

SUSTAINABLE AGRICULTURE TECHNIQUES

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Drip Irrigation: An Introduction

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Drip irrigation tubing used to irrigate wine grapes.

Drip irrigation provides slow, even application of low-pressure water to soil and plants using plastic tubing placed in or near the plants' root zone. It is an alternative to sprinkler or furrow methods of irrigating crops. Drip irrigation can be used for crops with high or low water demands.

Why consider drip irrigation?

Drip irrigation can help you use water efficiently. A well-designed drip irrigation system loses practically no water to runoff, evaporation, or deep percolation in silty soils. Drip irrigation reduces water contact with crop leaves, stems, and fruit. Thus, conditions may be less favorable for disease development. Irrigation scheduling can be managed precisely to meet crop demands, holding the promise of increased yield and quality.

Growers and irrigation professionals often refer to "subsurface drip irrigation," or SDI. When a drip tape or tube is buried below the soil surface, it is less vulnerable to damage due to UV radiation, cultivation, or weeding. With SDI, water use efficiency is maximized because there is even less evaporation or runoff.

Agricultural chemicals can be applied more efficiently through drip irrigation. Since only the crop root zone is irrigated, nitrogen already in the soil is less subject to leaching losses, and applied fertilizer can be used more efficiently. In the case of insecticides, less product might be needed. Make sure the insecticide is labeled for application through drip irrigation, and follow the label instructions.

Additional advantages of drip irrigation include the following.

- ◆ Drip systems are adaptable to oddly shaped fields or those with uneven topography or soil texture; these specific factors must be considered when designing the drip system. Drip systems also can work well where other irrigation systems are inefficient because parts of the field have excessive infiltration, water puddling, or runoff.

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- ◆ Drip irrigation can be helpful if water is scarce or expensive. Because evaporation, runoff, and deep percolation are reduced, and irrigation uniformity is improved, it is not necessary to “overwater” parts of a field to adequately irrigate the more difficult parts.
- ◆ Precise application of nutrients is possible using drip irrigation. Fertilizer costs and nitrate losses can be reduced. Nutrient applications can be better timed to meet plants’ needs.
- ◆ Drip irrigation systems can be designed and managed so that the wheel traffic rows are dry enough to allow tractor operations at any time. Timely application of herbicides, insecticides, and fungicides is possible.
- ◆ Proven yield and quality responses are possible through careful irrigation scheduling made possible with drip irrigation. Yield and quality benefits have been observed in onion, hops, broccoli, cauliflower, lettuce, melon, tomato, cotton, and other crops.
- ◆ A drip irrigation system can be automated. For an example of automated drip irrigation, see Shock, et al., 2011 (see “Additional Resources”).

There are some disadvantages to drip irrigation. For example:

- ◆ Drip irrigation systems typically have initial costs of \$1,200 to \$1,700 per acre. This cost range does not include the equipment to install or retrieve the drip tape or hose in nonpermanent systems. A drip system for use on an annual vegetable crop such as onion will cost about \$1,200 per acre, with approximately \$900 in capital costs for pumps, filtration, and water distribution, and \$300 in recurring annual costs for drip tape.
- A drip system using drip tubing with in-line emitters is more often used for grapes, hops, orchards, etc. It will cost about \$1,700 to \$2,100 per acre and can last 12 to 15 years. Part of the large variability in the per-acre cost of drip tubing is related to the distance between

plant rows. For example, grapes are planted in rows closer than hops, so more tubing is used per acre, leading to greater cost.

Hard hose with plug-in emitters is most frequently used for landscape and nursery applications. The cost per acre of these systems varies widely, depending on their complexity. Systems can be more elaborate and costly than necessary. Growers new to drip irrigation might want to start with a simple system on a small acreage.

- ◆ Drip tape or tubing must be managed to avoid leaking or plugging. Drip emitters are easily plugged by silt or other particles not filtered out of the irrigation water. Emitter plugging also can be caused by algae growing in the tape or by chemical deposits at the emitter. Filtration, acid injection, and chlorine injection remedies to these problems are addressed in “System management and maintenance,” page 5, and “Standard maintenance,” page 6. Also see the website Maintenance of microirrigation systems (see “Websites,” page 6).
- ◆ You might need to redesign your weed control program. Drip irrigation might be unsatisfactory if herbicides need rainfall or sprinkler irrigation for activation. However, drip irrigation can reduce weed populations or reduce weed problems in arid climates by keeping much of the soil surface dry. Tape depth must be chosen carefully to accommodate crop rotations and for compatibility with operations such as cultivation and weeding.
- ◆ Except in permanent installations, drip tape causes extra cleanup costs after harvest. You’ll need to plan for drip tape disposal, recycling, or reuse.

