDI systems within the Great Plains region.

Emitter types are also classified by their emitter exponent (i.e., typically referred to as X, the exponent on the pressure term in the emitter discharge equation). An exponent less than 0.5 allows an emitter to be classified as partially pressure compensating, whereas a value of zero represents full pressure compensation (PC). An emitter with an exponent greater than 0.5 is classified as non-pressure compensating. Many current SDI driplines have emitter exponents with values close to 0.5 and, traditionally, PC emitters were considered too expensive for SDI installations on lesser-value crops. However, manufacturers continue to evolve product lines and processes, and some driplines with PC emitter characteristics are becoming more economically competitive.

Emitter discharge rate

Wide ranges of emitter discharge rates are available from the various dripline manufacturers. The evapotranspiration (ETc) needs of the crop have little influence on the choice of emitter discharge rate because most emitter discharge rates at typical emitter and dripline spacings provide SDI system application rates in excess of peak ETc. Some designers prefer emitters with greater discharge rates because they are less subject to clogging and allow more flexibility in scheduling irrigation. However, when emitters with greater discharge are chosen, the length of run may need to be reduced to maintain good uniformity and to allow for adequate flushing within the maximum allowable operating pressure. In addition, the zone size may need to be reduced to keep the total SDI system flowrate within the constraints of the water supply system. The choice of emitter discharge rate must also account for the soil hydraulic properties in order to avoid backpressure on the emitters and surfacing of water, although this problem is not common on SDI systems in the Great Plains.

In general, designers in the Great Plains region prefer emitter discharge rates in the range of 0.11 to 0.25 gal/hr, so that zone length and zone area can be maximized, thus lowering SDI system costs. Physical limitations exist to further reducing emitter discharge rate because smaller passageways are more easily clogged. The nominal dripline flowrate can be reduced with smaller emitter discharge rates or by increasing the emitter spacing. Limitations also exist to increasing the emitter spacing that are related to adequately supplying the crop’s water needs. Using a smaller emitter discharge rate in combination with a greater emitter spacing is often economically attractive (reduced design and installation costs) on deeper, medium-textured soils for crops with extensive root systems.

Emitter spacing

Emitter spacings ranging from 4 to 30 inches are readily available from the manufacturers, and other spacings can be made to meet a specific application. Increasing the emitter spacing can be used as a techniques to allow larger emitter passageways less subject to clogging, to allow for economical use of emitters that are more expensive to manufacture, or to allow for longer length of run or increased zone size by decreasing the dripline nominal flowrate per unit length. The rationale for increased emitter spacing must be weighed against the need to maintain adequate water distribution within the root zone. An excellent conceptual discussion of the need to consider the extent of crop rooting in irrigation design is presented by Seginer (1979). Although the effective uniformity of microirrigation experienced by the crop is high, the actual detailed uniformity within the soil may be quite low. Emitter spacing ranging from 1 to 4 ft had little effect on corn production and soil water redistribution in a three-year study at the KSU Northwest Research-Extension Center at Colby, Kansas (Arbat et al., 2010). It should be noted that using the widest possible emitter spacing consistent with good water redistribution can cause significant problems when emitters become clogged or under drought conditions. As a result, some plants will be inadequately watered. Generally, emitter spacing of 1 to 2 ft are used for SDI systems in the Great Plains.

Dripline installation aspects

Some dripline installation aspects require basic decisions about dripline spacing, dripline depth, and zone size (length and width). As noted earlier in the paper, these installation aspects may interact with the selection of the dripline.

Dripline spacing and orientation

Crop row, or bed spacing, is usually set by cultural practices for a given crop in a given region and by planting and harvesting equipment specifications. As a general rule, SDI dripline spacing is a multiple of the crop row spacing, whereas emitter spacing is usually related to the plant spacing along the row. Providing the crop with equal or nearly equal opportunity to the applied water should be the goal of all SDI designs. This presents a conflicting set of constraints when crops with different row spacing are grown with SDI. Mismatched crop row/bed and dripline spacing may not only result in inadequate irrigation and salinity problems, but also in increased mechanical damage to the SDI system. Adoption of similar row/bed spacing for crops on a farming enterprise may be advantageous, provided that the crops produce adequate yields under that spacing.

