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Row Crops: Agronomy

CLEMSON COOPERATIVE EXTENSION

Subsurface Drip Irrigation (SDI) for Row Crops: An Introduction

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What is Subsurface Drip Irrigation?

Irrigation is the most common and effective way of avoiding the negative impact of drought in agricultural production. Subsurface drip irrigation (SDI) is the most efficient method of delivering irrigation water directly to the crop root zone, which has been successfully used for decades to irrigate row crops in many areas. SDI delivers water to the crop through thin-wall drip laterals (also called drip tapes) that are permanently installed at a given depth below the soil surface. addition to water, crop nutrients and other substances can be dissolved and applied together with the irrigation water. The system can be automated using irrigation controllers to apply irrigation and nutrients at the time and amount required by the crop.

The drip tapes are usually installed between crop rows at a depth that depends on the crop, soil type, and tillage requirements (Figure 1). For example, for corn and cotton, which have a deep root zone, the tape can be installed at a depth of 12 to 14 inches; but for peanuts, which has a shallower root zone, a depth of 8 inches would be better. Also, the presence and depth of a hardpan would affect the depth of installation. Installing the tape above the hardpan would be preferable or deep tillage may be needed to break the hardpan.

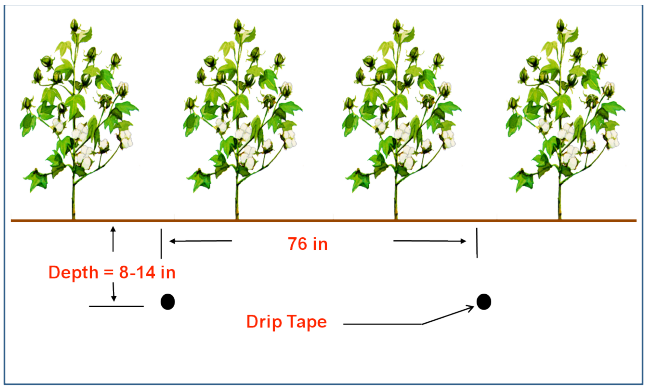

Figure 1. Sample placement of drip tape for cotton.

The drip tapes have small holes called emitters spaced at regular distance through which water flows at low pressure (drop by drop). Although the water pressure inside the tape is typically around 10 PSI, before leaving the emitters water is forced through a tortuous path imbedded inside the drip tape that reduces flow to the point where water is released drop by drop, preventing soil erosion. Different tape emitter size and spacing can be selected to match the required water flow rate. The drip tapes come in different diameters and thicknesses (Figure 2). Longer fields require larger diameter tapes to maintain acceptable irrigation application uniformity. Thicker tapes will last longer. The price of the type, however, increases with both diameter and thickness. The drip tapes normally come in rolls and are buried with a customized shank that is attached to a tractor (Figure 3).

The water supply line, usually a PVC pipe, is installed in a trench perpendicular to the drip tapes (Figure 4). The drip tapes are connected to the water supply line using polyethylene flexible hoses. Holes are drilled in the supply line and the flexible hoses can be connected to the supply line using a variety of attachments, such as a glued saddle connection or a compression fitting (Figure 5). The other end of the flexible hose connects to the drip tape with a quick-connect attachment or with a stainless steel wire

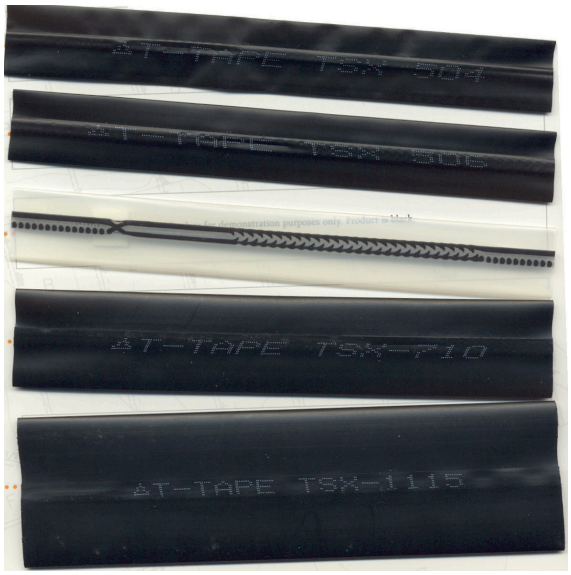

Figure 2. Drip tapes come in different sizes.