Despite all of drip irrigation’s potential benefits, converting to drip irrigation can increase production costs, especially where an irrigation system already is in place. Ultimately, there must be an economic advantage to drip irrigation to make it worthwhile.

Table 1. Types of drip irrigation systems.

System type	Internal diameter (inches)	Wall thickness (mil)	Emitter spacing (inches)	Emitter flow rate (gal/h)
Drip tape	0.375–1.375	4–35	2–36	0.07–0.84
Tubing (drip line) with in-line emitters	0.410–0.800	23–47	12–60	0.40–1.80
Hard hose with punch-in emitters	0.125–1.5*	29–125	custom	0.50–4.0*

*Larger diameter hose and higher rate microsprinkler emitters are available for hard hose systems.

Components and design

A wide range of components and system design options is available. The Digital Drip Directory (see “Websites,” page 6) lists equipment and suppliers. Drip tapes, tubes, and emitters vary greatly in their specifications, depending on the manufacturer and product use (Table 1). The distribution system, valves, and pumps must match the supply requirements of the tape. Tape, depth of tape placement, distance between tapes, emitter spacing and flow, and irrigation management all must be chosen carefully based on crop water requirements and the soil’s properties. Drip tubing, rather than drip tape, usually is used for perennial crops such as grapes or poplar trees.

The wetting pattern of water in the soil from the drip irrigation tape or tube must reach plant roots. Selection of emitter spacing and tape depth depends on the crop root system and soil properties. Seedling plants such as onions have relatively small root systems, especially early in the season.

Drip irrigation system design requires careful engineering. Design must take into account the effect of the land’s topography (slope and contour) on pressure and flow requirements. Plan for water distribution uniformity by carefully considering the tape, irrigation lengths, topography, and the need for periodic flushing of the tape. Design vacuum relief valves into the system as needed.

When designing a drip system, first identify fairly similar *irrigation zones*. Irrigation zones are based on factors such as topography, field length, soil texture, optimal tape run length, and filter capacity. Irrigation system designers use computer programs to analyze these factors to design efficient drip systems. Once the drip system is designed and installed, it is possible to schedule irrigations to meet the unique needs of the crop in each zone.

Consider power and water source limitations. Have your water analyzed by a laboratory that is qualified to evaluate emitter plugging hazards. Water quality might create limitations and increase system costs. Filters must be able to handle worst-case scenarios. For excellent resources on water quality assessment and filter maintenance, see *Filtration and Maintenance Considerations for Subsurface Drip Irrigation (SDI) Systems* (“Other publications,” page 7).

Finally, be sure to include both injectors for chemigation and flow meters to confirm system performance.

Filters and pumps

Every trickle counts when you are battling a water shortage. An ineffective or improperly managed filter station can waste a lot of water and threaten a drip system’s fitness and accuracy.

In the western U.S., sand media filters have been used extensively for microirrigation