Dripline spacing in the Great Plains region is typically one dripline per row/bed or an alternate row/bed middle pattern (Figure 1) with one dripline per bed or between two rows. The soil and crop rooting characteristics affect the required lateral spacing, but general agreement exists that the alternate row/bed dripline spacing (about 5 ft) is adequate for most of the deeper-rooted agronomic crops on medium- to heavy-textured soils. Closer dripline spacing may be used for high-valued crops, on sandy soils, for small seeded crops where germination is problematic, and in arid areas to ensure adequate salinity management and consistent crop yield and quality. However, closer dripline spacing will probably result in smaller zone sizes because of the limitation on choosing smaller emitter discharge rates.

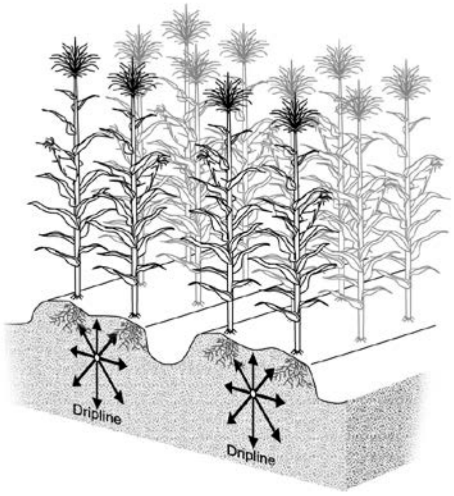


Figure 1. Alternate row/bed 5 ft SDI dripline spacing for corn rows spaced at 2.5 ft. Each plant row is approximately 1.25 ft. from the nearest dripline and has equal opportunity to the applied water.

The orientation of driplines with respect to crop rows has not been a critical issue with SDI systems used for corn production on deep-silt loam soils of the U.S. Great Plains. Traditionally, driplines are installed parallel to crop rows. This may be advantageous in planning long-term tillage, water, nutrient, and salinity management. However, K-State research has shown either parallel or perpendicular orientations are acceptable for the 5-foot dripline spacing on deep silt loam soils (Lamm et al., 1998).

Dripline depth

The choice of an appropriate dripline depth is influenced by crop, soil, and climate characteristics, anticipated cultural practices, grower experiences and preferences, the water source, and prevalence of pests. In an extensive review of SDI, Camp (1998) reported that the placement depth of driplines ranged from less than an inch to as much as 28 inches. In most cases, dripline depth was probably optimized for the local site by using knowledge and experiences about the crop for the soils of the region. For example, driplines for alfalfa are sometimes installed at deeper depths so that irrigation can continue during harvest. When irrigation is often required for seed germination and seedling establishment, shallower dripline depths are often used. Deeply placed driplines may require an excessive amount of irrigation for germination and can result in excessive leaching and off-site environmental effects.

Soil hydraulic properties and the emitter flowrate affect the amount of upward and downward water movement in the soil and thus are factors in the choice of dripline depth. When surface wetting by the SDI system is not needed for germination or for salinity management, deeper systems can reduce soil water evaporation and weed growth. Deeper dripline placement minimizes soil water evaporation losses, but this must be balanced with the potential for increased percolation losses while considering the crop root-zone depth and rooting intensity. Soil layering or changes in texture and density within the soil profile affect the choice of dripline depth. Driplines should be installed within a coarse-textured surface soil overlaying fine-textured subsoil so that there is greater lateral movement perpendicular to the driplines. Conversely, when a fine-textured soil overlays a coarse-textured subsoil, the dripline should be installed within the fine-textured soil to prevent excessive deep percolation losses. An excellent discussion of how soil texture and density affect soil water redistribution is provided by Gardner (1979).

