C R O P S E R I E S

IRRIGATION

Subsurface Drip Irrigation (SDI) no. 4.716

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Quick Facts…

Subsurface drip (SDI) is a low-pressure, high efficiency irrigation system that uses buried drip tubes or drip tape to meet crop water needs.

Subsurface irrigation saves water and improves yields by eliminating surface water evaporation and reducing the incidence of disease and weeds.

A subsurface drip system may require higher initial investment and cost will vary due to water source, quality, filtration need, choice of material, soil characteristics and degree of automation desired.

Subsurface drip (SDI) is a low-pressure, high efficiency irrigation system that uses buried drip tubes or drip tape to meet crop water needs. SDI technologies have been a part of irrigated agriculture since the 1960s; with the technology advancing rapidly in the last two decades. A SDI system is flexible and can provide frequent light irrigations. This is especially suitable for arid, semi-arid, hot, and windy areas with limited water supply. Farm operations also become free of impediments that normally exist above ground with any other pressurized irrigation system.

Since the water is applied below the soil surface, the effect of surface infiltration characteristics, such as crusting, saturated condition of ponding water, and potential surface runoff (including soil erosion) are eliminated during irrigation. With an appropriately sized and well-maintained SDI system, water application is highly uniform and efficient. Wetting occurs around the tube and water moves out in all directions.

Subsurface irrigation saves water and improves yields by eliminating surface water evaporation and reducing the incidence of disease and weeds. Water is applied directly to the root zone of the crop and not to the soil surface where most weed seeds winter over. As a result, germination of annual weed seed is greatly reduced, and lowers weed pressure on beneficial crops. In addition, some crops may benefit from the additional heat provided by dry surface conditions, producing more crop biomass, provided water is sufficient in the root zone. When managed properly, water and fertilizer application efficiencies are enhanced, and labor needs are reduced. Field operations are also possible, even when irrigation is applied.

Crops

The degree to which one is willing to invest in SDI technology and maintenance determines its suitability for certain crops. Although it can be tailored to work with almost all crops across a wide spectrum of enterprise types, it is mostly used for high-value vegetable crops, turf and landscapes. In addition, strawberry, tomato, potato, cantaloupe, onions and other vegetables have also shown improvements, both in yield and quality, with melon crops maturing earlier and more uniformly. The improvements on these crops are enhanced when SDI is used in conjunction with plastic mulches. Similarly, sweet corn and field (grain) corn production has seen benefits in terms of water savings and improved or sustained yields when watered with SDI systems.

Soils with low infiltration rates, like many on the Colorado Western Slope, pose a challenge for deep rooting perennial crops like alfalfa. Alfalfa is best irrigated with deeper (1-2 ft) drip tube placement than annual vegetable crops (6-8 inches), but the cost of irrigating in the first year may outweigh the benefits since water struggles to wick up through these tight soils to germinate

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seed and sustain seedlings. Apart from depth, spacing of drip tubes will also impact crop health. It is also important to know characteristics of the soil type for your crop to optimize irrigation scheduling with SDI. Contact your county CSU Extension or USDA-NRCS office for assistance.

If alfalfa germination is economically achievable – possibly with hand-set sprinklers – then many benefits are available; such as: 1.) SDI tube can be semi-permanently installed, eliminating most of the annual replacement cost; 2.) Irrigation can occur much closer to cutting dates since the surface can remain dry for machinery; also 3.) alfalfa regrowth after a cutting may be enhanced by subsurface irrigation since it does not contribute to the emergence of shallow-rooted weeds.

Materials

A large variety of drip tubes are available on the market. The spacing and the flow rate of the emitters in subsurface drip tubes vary according to the product and should match the water needs of the crop grown and soil type. The polyethylene tubes have built-in emitters that can vary from 4 to 24 inch spacings, operating at low nominal pressure (7-14 psi), to dribble water into the soil at a consistent and predictable rate (0.07-2.5 gph). Pressure-compensating emitters means SDI is suitable to distribute water uniformly in sloping fields. Furthermore, research has shown that emitter discharge of SDI systems resulted with greater irrigation uniformity than surface drip irrigation, due to the interaction between effects of emitter discharge and soil pressure.