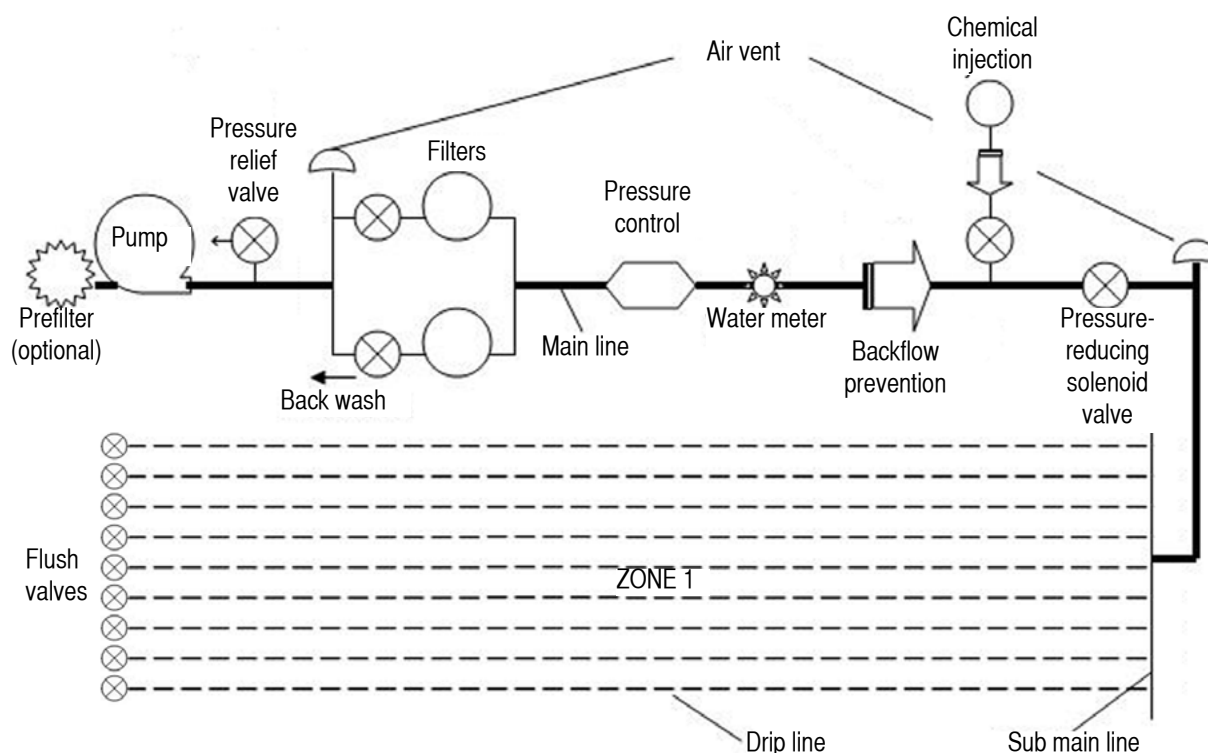


Figure 1. Drip irrigation system with a prefilter, pump station with backflow prevention, and chemical injection site. A pressure control valve is recommended to adjust the water pressure as desired before it enters the drip lines. A water meter can be placed after the pressure control or between a solenoid valve and each zone. An air vent provides vacuum relief. Vacuum relief is necessary between the solenoid valve and the drip tapes to avoid suction of soil into the emitters when the system is shut off.

systems. Screen filters and disk filters are common as alternatives or for use in combination with sand media filters.

Sand media filters provide filtration to 200 mesh, which is necessary to clean surface water and water from open canals for drip irrigation. These water sources pick up a lot of fine grit and organic material, which must be removed before the water passes through the drip tape emitters.

Sand media filters are designed to be self-cleaning through a “back-flush” mechanism. This mechanism detects the drop in pressure due to the accumulation of filtered particles. It then flushes water back through the sand to dispose of clay, silt, and organic particles.

Sand used for filters should be between sizes 16 and 20 to prevent excess back flushing. Because clean water from one filter is needed to back flush another filter, at least two sand media filters are generally used. In addition to a sand media filter, a screen filter can be used as a prefilter to remove larger organic debris before it reaches the sand media filter, or as a secondary filter before the irrigation water enters the drip tube (Figure 1).

For best results, filters should remove particles four times smaller than the emitter opening, as particles may clump together and clog emitters. Screen filters can act as a safeguard if the main filters fail, or may act as the main filter if a sufficiently clear underground water source is used.

System management and maintenance

If a drip hose system is used on the soil surface for perennial crops over a number of years, the drip hose should be lifted periodically so that leaves, soil, and debris do not cover the hose. If the drip hose is not lifted, roots can grow over the hose, anchor it to the ground, and eventually pinch off the flow of water.

Flow of water

Place a water flow meter between the solenoid valve and each zone and record its gauge daily. This provides a clear indication of how much water was applied to each zone. Records of water flow can be used to detect deviations from the standard flow of the system, which may be caused by leaks or clogged lines. The actual amount of water applied recorded on the meter can be compared with the estimated crop water use (crop evapotranspiration) to help assure efficient water management.

Watch for leaks

Leaks can occur unexpectedly as a result of damage by insects, animals, or farming tools. Systematically monitor the lines for physical damage. Leaks in buried hose or tape are generally difficult to detect. Ponding on the surface often indicates a leak. Also, pressure drop and/or flow increase can indicate leaks. It is important to fix holes as soon as possible to prevent uneven irrigation.

Chlorine clears clogged emitters

If the rate of water flow progressively declines during the season, the tubes or tape may be slowly plugging, resulting in severe damage to the crop. In addition to maintaining the filtering stations, regular flushing of the drip tube and application of chlorine through the drip tube will help minimize clogs. Once a month, flush the drip lines by opening the far ends of a portion of the tubes at a time and allowing the higher velocity water to flush out the sediment.

Because algae growth and biological activity in the tube or tape are especially high during

warmer months, chlorine usually is applied at 2-week intervals during these months.

If drip lines become plugged in spite of maintenance, many cleaning products are available through irrigation systems suppliers. Choose a product appropriate for the specific source of contamination.

Chemigation

Manage irrigation and fertilization together to optimize efficiency. Chemigation through drip systems efficiently delivers chemicals in the root zone of the receiving plants. Because of the precision of application, chemigation can be safer and use less material. Several commercial fertilizers and pesticides are labeled for delivery by drip irrigation. Make sure injected products are compatible with water to prevent chemical precipitation and subsequent plugging of emitters.