For lesser-valued commodity crops (fiber, grains, forages, and oilseeds), SDI systems are usually set up exclusively for multiple-year use with driplines installed in the 12 to 18 inch depth range. Most of these crops have extensive root systems that function properly at these greater depths. Corn, soybean, sunflower, and grain sorghum yields were not affected greatly by dripline depths ranging from 8 to 24 inches on a deep Keith silt loam soil at Colby, Kansas (Lamm and Trooien, 2005; Lamm et al., 2010). Their results suggest that, in regions that typically receive precipitation during the growing season, dripline depth will not be the overriding factor in crop development and soil water redistribution. The dripline should be deep enough that the anticipated cultural practices can be accommodated without untimely delays, soil compaction, or damage to the SDI system. Pests such as rodents and insects are often more troublesome at the shallow dripline depths.

Zone size (length and width) considerations

The overall field size that can be subsurface drip irrigated is limited by the available water supply and SDI system flowrate. However, the ability to economically adjust the size of the irrigated field to the available water supply is a distinct advantage of SDI systems as compared to center pivot sprinklers. If sufficient water supply is available to adequately irrigate the crop for the overall field size, then system flowrate, field shape, and topography, along with the dripline hydraulic characteristics (i.e., emitter discharge characteristics and dripline diameter) are used to determine the number of zones and the zone dimensions. Minimizing the number of necessary zones and using longer driplines typically results in a more economical system to install and operate, which is of great importance to those growers using SDI on lesser-valued crops.

Systems are sometimes designed so that irrigation zones can be sub-divided into flush zones. Flushing, discussed in detail later, is an important maintenance requirement for SDI systems.

The combination of the emitter discharge, emitter spacing, and dripline spacing determine the flowrate per unit area. The flowrate per unit area in combination with the water supply flowrate (i.e., system or well flowrate) in turn determines the zone size. The system flowrate can be used to determine the total number of acres that can be reliably irrigated. The irrigation capacity (IC) of an irrigation system is the depth of water that the system could apply to the entire field in one day. As a rule of thumb, a net IC of about 0.25 inches per day is sufficient to meet corn water needs for the deep silt loam soils of western Kansas. Irrigation capacity can also be reported in gpm/acre, so an IC of 0.25 in/day is equivalent to 4.7 gpm/acre. Typical surface-irrigated (flood) systems need 8 to 10 gpm/acre, while center pivot systems might need 5.2 to 5.6 gpm/acre range to have the same net IC and SDI systems would need around 5.0 gpm/ac to match a net IC of 4.7 gpm/acre. There is some evidence to suggest that SDI systems may allow more effective utilization of precipitation and some systems have been installed with gross IC as low as 3.4 gpm/acre. This allows the available water supply to be stretched over more land area but does leave the SDI system's crop vulnerable to crop water stress during drought years.

The design process may require several iterations to select the correct emitter discharge, emitter spacing, dripline spacing (usually fixed at twice the row spacing) with zone size, field size and system flowrate given the producers desired level of irrigation system reliability.

SDI COMPONENTS FOR EFFICIENT WATER DISTRIBUTION AND SYSTEM LONGEVITY

SDI system design must consider individual management restraints and goals, as well as account for specific field and soil characteristics, water quality, well capabilities, desired crops, production systems, and producer goals. However, certain basic features should be universal throughout all SDI systems (Figure 2). The long-term efficient operation and maintenance of the system is seriously undermined if any of the minimum components are omitted during the design process. Minimum SDI system components should not be sacrificed as design and installation cost-cutting measures. If minimum SDI components cannot be included as part of the system, an alternative type of irrigation system or a dryland production system should be considered.