Drip tubes vary in wall thickness (5 mil-15 mil). The higher the "mil" number the thicker the wall (e.g., 10 mil = 0.25 mm = 0.01 inches), which extends the life of the tube. The cost tends to increase with increases in wall thickness. However, for semi-permanent systems such as alfalfa, more robust tubing is key to minimizing maintenance and rodent problems. Consult with your county CSU Extension or USDA-NRCS office on which emitter spacing or tube thickness combination works best for your soils and operation.

Layout

A typical system layout consists of a settling pond (where possible), pumping unit, pressure relief valve, check valve or back flow prevention valves, a hydrocyclone separator (when a pond is not feasible to take out the coarse materials), chemical injection unit, filtration unit equipped with back-flush control solenoid valves, pressure regulators, air vent valves, and PVC pipe lines delivery system to carry the water to the field (Figure 1).

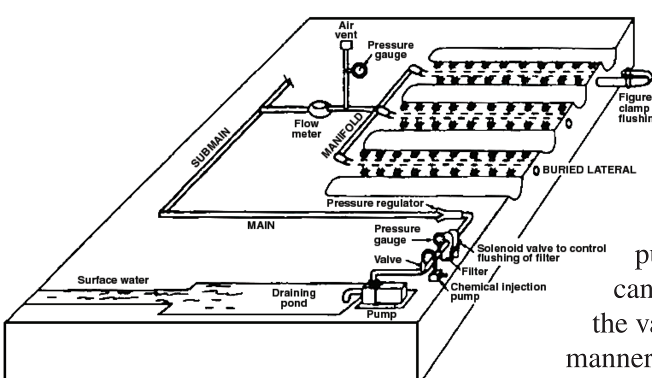

Figure 1. A typical subsurface microirrigation field layout.

The delivery system is composed of main, sub-main and manifold, to which the lateral drip tubes are attached. Items such as a flow meter and a pressure gauge are essential to monitor the performance of the system and provide early warning for leaks and blockages.

It is essential to provide an air release/vacuum breaker valve at the manifold for easy drainage of the tubes when the pump is shut off. This will allow the release of trapped air that can damage the pump (i.e., cavitation) and disrupt irrigation. Install the valve at the highest point in the pump's discharge piping, but in a manner that makes it safely and easily accessible. These vacuum breakers help maintain line pressure when shutting down after an irrigation. A rapid drop in line pressure can cause tubes to collapse or flatten. In a newly installed system, loose soil may settle around a collapsed tube, making it difficult for the tube to regain its shape, at the commencement of the next irrigation.

Placement

The tubes are inserted below the soil surface, using an attachment pulled by a tractor. The placement depths vary from 6 to 24 inches, depending on the soil and crop. Shallow-rooted crops, like strawberries, may require placement as shallow as 3 to 4 inches below the surface. Laying tape or tube higher in the soil profile depends on the capillary action or "wickability" of the soil. Some soils, such as quick draining sandy or gravel soils, do not wick moisture evenly out from emitters, with the soil above the emitters typically receiving less water (gravity/soil characteristics interaction). In these instances, place tape or tube closer to the surface to germinate seed and sustain seedlings. Otherwise, a portable sprinkler system should be available. In heavier soils (i.e., silt loam to clay loam soils), water moves upward easier, thus tubes can be placed deeper. Placing SDI deeper in the soil also helps prevent rodent attack and enhances soil tillage benefits. In all cases, face the emitters on the tube upward at installation. Once an emitter depth is decided on, consistent depth placement of tubing or tape is key to achieve uniform soil-water content throughout the field.

Filtration

It is essential to have a filtration unit that will filter all the particles that are bigger than the emitter openings. As a rule of thumb, filters should remove particles four times smaller than the emitter opening; since particles my group and clog emitters. A filtration system mainly consists of sand media filters; however, a combination of screen and disk filter with sand media filters is highly desirable. A screen filter installed before sand media filters (several smaller sand media filters are better than one large filter) will remove larger organic and inorganic debris (e.g., leaves, algae, diatoms, larvae, fish, snails, seeds, bacteria, and other parts of plants) before the suspended material reaches the sand filter. A 200 mesh filter is adequate for most types of emitters although some drip tapes require only 100 mesh. Filtration can be viewed as the heart of a SDI system and should be designed properly to fit the level of contamination in the water source. Filtration may not be a concern for SDI in urban areas where domestic or higher quality well water is used. When filtration is correctly sized, installed and operated crop rots, molds or blemishes from hard water are eliminated.

