Subsurface Drip Irrigation (SDI) in Kansas: An Overview

K·STATE Research and Extension

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What is SDI?

Subsurface drip irrigation (SDI) is a type of microirrigation where water is applied to the crop root zone below the soil surface. Application is by means of small emission points (emitters) at fixed intervals in a series of plastic tubes, which are typically placed either under each row or between crop rows (Figure 1). Although the American Society of Agricultural and Biological Engineers includes in their definition of SDI (ASAE S526.2, 2001) that the discharge rate of the emitters is usually less than 2 gallons/hour, in practice in the Great Plains, most emitter discharge rates are in the range of 0.15 to 0.50 gallons/hour. The driplines also come in a variety of diameters (0.625 to 1.375 inches), wall thicknesses (typically 8 to 15 mil), and emitter spacings (typically 12 to 24 inches). These options allow for the design and installation of SDI systems that can deliver water and nutrients to crops with high efficiency and uniformity since the water is delivered directly to the root zone.

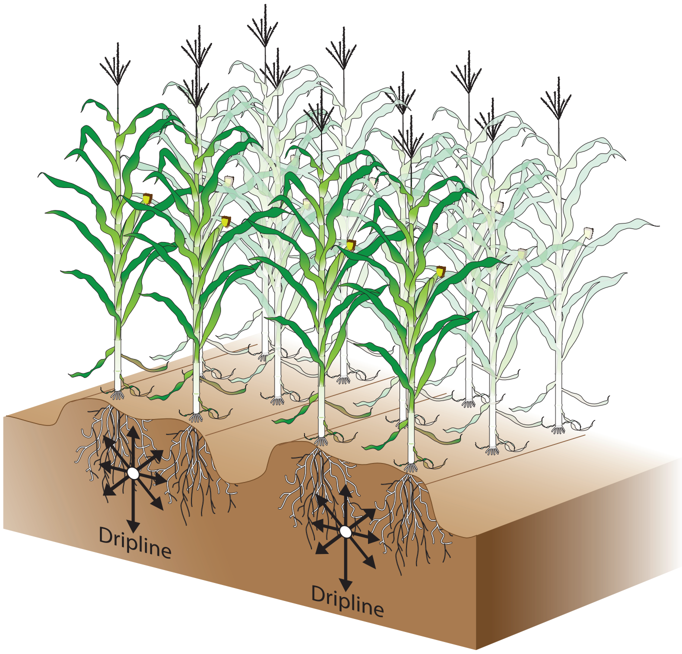

Figure 1: Cross section schematic of an SDI system with a typical alternate row middle configuration of driplines. (Drawing courtesy of K-State)

Subsurface drip irrigation is not the same and should not be confused with subirrigation. Subirrigation applies water below the ground surface by raising the water table to within or near the root zone. There is little or no subirrigation in the Central Great Plains. To avoid confusion as one tries to obtain information about SDI, practitioners need to be precise and use either the term SDI or subsurface drip irrigation and avoid terms such as subirrigation, subsurface irrigation, sub-surface irrigation, subdrip, and other associated terms. Avoid using even the simpler terminology of drip irrigation, because in many aspects surface drip irrigation (DI) and subsurface drip irrigation (SDI) may perform very differently.

Some shallow subsurface systems (less than 8-inch depth) are retrieved and/or replaced annually and are very similar to surface drip irrigation. Many research reports refer to these systems as surface drip irrigation, and reserve the term SDI for systems intended for multiple-year use that are installed below tillage depth (Camp and Lamm, 2003).

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. Shallower dripline depth tends to improve chances for germination and crop establishment.

Soil layering or changes in texture and density within the soil profile can also affect the choice of dripline depth. In general, subsurface water applications will not cross soil textural boundaries easily and uniformly until the current soil texture approaches a more saturated condition. For example, a layered soil profile consisting of an 8-inch clay layer on top of sandy sub-soil with a dripline placed at 12 inches will not have water movement into the clay soil until the sand layer approaches saturation. In this case, it is likely that water movement into the clay surface soil will always be limited, making irrigation management of this field difficult. But in a case of a 15-inch sand layer on top of a clay soil with an SDI line placement of 12 inches, water will not infiltrate into the clay layer until the sandy layer approaches saturation, making irrigation management of this field easier.