Water distribution components of an SDI system include the pumping station, the main, submains, and dripline laterals. Sizing requirements for the mains and submains are somewhat similar to underground service pipe to center pivot sprinklers or main pipelines for surface-irrigated gravity systems and are determined by the flowrate and acceptable friction loss within the pipe. In general, the flowrate and friction loss determine the dripline size (diameter) for a given dripline lateral length and land slope. An SDI system consisting of only the distribution components has no method to monitor system performance or conduct system maintenance, and the system would not have any protection from clogging. Clogging of dripline emitters is the primary reason for SDI system failure. In addition to basic water distribution components, other components allow the producers to monitor SDI system performance, allow flushing, and protect or maintain performance by injection of chemical treatments. The injection equipment can also be used to provide additional nutrients or chemicals for crop production. A backflow prevention device is required to protect the source water from accidental contamination if backflow should occur.

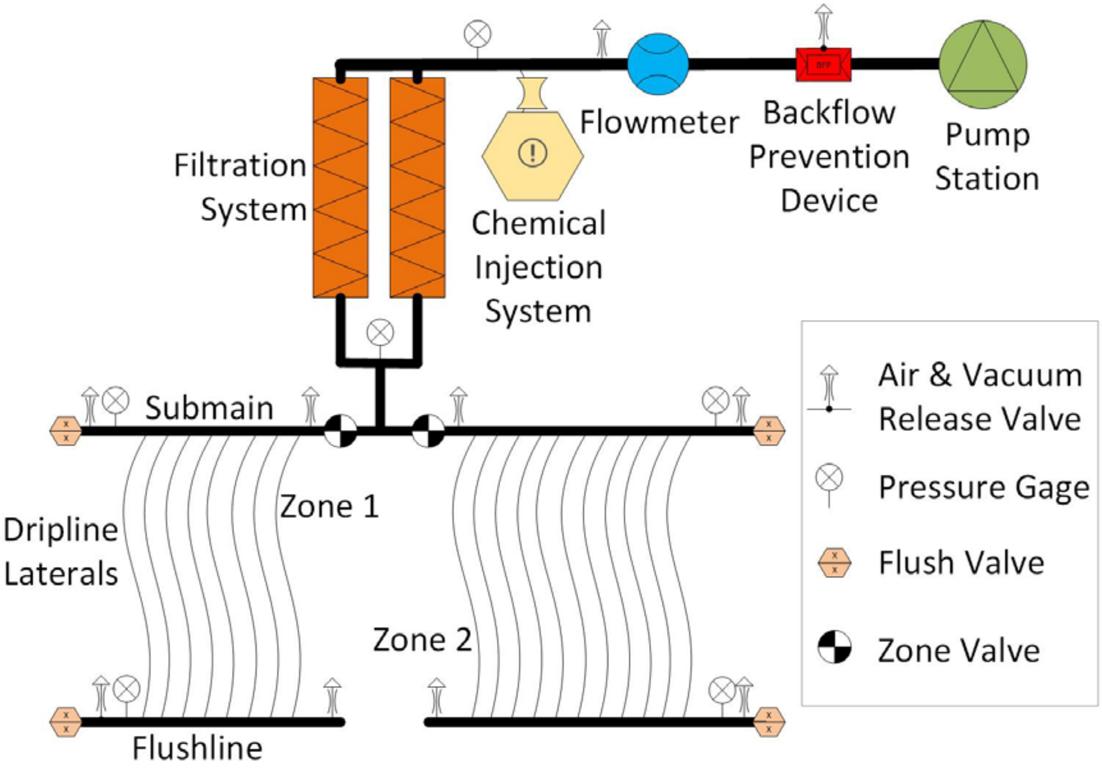
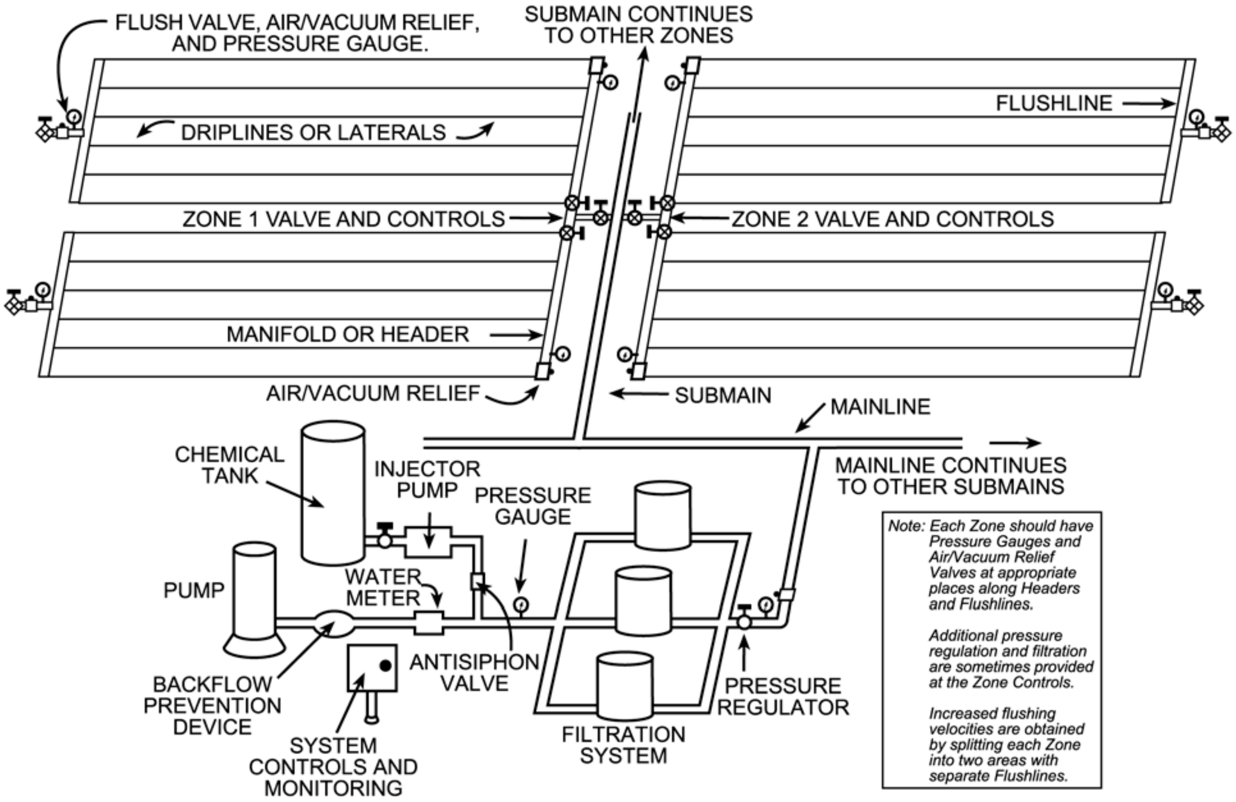