tie. Because the drip tapes need to be regularly flushed to get rid of sediments (such as small soil particles), the far end of the drip lines need to be provided with a way of allowing flushing. Flushing options are to (1) leave the ends of the drip line above ground and either bend and tie each end, which can be untied when flushing is needed, (2) leave the ends of the drip line above ground and install an automatic flushing valve in each drip tape (this valve is normally open and closes when a given pressure is reached), or (3) attach all the ends of the drip tapes together to a common flushing line.

Figure 3. Equipment used to install the drip

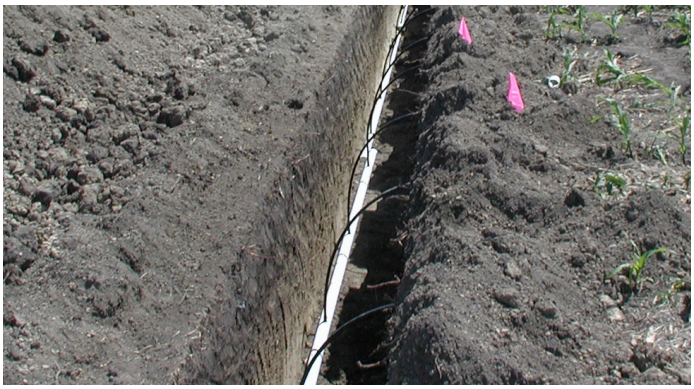

Figure 4. Buried water supply line connected to drip tapes.

Figure 5. Options to attach flexible hose to water supply line.

A typical SDI installation will have central control station (Figure 6). The central control station normally includes the following key components:

1. **The pumping station**, to provide water at the required flow rate and pressure. It is important to match the pump capacity (flow rate and pressure) to those required by the SDI system; otherwise the pump will operate at low efficiency, wasting energy.
2. **The filtration system**, to filter impurities in the water (such as soil particles and trash), which can potentially plug the emitters. There are different types of filters (such as screen filters, sand media filters, disc filters) that can be selected depending on water quality and filtration requirements, among other considerations. Proper filtration is critical to a successful SDI operation.
3. **The fertigation system**, to apply liquid or dissolved fertilizers with the irrigation water. This system usually includes a fertigation tank to store the fertilizer and a device to inject the fertilizer into the pipeline. Injection can be done either with an electric injection pump or with a venturi device that does not require electricity.
4. **The chemical injection system**, to apply other chemicals like chlorine or acid into the water. The application of these chemicals is part of the normal operation and maintenance of an SDI system and prevents the formation of substances that can potentially plug the emitters. Injection of chlorine is needed to prevent the formation of algae and bacteria slime. The injection of acid is sometimes needed to prevent formation of chemical precipitates, like calcium carbonate. Sometimes, injection of herbicides could be needed to prevent small roots from obstructing the emitters. Great care should be taken when handling chemicals to prevent potential injuries and damage to equipment and crop and comply with legal requirements.
5. **The irrigation controller**, which is an electronic device used to set when to irrigate and how much to irrigate. There are many options for irrigation controller, ranging from simple manual timers to more "intelligent" systems that can decide irrigation applications based on external inputs.

6. **Other devices**, which include valves, pressure regulators, pressure tank, and flow meters. Different types of valves such as solenoid valves, air relieve/ vacuum relieve valves, pressure sustaining valves, back flush flow rate adjustment valves, pressure relieve valves, backflow prevention valve, etc, are typically included in an SDI installation.

Figure 6. Sample SDI central control station.

How does SDI reduce climate risk?