Operation and Maintenance

The performance and life of any system depends on how well it is designed and operated. Whether automatically controlled or otherwise, inspect the system regularly. What's more, since SDI is under the surface, repairing tubes is difficult and cumbersome. Rodents tend to chew the tubes, therefore use precaution to prevent rodent damage. The back-flush system needs to be well maintained and the laterals flushed at regular intervals (flushing valves/ball valves) are needed at the end of the lateral line.) Clogging is also not readily apparent, so you may choose to use acid solutions (e.g., to remove bicarbonates) and/or chlorine (to control algae and slime) that often boost flushing effectiveness. Sometimes chemical coagulants are also required to control silt, clay, or suspended colloids in the irrigation water. Cleanout valves installed at the end of the tube lines are important to remove blockages and draining the system.

The quality of water affects the system. High pH water will tend to precipitate a white calcium salt residue, especially with pressure changes that occur across SDI emitters. Calcium and iron precipitates are a problem with most well waters. High salinity or iron concentrations in the water will also cause precipitates; which are aggravated by the presence of organic matter, bacteria and algae. Deep well water may be free of scum, but check the pH to avoid precipitate buildup. Other sources of emitter clogging can be plant roots that tend

References

For additional information on irrigation management and scheduling, see Colorado State University Extension fact sheets:

- 4.707, *Irrigation Scheduling: The Water Balance Approach*
- 4.708, *Irrigation Scheduling*
- 4.702, *Trickle Irrigation for the Home Garden*
- 4.703, *Microirrigation for Orchards*

Additional Information on the Web:

- www.oznet.ksu.edu/sdi/
- www.oznet.ksu.edu/sdi/Reports/2002/ADofSDI.pdf
- www.cprl.ars.usda.gov/wmru/wmpubs.htm#2001
- www.geoflow.com/rootguard

to grow into the small emitters. Emitter blockage is often a function of poor SDI design, consult with CSU Extension staff to ensure you have sized pumps, lines, filters and zones correctly.

Contaminants can be controlled with chemical flushes or injection. Chemicals to consider are acid, acid-forming chemicals or chlorine. Rootguard products may also be used to prevent root growth into the emitter openings that can cause clogging. Contact your local CSU Extension office for advice on flushing drip tubes and emitters with acid solutions, chlorine or Rootguard. Never mix acid and chlorine! Be sure to flush lines thoroughly with untreated water in between chemical flushes.

N-phuric, a commercial mixture of acid and N-fertilizer available in the market, is useful. In addition to lowering the pH to reduce precipitate formation, the product will provide nitrogen fertilizer to the crop. It is essential to winterize the system at the end of the cropping season by thoroughly draining all pipes and ancillaries. An air compressor may help blow out the residual water, especially from the above ground fixtures. Polyethylene tubes are flexible and won't typically break due to freeze.

Sand media filters need to have the sand replaced every season, screen and disk filters need to be cleaned and inspected for physical damage and wear.

It is essential to have a filtration unit for a drip system, irrespective of whether the dripper is used above ground or below the ground surface.

Cost

A subsurface drip system may require higher initial investment and cost will vary due to water source, quality, filtration need, choice of material, soil characteristics and degree of automation desired. System cost, including installation, may range from $1000 to $2000 per acre.

Research consistently shows yield and quality of produce improves when a buried drip system is used. Normal life expectancy of a system is considered to be 12 to 15 years. Some systems have been reported to last 20 years with good maintenance, and could last longer provided good quality water is used. The system remains buried in the ground for many years. SDI system life must be at least 10 to 15 years to reasonably approach economic competitiveness with full sized center pivot sprinkler systems that typically last 20 to 25 years. Cost-share programs such as the Environmental Quality Incentives Program (EQIP) also exist to assist with improvements.

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