Figure 2. Minimum required components of an SDI system. Components are not to scale. After Rogers, 2003b.

The actual characteristics and field layout of an SDI system vary from site to site, but irrigators often add additional capabilities to their systems. For example, the SDI system in Figure 3 shows additional valves that allow the irrigation zone to be split into two flushing zones. When the well or pump does not have the capacity to provide additional flow and pressure to meet the flushing requirements for the irrigation zone, splitting the zone into two parts may be an important design feature.



Note: Each Zone should have Pressure Gauges and Air/Vacuum Relief Valves at appropriate places along Headers and Flushlines.

Additional pressure regulation and filtration are sometimes provided at the Zone Controls.

Increased flushing velocities are obtained by splitting each Zone into two areas with separate Flushlines.

Figure 3. Schematic of a complete SDI system. After Lamm and Camp (2007).

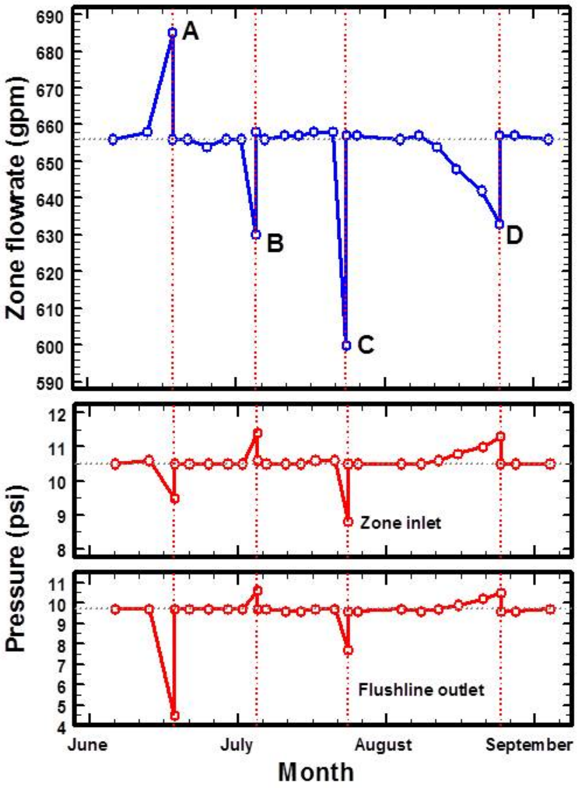
Filtration, chemical injection and flushing components

These three systems of components are very important design topics and will be covered in a separate paper presented at this conference. This paper follows in the conference proceedings or can be accessed electronically at:

http://www.ksre.k-state.edu/sdi/reports/2018/LammFM18.pdf

Components for monitoring the SDI system

In SDI systems, all water application is underground. Because surface wetting seldom occurs in properly installed and operated systems, no visual cues of system operation are available to the manager. Therefore, the flow meter and pressure gauges must be used to provide operational feedback cues. The pressure gauges along the submain of each zone measure the inlet pressure to driplines. Decreasing flowrates and/or increasing pressure may indicate clogging, and increasing flowrates with decreasing pressure may indicate a major line leak. The inlet pressure gauges, along with those at the distal ends of the dripline laterals at the flushline valve, help establish the baseline performance characteristics of the system. Good quality pressure gauges should be used at each of these measurement locations and the gauges should be periodically replaced or inspected for accuracy. The flowrate and pressure measurements should be recorded and retained for the life of the system. A time series of flowrate and pressure measurements can be used as a diagnostic tool to discover operational problems and determine appropriate remediation techniques (Figure 6).



Anomaly A: The irrigator observes an abrupt flowrate increase with a small pressure reduction at the Zone inlet and a large pressure reduction at the Flushline outlet. The irrigator checks and finds rodent damage and repairs the dripline.

Anomaly B: The irrigator observes an abrupt flowrate reduction with small pressure increases at both the Zone inlet and the Flushline outlet. The irrigator checks and finds an abrupt bacterial flare-up in the driplines. He immediately chlorinates and acidifies the system to remediate the problem.

Anomaly C: The irrigator observes an abrupt flowrate decrease from the last irrigation event with large pressure reductions at both the Zone inlet and Flushline outlet. A quick inspection reveals a large filtration system pressure drop indicating the need for cleaning. Normal flowrate and pressures resume after cleaning the filter.

Anomaly D: The irrigator observes a gradual flowrate decrease during the last four irrigation events with pressure increases at both the Zone inlet and Flushline outlet. The irrigator checks and finds that the driplines are slowly clogging. He immediately chemically treats the system to remediate the problem.

Figure 6. Hypothetical example of how pressure and flowrate measurement records could be used to discover and remediate operational problems. After Lamm and Camp (2007).

