Colorado State University
Extension

Subsurface Drip Irrigation (SDI)

Fact Sheet No. **4.716** Crop Series | **Irrigation**

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Subsurface drip irrigation is a low-pressure, high efficiency irrigation system that uses buried drip tubes or drip tape to meet crop water needs. These technologies have been a part of irrigated agriculture since the 1960s; with the technology advancing rapidly in the last three decades. A subsurface 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, especially on sandy type soils.

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

Subsurface irrigation saves water and improves yields by eliminating surface water evaporation and reducing the incidence of weeds and disease. Water is applied directly to the root zone of the crop and not to the soil surface where most weed seeds germinate after cultivation. As a result, germination of annual weed seeds is greatly reduced which lowers weed pressure on cash 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 with a fertilizer injector, water and fertilizer application efficiencies are enhanced, and labor needs are reduced. Field operations are also possible, even when irrigation is applied.

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Crops

The degree to which one is willing to invest in subsurface irrigation 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 subsurface irrigation is used in conjunction with plastic mulches.

Soils with low infiltration rates, like many on the Colorado western slope soils, pose a challenge for subsurface irrigation and drip tube spacing needs to be adjusted for clayey type western slope soils. 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 subsurface irrigation. Contact your county CSU Extension or USDA-NRCS office for assistance.

Alfalfa germination may need to be done with hand-set sprinklers before using the subsurface irrigation—then many benefits are available; such as:

1. subsurface irrigation tubing 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 germination and emergence of shallow-rooted weeds.

Quick Facts

- Subsurface drip irrigation 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 weeds and disease.
- A subsurface drip system may require higher initial investment than a gated pipe/furrow system and cost will vary due to water source, water quality, filtration needs, choice of material, soil characteristics and degree of automation desired.

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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 soil type and should match the water needs of the crop grown. The polyethylene tubes have built-in emitters that can vary from 4 to 24 inch spacing, 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 subsurface irrigation is suitable to distribute water uniformly in sloping fields. Furthermore, research has shown that emitter discharge of subsurface irrigation systems resulted in 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. If burrowing rodents are common in your area you should consult with your county CSU Extension or USDA-NRCS office prior to moving forward with a subsurface irrigation system. Also consult with your county CSU Extension or USDA-NRCS office or subsurface irrigation supplier about 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 sand media filter (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).

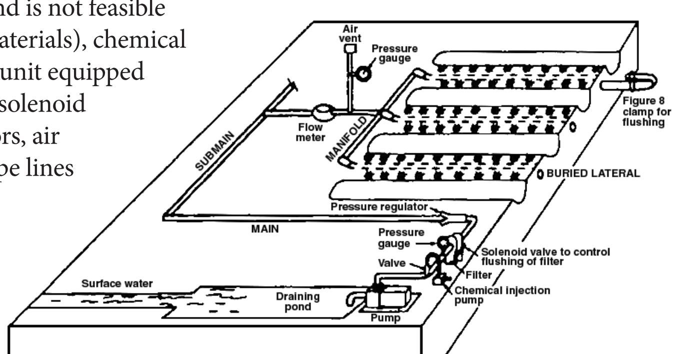
The delivery system is composed of main, sub-main and manifold, to which the lateral drip tubes are attached. Items such as a flow meter and pressure gauges are essential to monitoring the performance of the system and providing warning of leaks and blockages.

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. This is one of the drawbacks 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. Drainage valves at the end of each tube at the end of the field are also essential for clearing small soil particles that have passed through the filter system and for draining the tubes at the end of the irrigation season.

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, top soil depth 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 seeds and sustain seedlings. Otherwise, a portable sprinkler system should be available for seed germination. Placing subsurface irrigation deeper in the soil also enhances soil tillage benefits. In all cases, face the emitters on the tubes upward at installation. Once an emitter depth is decided on, consistent depth placement of tubing or tape is helps to achieve uniform soil-water content throughout the field but is not necessary if tubing has pressure-compensating emitters.

Figure 1: A typical subsurface microirrigation field layout.



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, or as small as economically feasible; 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, however, with large amounts of early season debris mesh filters may not be feasible as labor is needed to flush almost hourly. 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 subsurface irrigation system and should be designed properly by agencies mentioned above or your professional system supplier, to fit the level of contamination in the water source. Filtration may not be a concern for subsurface irrigation in urban areas where domestic or higher quality well water is used.

Operation and Maintenance

The performance and life of any system depends on how well it is designed, operated and maintained. Whether automatically controlled or otherwise, inspect the system regularly. What’s more, since subsurface irrigation is under the surface, repairing tubes is difficult and cumbersome. Another drawback is that plugged emitters are not noticeable until the plants are wilted. Also, rodents tend to chew the tubes, therefore use precaution to prevent rodent damage, or do not use a buried system where rodents are common. The filtration 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 as mentioned earlier). 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. In Colorado, acid is most often used for flushing since it will also eliminate algae and carbonate (lime) build up. 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 subsurface irrigation 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. These will require more frequent flushing measures. 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 to grow into the small emitters. Emitter blockage is often a function of poor subsurface irrigation design, consult with CSU Extension or NRCS 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. Contact your local CSU Extension office for advice on flushing drip tubes and emitters with acid solutions. 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. However, caution should be used and N-phuric should not be used late in the growing season as it will delay maturity and delay dormancy in perennial crops. 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.

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.

Layout

A subsurface drip system may require higher initial investment and cost will vary due to water source, water quality, filtration needs, choice of material, soil characteristics and degree of automation desired. System cost, including installation, may range from $2000 to $4000 per acre, however, economies of scale do also apply to subsurface drip.

Research consistently shows yield and quality of produce improves when a subsurface irrigation 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. Cost-share programs such as the Environmental Quality Incentives Program (EQIP) also exist to assist with improvements.

Additional Resources

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, Drip Irrigation for Home Gardens
- 4.703, Micro-Sprinkler Irrigation for Orchards

Additional information on the Web:

- www.ksre.ksu.edu/sdi/
- www.ksre.ksu.edu/sdi/Reports/2002/ADofSDI.pdf
- www.geoflow.com