SDI can supply the water needed by the crop, reducing potential negative impacts of drought, which is normally the most important climate risk in agricultural production. The system is very efficient, with typical application efficiencies in the order of 95%. Therefore, very little water is wasted and less water is required to produce crops using SDI compared with other irrigation methods. This is important during drought periods when water may be limited. When compared to dryland farming, irrigation can significantly increase and stabilize crop yields and farm income from season to season, reducing farming risk.

What are the agronomic benefits?

Since SDI is more efficient than other irrigation systems, less irrigation water is needed to produce crops. Potential reduction in nutrient needs and losses, since some nutrients like nitrogen can be "spoon-fed" to the crop. Amounts and timing of applications can then be adjusted to match the crop needs. Since a tractor is not needed to apply the fertilizer, then energy requirements and cost are also reduced. Crop yield can be increased or the same yield can be produced with less water, which increases farm profits while protecting the environment. For example, in a three-year cotton study in South Carolina, SDI increased lint yield by an average of 65%, increasing revenue by an average of $396/acre/year (Table 1). Since water is applied underground, there is no farm runoff, which eliminates potential soil erosion and pollution of surface water sources. The soil surface stays dry during and after irrigation. This reduces weed problems, reduces evaporation water losses, and allows performing farm operations while irrigating the crop.

Table 1. Cotton production with SDI compared to dry land during three years in South Carolina (cotton price = $ 0.80/lb).

Effects of SDI on cotton lint yields compared to dry land

(Edisto Research & Education Center)

	Yield and Revenue Increase	
1997	370 lb/acre (37%)	$300/acre
1998	534 lb/acre (56%)	$427/acre
1999	577 lb/acre (103%)	$462/acre

What are the impacts on production costs?

Reduced pumping cost since less water is required and water is applied at low pressure. Reduced irrigation labor cost since the system can be automated. Reduced fertilizer cost since less nutrients are lost due to leaching, runoff, and volatilization. Potential reduction in herbicide cost due to less weed problems.

What is the investment cost?

The cost of installing an SDI system is quite variable depending on the specific design, water filtration needs and automation options. Estimates from SDI suppliers in South Carolina are that SDI costs around $800-$1000 per acre. This is just the cost of materials and does not include the cost of installation. The cost of installation depends on whether the farmer installs the system himself or hires someone to do it (at a cost of around $500/acre). The pump station costs an additional $200-$500 per acre, depending on water sources and distances from fields.

What are the barriers to adoption?

There are several barriers to adoption of SDI in the Southeast USA. These barriers include farmer aversion to adopting new technology; high initial investment; and lack of local information, experience, and installers. Also, although drip irrigation is commonly used to irrigate high value crops (like fruits and vegetables); using SDI for low value row crops is less profitable. There are also some technical barries that have restricted the adoption of SDI. However, all of them can be resolved by proper management strategies. For example, In some areas, the drip tapes can be damaged by animals (like gophers and field mice) and leaks are difficult to find and repair. In addition, emitters can be clogged by bacteria, algae, soil sediments, chemical deposits and roots. Preventing clogging requires regular preventive maintenance, including proper water filtration, injection of chemicals and flushing. Since the drip tape is buried, supplying water for crop germination can be a problem, especially in sandy soils. Knowing the location where the tapes are buried in the field in relation to the crop rows has been a problem in the past, however, this problem can be eliminated by using tractors equipped with a GPS guidance system. Likewise, deep tillage operation, which is a common practice to break shallow hard pans in coastal plain soils, can be successfully performed using GPS guiding systems to avoid damaging the SDI laterals. SDI systems usually require a permanent and reliable water source, which may be a limitation for some growers relying on intermittent surface water sources.

What are the incentives to adoption?

Incentives to adoption of SDI include the fact that it can be implemented to irrigate small, irregularly-shaped fields where other irrigation systems would not be practical or cost-effective, and it may still be economical to invest in SDI rather than relying on rainfall for dryland production. Also, since SDI offers water-saving potential and environmental benefits, farmers may qualify to receive government cost-share from incentive programs like the NRCS EQIP program.

The mission of the Irrigation Water Management program at Clemson University is to develop advanced irrigation technologies and educate farmers on how to improve irrigation water management to increase farm profitability and environmental sustainability in South Carolina.

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