SDI systems for lower-valued commodity crops (fiber, grains, and oilseeds) and perennial crops (trees and grapes) 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 damaging the SDI system. Pests such as rodents and insects are often more troublesome at shallow dripline depths (Van der Gulick, 1999).

SDI systems are adaptable to a wide variety of field shapes, soil conditions, and crops but do need to have, at a minimum, properly filtered water and occasional treatment of the driplines to prevent emitter clogging.

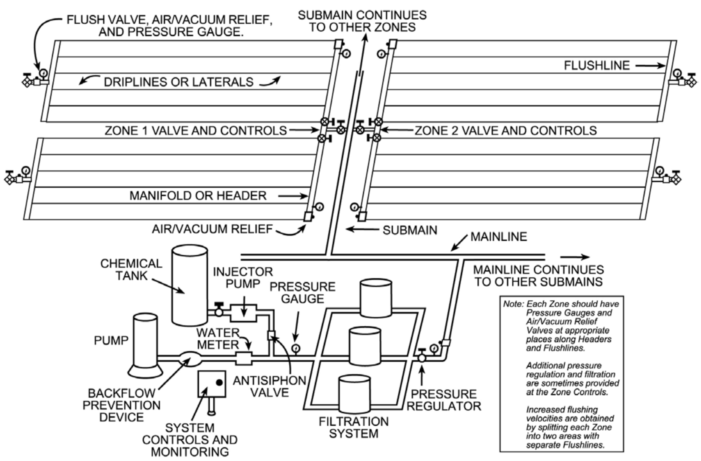

Figure 2: Schematic of an SDI system illustrating a typical system layout including the pumping plant, and filtration and injection systems needed to manage and maintain an SDI system in top working condition and achievement of high crop water use productivity. (Drawing courtesy of K-State)

As with any new technology, there are issues and constraints that need to be understood before the technology can be fully utilized in a successful manner. Many of the advantages and disadvantages of SDI are discussed by Lamm (2002).

History and Progression of SDI in Kansas

Irrigation and humanity have had a long association, with irrigation possibly being the first modification of the natural environment by humans, as suggested by several (Hoffman et al., 1990, Sojka et al., 2002) beginning with evidence of irrigation in the Nile, Tigris, and Euphrates river valleys as early as 6,000 B.C. These irrigation works would be broadly classified as surface water diversions and surface irrigation, where water is distributed on the soil surface for eventual infiltration into the soil.

The first application of irrigation water through a non-surface irrigation method may have been described in a first century B.C. agricultural text from China (Bainbridge, 2001). Water was made available to the plant through the use of a buried clay pot. The water in the pot seeped into the soil surrounding the pot where the crop was planted.

The application of water beneath the soil surface was extended to the use of clay pipes, which was part of a study in Germany in 1869 (Howell et al., 1983; Keller and Bliesner, 2000). In the U.S., a study using widely-spaced, buried drainage tile for irrigation was conducted beginning in 1913 at Colorado State University (House, 1918). He concluded that the technology would not be cost effective for ordinary farm crops such as corn, that narrower lateral spacings would be needed for grain crops on this soil type, and that a smaller water supply that would be infeasible for a surface gravity system could be sufficient for a subsurface system.

Camp (1998) reviewed SDI development, beginning his review with the 1920 patent by Charles Lee of an irrigation tile that included orifices as water outlets. He then noted rapid development following WWII with the availability of plastics that allowed multiple options of developing drip tubing with commercial application by 1959, especially in California and Hawaii. The initial crops tended to be high value horticultural crops, fruits, and sugar cane.

In a three-year study (1965-1967) near Georgetown, Delaware, Mitchell et al. (1969) reported some early SDI corn research evaluating flexible plastic tubing with various orifices and dripline spacings. They reported yield increases of 12 to 2515 percent, with SDI compared to rainfed production on a loamy sand. This report also provides some of the earliest details about installation implements and procedures for SDI, some of which are similar to today's procedures.

In another related early publication, Mitchell and Tilmon (1982) suggested SDI as a good, economical irrigation system alternative for the small farmer in the United States. This is because the components of SDI systems can be easily and economically designed to accommodate the field size (Bosch et al., 1992; O'Brien et al., 1998). The first reported use of SDI for cotton research that was found in this literature review was in 1963 near Lubbock, Texas (Zetzsche and Newman, 1996).