PRODUCER RESPONSIBILITIES

As with nearly all investments, the decision of whether an SDI investment is sound lies with the investor. Wise decisions generally require a thorough understanding of the fundamentals of the particular opportunity and/or the recommendations from a trusted and proven expert. While the microirrigation (drip) industry dates back nearly 50 years and SDI application in Kansas has been researched since 1989, the network of industry support is still evolving in portions of the Great Plains region. Individuals considering SDI should spend time to determine if SDI is a viable systems option for their situation. They might ask themselves:

What things should I consider before purchasing an SDI system?

1. Educate yourself before contacting a service provider or salesperson by
    a. Seeking out university and other educational resources. A good place to start is the K-State SDI website at www.ksre.ksu.edu/sdi
    Read the literature or websites of microirrigation companies as well.
    b. Review SDI minimum design components as recommended by K-State. http://www.ksre.ksu.edu/sdi/reports/2003/mf2576.pdf
    c. Visit other producer sites that have installed and are using SDI. Most current producers are willing to show their SDI systems to others.

2. Interview at least two companies.
   a. Ask them for references, credentials (training and experience) and completed sites (including the names of contacts or references).
   b. Ask questions about design and operation details. Pay particular attention if the minimum SDI system components are not met. If not, ask why. System longevity is a critical factor for economical use of SDI.
   c. Ask companies to clearly define their role and responsibility in designing, installing, and servicing the system. Determine what guarantees are provided.
3. Obtain an independent review of the design by an individual that is not associated with the sale. This adds cost but is relatively minor in comparison to the total cost of a large SDI system.

CONCLUSION

SDI can be a viable irrigation system option, but many issues should be carefully considered by producers before any financial investment is made.

OTHER AVAILABLE INFORMATION

Additional SDI-related bulletins and irrigation-related websites are listed below:

MF-2361 *Filtration and Maintenance Considerations for Subsurface Drip Irrigation (SDI) Systems*
http://www.ksre.ksu.edu/sdi/reports/2003/mf2361.pdf

MF-2576 *Subsurface Drip Irrigation (SDI) Components: Minimum Requirements*
http://www.ksre.ksu.edu/sdi/reports/2003/mf2576.pdf

MF-2578 *Design Considerations for Subsurface Drip Irrigation*
http://www.ksre.ksu.edu/sdi/reports/2003/mf2578.pdf

MF-2590 *Management Consideration for Operating a Subsurface Drip Irrigation System*
http://www.ksre.ksu.edu/sdi/reports/2003/MF2590.pdf

MF-2575 *Water Quality Assessment Guidelines for Subsurface Drip Irrigation*
http://www.ksre.ksu.edu/sdi/reports/2003/mf2575.pdf

MF 2589 *Shock Chlorination Treatment for Irrigation Wells*
http://www.ksre.ksu.edu/sdi/reports/2003/mf2589.pdf

Subsurface Drip Irrigation website: www.ksre.ksu.edu/sdi

General Irrigation website: www.ksre.ksu.edu/irrigate

Mobile Irrigation Lab website: http://www.bae.ksu.edu/mobileirrigationlab/

ACKNOWLEDGEMENTS

This paper is also part of SDI technology transfer effort beginning in 2009 involving Kansas State University, Texas A&M University and the USDA-ARS and is funded by the Ogallala Aquifer Program. To follow other activities of this educational effort, point your web browser to http://www.ksre.ksu.edu/sdi/.

This paper was first presented at the Central Plains Irrigation Conference, Feb. 20-21, 2018, Colby, Kansas.