Injection pumps with backflow prevention devices are necessary to deliver the product through the drip lines. These pumps allow for suitable delivery rate control, while backflow prevention protects both equipment and the water supply from contamination. Remember that in Oregon water belongs to the public, not to the landowner. Other safety equipment may be required; contact a drip irrigation system supplier for details.

Fertilizer

Soil microorganisms convert nitrogen (N) fertilizers to nitrate. Nitrate is water soluble, available to plants, and subject to leaching loss. One of the benefits of drip irrigation is reduction or prevention of nitrate loss.

Typically, when irrigation is monitored closely, less N fertilizer is needed with drip irrigation systems than with furrow irrigation systems because the fertilizer is spoon-fed to the root system and little is lost due to leaching. For example, if a field is converted from furrow irrigation to drip irrigation and the amount of N fertilizer is not reduced, the crop may become excessively leafy, which can inhibit curing and

increase harvest costs as well as losses. Plant tissue analysis performed by a qualified analytical lab can help you determine crop nutrition needs during the season and tailor N fertilizer applications to actual crop needs.

Fertilizer can be injected through the drip system. Fertilizers containing sulfate, phosphate, calcium, or anhydrous or aqua ammonium can lead to solid chemical precipitation inside the drip lines, which can block emitters. Obtain chemical analysis of your irrigation water and seek competent technical advice before injecting chemical fertilizers into drip systems.

Placement of tape

Plan for seed emergence. The drip tape must be close enough to the surface to germinate the seed if necessary, or a portable sprinkler system should be available. A tape tube 4 to 5 inches deep has successfully germinated onion seeds in silt loam soil. Tape at 12 inches failed to uniformly germinate onions. Tape placement is often deeper in other row crops.

Timing and rates

The total irrigation water requirement for crops grown with a drip system is greatly reduced compared to a surface flood system because water can be applied much more efficiently with drip irrigation. For example, with furrow irrigation, typically at least 4 acre-feet/acre/year of water are applied to onion fields in the Treasure Valley of eastern Oregon and southwestern Idaho. Depending on the year, summer rainfall, and the soil, 20 to 32 acre-inches/acre of water have been needed to raise onions under drip irrigation in the Treasure Valley.

Applying more water than plants need will negate most of drip irrigation's benefits. The soil will be excessively wet, promoting disease, weed growth, and nitrate leaching.

To determine application rates, use measurements of soil water and estimates of crop water use (crop evapotranspiration, or "ET"). For shallow-rooted crops, irrigate only to replace the

soil moisture deficit in the top 12 inches of soil. It usually is not necessary to exceed ET. Local daily crop evapotranspiration estimates are available for some U.S. Pacific Northwest locations on the AgriMet website. For measuring soil water, see *Instrumentation for soil moisture monitoring* ("Websites," page 7) and *Irrigation Monitoring Using Soil Water Tension* ("OSU Extension Service publications," page 7). For planning irrigation scheduling, see *Irrigation Scheduling*. (OSU Extension Service publications," page 7).

Standard maintenance

Add chlorine or other chemicals to the drip line periodically to kill bacteria and algae. Acid might also be needed to dissolve calcium carbonates. Be sure to follow chemical labels for safe handling instructions. Acids and chlorine can be very hazardous.

Filters must be managed and sand changed as needed. Even with filtration, drip tape must be flushed regularly. The frequency of flushing depends on the amount and kinds of sedimentation in the tape.

Other management factors

Root intrusion must be controlled for some crops. Rodents must be controlled, especially where drip tape is buried.

Additional resources

Websites

AgriMet—daily crop evapotranspiration estimates for some U.S. Pacific Northwest locations (<http://www.usbr.gov/pn/agrimet/>)

Digital Drip Directory—a list of equipment and suppliers (<http://www.trickle-l.com/new/directory/>)

Drip irrigation discussion group—search features and discussions of all sorts of problems (<http://www.trickle-l.com>)

How to find irrigation information on the Internet (<http://www.trickle-l.com/new/onthenet>)

Instrumentation for soil moisture monitoring (<http://www.cropinfo.net/AnnualReports/1997/instrumentation.wq.php>)

Kansas State University SDI website (<http://www.oznet.ksu.edu/sdi>)

Maintenance of microirrigation systems (<http://ucanr.org/sites/Microirrigation>)

Microirrigation for Sustainable Water Use. Microirrigation Research Group W2128. (<http://www.cropinfo.net/W-128/w128.html>)

OSU Extension Service Catalog (<http://extension.oregonstate.edu/catalog/>)

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