Performance of early SDI systems was often plagued by problems such as emitter clogging (chemical precipitation, biological and physical factors, and root intrusion) and poor distribution uniformity. However, as improved plastic materials, manufacturing processes, and emitter designs became available, resurgence in SDI occurred, both in research activities and commercial operations in the 1980s (Camp et al. 2000). Use of SDI on a large commercial farm in Arizona for the production of wheat and cotton, which started as a test in 1979, was reported by Tollefson (1985 a,b).

These earlier efforts set the stage for the potential use of SDI systems on field crops in Kansas, especially for the most commonly irrigated crop — corn. In 1989, the first SDI research plots in Kansas were installed at the KSU

Northwest Research and Extension Center in Colby. The three primary goals of the research conducted on this site and in other subsequent studies that followed have been to 1) enhance water conservation, 2) protect water quality, and 3) develop appropriate SDI technology for Great Plains conditions (Lamm and Rogers, 2014).

The SDI research system that was installed in 1989 was used for 26 years until it was decommissioned in the fall of 2015. The system's performance was monitored throughout the period of use and the flowrate of the system at the time of replacement was within +/- 5 percent of the initial value (Figure 3). The SDI system was replaced due to the increasing number of splits within the dripline creases, which could impact successful completion of research studies (Lamm and Rogers, 2017; Velasquez et al., 2017).

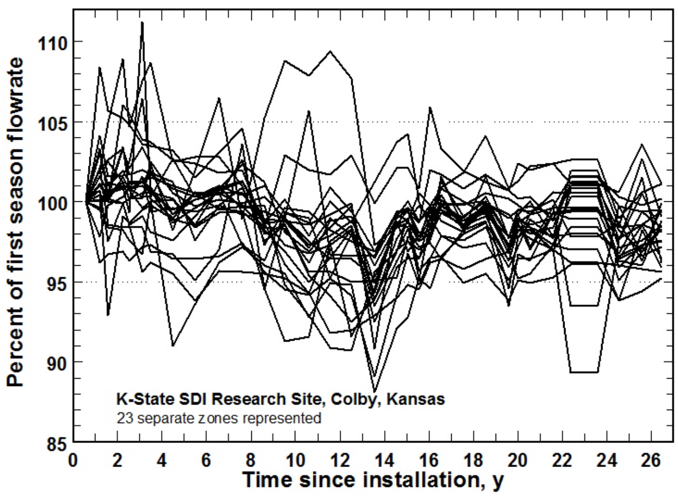

Figure 3. Zone flowrates as affected by years of operation for a 23-zone research SDI system at the KSU Northwest Research-Extension Center, Colby Kansas (1989-2015).

At the time of the NWREC installation, a few commercial SDI systems were in existence in Kansas (authors' personal observations). In 1992, K-State extension engineers began surveying industry representatives and dealers to improve estimates of SDI land area. The estimated number of SDI acres in 1992 was 4,500 and increased to 17,500 acres by 2002.

In 2003, the Kansas Dept. of Agriculture Division of Water Resources (KDA DWR) added the distinction of SDI systems as information included in the required annual water use reports. These producers were surveyed by phone to estimate SDI land area in 2003, which resulted in an estimate of 14,018 acres. Beginning in 2004, SDI data from the KDA DWR Irrigation Water Use Reports are plotted on Figure 4. The data includes land area for both fields using only SDI and for those using SDI in combination with another irrigation system type. This means the actual number of SDI acres would be less than the value shown but still indicates there is an upward trend in the number of SDI land areas.

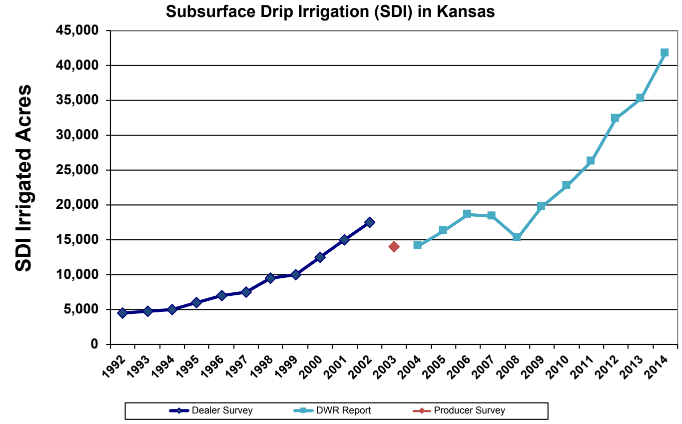

Figure 4. Progression of SDI land area in Kansas, 1992-2015

Figure 5 shows the top 10 counties in terms of SDI irrigated land area based on 2013 irrigation water use reports. The top SDI county in Kansas is McPherson county with 5,846 SDI acres, which represents more than 16 percent of the total irrigated acreage base for the county. Statewide, SDI is still only used on about 1 percent of irrigated land area.