REFERENCES

Alam, M. and D.H. Rogers. 2005. Field Performance of Subsurface Drip Irrigation (SDI) in Kansas. In: Proc Irrigation Association International Irrigation Technical Conference, IA 05-1209. November 6-8, 2005. Phoenix, AZ. pp. 1-5. Also at http://www.ksre.ksu.edu/sdi/reports/2005/IA05-1209.pdf

Arbat, G., F. R. Lamm, and A. A. Abou Kheira. 2010. Subsurface drip irrigation emitter spacing effects on soil water redistribution, corn yield and water productivity. Applied Engr. in Agric. 26(3):391-399. Also available at http://www.ksre.ksu.edu/sdi/reports/2010/ESpace10.pdf

Bucks, D. A., F. S. Nakayama, and R. G. Gilbert. 1979. Trickle irrigation water quality and preventive maintenance, Agric. Water Manage. 2(2):149-162.

Burt, C. and S. Styles. 2007. Ch. 11. Chemical injection for water treatment. pp 223-236 in Drip and micro irrigation design and management for trees, vines and field crops- Practice plus theory, C. Burt and S. Styles, 3rd Ed., ITRC, Cal Poly, San Luis Obispo, CA. 396 pp.

Camp, C. R. 1998. Subsurface drip irrigation: A review. Trans. ASAE 41(5):1353-1367.

Gardner, W. H. 1979. How water moves in the soil. Crops & Soils 32(2):13-18.

Hanson, B., Schwankl, L., S. R. Grattan, and T. Prichard. 1997. Drip Irrigation for Row Crops. Water Management Series #93-05. University of California, Davis. Davis, CA. 175 pgs.

Hassan, F., 1998. Microirrigation Management and Maintenance. Agro Industrial Management. Fresno, CA. 233 pgs.

Lamm, F. R. 2016. Cotton, Tomato, Corn, and Onion Production with Subsurface Drip Irrigation - A Review. Trans. ASABE Vol. 59(1):263-278. Also at http://www.ksre.k-state.edu/sdi/reports/2016/LammSDIReview.pdf

Lamm, F.R. and C.R. Camp. 2007. Subsurface drip irrigation. Chapter 13 in Microirrigation for Crop Production - Design, Operation and Management. F.R. Lamm, J.E. Ayars, and F.S. Nakayama (Eds.), Elsevier Publications. pp. 473-551.

Lamm, F. R. and T. P. Trooien. 2005. Dripline depth effects on corn production when crop establishment is nonlimiting. Appl. Engr in Agric. 21(5):835-840. Also at http://www.ksre.ksu.edu/sdi/reports/2005/DepthSDI.pdf

Lamm, F. R., A. A. Aboukheira, and T. P. Trooien. 2010. Sunflower, soybean, and grain sorghum crop production as affected by dripline depth. Applied Engr. in Agric. 26(5):873-882. Also at http://www.ksre.ksu.edu/sdi/reports/2010/DDepth10.pdf

Lamm, F. R., W. E. Spurgeon, D. H. Rogers, and H. L. Manges. 1998. KSU research for corn production using SDI. In: Proc. Central Plains Irrigation Short Course, North Platte, NE, Feb. 17-18, 1998. Available from CPIA, 760 N. Thompson, Colby, KS. pp. 13-21.

Nakayama, F. S. and D. A. Bucks. 1991. Water quality in drip/trickle irrigation: A review. Irrig. Sci. 12:187-192.

Rogers, D. H., F. R. Lamm, and M. Alam. 2003a. Subsurface drip irrigation systems (SDI) water quality assessment guidelines. K-State Research and Extension, MF-2575. July 2003. 8 pp. Also at http://www.ksre.k-state.edu/sdi/reports/2003/mf2575.pdf

Rogers, D. H., F. R. Lamm, and M. Alam. 2003b. Subsurface drip irrigation (SDI) components: Minimum requirements. K-State Research and Extension, MF-2576. 4 pp. Also at http://www.ksre.ksu.edu/sdi/reports/2003/mf2576.pdf

Seginer, I. 1979. Irrigation uniformity related to horizontal extent of root zone. Irrig. Sci. 1:89-96.

Schwankl, L., B. Hanson, and T. Prichard. 2008. Maintaining microirrigation systems. Univ. of California Agriculture and Natural Resources Pub. 21637. 53 pp.