Over the years since 1989, K-State Research and Extension has conducted research and engaged in technology transfer for SDI in the topic areas of design, operation, management and maintenance, with particular emphasis on the usage of SDI for commodity crops typical to the Central Great Plains (corn, soybeans, grain sorghum, sunflowers, and alfalfa. The first 10 years of research results were summarized by Lamm and Trooien, 2003. A later summary of 25 years of water and nitrogen management SDI studies was provided by Lamm and Rogers, 2014.

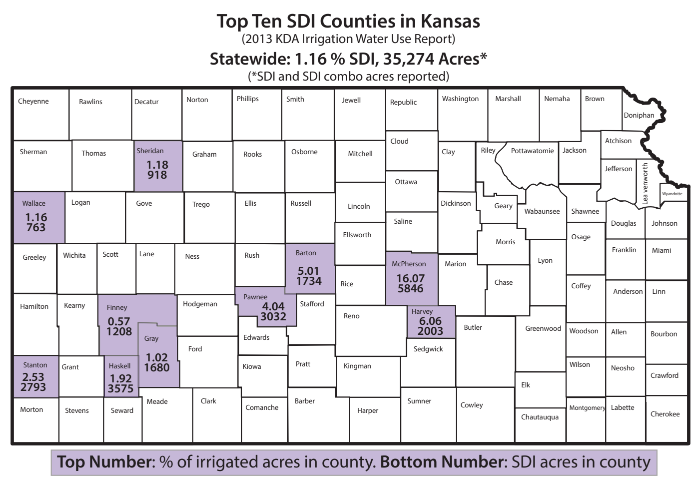

Figure 5: Top Ten SDI Counties in Kansas (KDA-DWR, 2013).

Concluding Statements

Research progress has been steady since 1989. Much of K-State's Research and Extension efforts with SDI is summarized at the website SDI in the Great Plains at http://www.ksre.ksu.edu/sdi/. Irrigators are watching the results of K-State closely. Each year several new irrigators begin to experiment with SDI on their own farms and most appear happy with the results they are obtaining. SDI can be a viable irrigation system option for improving crop production, enhancing the opportunities for wise use of limited water resources, and also in protecting water quality.

This overview and history summary is provided as the first of a series of K-State Research and Extension publications concerning SDI.

Related KSRE SDI Resources

MF2361, Filtration and Maintenance Considerations for Subsurface Drip Irrigation (SDI) Systems http://www.ksre.ksu.edu/sdi/reports/2003/mf2361.pdf

MF2576, Subsurface Drip Irrigation (SDI) Components: Minimum Requirements http://www.ksre.ksu.edu/sdi/reports/2003/mf2576.pdf

MF2575, Water Quality Assessment Guidelines for Subsurface Drip Irrigation http://www.ksre.ksu.edu/sdi/reports/2003/mf2575.pdf

MF2578, Design Considerations for Subsurface Drip Irrigation http://www.ksre.ksu.edu/sdi/reports/2003/mf2578.pdf

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

(forthcoming) SDI injection (New)

MF2867, Subsurface Drip Irrigation for Alfalfa http://www.ksre.k-state.edu/sdi/reports/2009/MF2867.pdf

MF2727, Subsurface Drip Irrigation with Livestock Wastewater, http://www.ksre.k-state.edu/sdi/reports/2006/MF2727.pdf

Other Related KSRE Resources

MF2589 Shock Chlorination Treatment for Irrigation Wells http://www.ksre.ksu.edu/sdi/reports/2003/mf2589.pdf

(forthcoming) Irrigation Water Quality Criteria Guidelines (new)

MF2849 (Rev.) Kansas Irrigation Trends

https://www.bookstore.ksre.k-state.edu/pubs/MF2849.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/

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This publication is also part of an SDI technology transfer effort that began in 2009 involving Kansas State University, Texas A&M University, and the USDA-ARS that was funded by the Ogallala Aquifer Project.

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