Drip Irrigation for Agricultural Producers
R. Troy Peters, Ph.D., P.E.
WSU Extension Irrigation Specialist

Drip irrigation (also trickle or micro irrigation) involves emitting water directly to the soil where the roots of plants are growing at a very slow rate.

Drip compared with sprinkler or surface irrigation:

- Drip is the most efficient way to irrigate. It is usually about 90% efficient compared to about 70% for sprinkler, and often 50% for surface irrigation. Because there is very little wetted soil surface area, and the water doesn't travel through the air like in sprinkler irrigation, there is very little opportunity for water loss due to evaporation.
- The very slow water application rates used in drip irrigation requires very small orifices. These small orifices are easily plugged with very small bits of debris and therefore a good filtration system is required.
- Due to high filtration requirements and additional tubing to get the water placed directly at each plant drip has the highest initial costs per unit land area of any irrigation system.
- Drip usually operates at much lower pressures (8-20 psi) than sprinkler (typically 45-70 psi). Therefore less pumping power is used. This normally results in significant energy savings and consequently lower power bills.
- Drip irrigation is easily automated since the distribution system is always in place and ready to be used.
- Drip allows the most control over irrigation timing and amounts. This allows a great deal of control over plant behavior as is desired for deficit irrigation of wine grapes.
- Surface irrigation is difficult to use effectively in sandy soil due to high infiltration rates. Sprinkler irrigation is difficult to use effectively in heavy clay soils due to low infiltration rates. Drip is suitable to all soil types because of its extremely slow application rate and high degree of control over timing and amounts.
- Plant foliage stays dry with drip and therefore there are fewer problems with plant diseases that do better on wet leaves and in humid conditions.
- Because a large portion of the soil surface always stays dry, there are fewer problems with weed germination in the inter-rows.
- A drip irrigation system makes fertigation and chemigation easy and convenient.
- Drip irrigation usually requires less unskilled labor, but more skilled or educated management than sprinkle or surface irrigation.

Drip Irrigation and the Soil

- Heavier textured soils like loams and clays will move the water further laterally than a sandy soil. In a sandy soil the water will tend to move directly down and not very far laterally away from the emitter (1 – 1.5 ft radius is common). A loam soil will move water a radius of about 1.5 to 2.5 ft laterally away from the emitter. A clay soil will move water a radius of about 2.5-3.5 ft laterally away from the drip emitter. However, even within the same texture class every soil will be different.

- Irrigating on short intervals with small amounts of water each time will lead to a small wetted soil volume. Roots have no motivation to and will not grow into dry soil. Therefore this will lead to a very restricted root zone and the plant will consequently have a smaller volume to draw water and nutrients from. Under proper management very good crops can be grown under these conditions but there is a smaller margin for error. If the system goes down the plants will see water and nutrient stress much quicker than they would if they had a larger root zone. A larger root zone can be encouraged by running the drip system for longer amounts of time, and at longer intervals.

Drip Irrigation System Considerations

Drip Tape or Tubing

Drip tape is merely thin-walled drip tubing that lays flat when there is no pressure on it. Drip tape or tubing is almost always made from low density polyethylene (plastic) and the costs of tape and tubing is closely related to plastic prices. The greater the wall thickness, the more plastic goes into making it, the more it will cost, but it will be more rugged, resistant to abuse, and will last longer. If it will be buried, drip tape is almost always used due to lower costs and lower need to be rugged. Because it needs to be stiffer and more robust, thicker walled tubing is almost always attached to trellis wires in vineyards and orchards.

Dripper Selection

The job of a drip emitter is to move a small amount of water from a high pressure region inside the distribution tubing out to atmospheric pressure. The simplest way to do this is with a very small orifice. However, small orifices get easily plugged with very small particles. With a simple orifice the emitter flow rate is very sensitive to minor changes in the orifice diameter and it is therefore difficult to get high distribution uniformity (same amount of water coming out of each and every emitter).

A more commonly used method is to force the exiting water to travel through a long “tortuous path.” (Sound like your life?) These pathways are confined to small areas within the emitter. The “tortuous path” design allows larger pathway openings (fewer plugging problems) while still dissipating the pressure and maintaining pretty uniform flow rates out of each emitter.

If there are large elevation differences in the field then pressure compensating emitters should be considered. Large elevation differences cause the low spots to be at much higher pressure than the high spots. These different pressures will result different flow rates from drip emitters and consequently differing amounts of irrigation applied to the different areas of the field. A pressure compensating emitter usually involves a small flexible diaphragm that will restrict the flow more at higher pressures than lower pressures.

Surface vs. Buried Drip

Drip emitters work fine when buried. This is called subsurface drip irrigation (SDI). Buried drip tubing and tape lasts longer because it is not exposed to the sun, weather, cultural operations (tractors and implements), and traffic (people and animals). Because of this thinner walled, and therefore less expensive, drip tape can be used when it will be buried. Many growers have problems with coyotes and rodents biting holes in drip tubing to get a drink. Buried drip can help keep the tubing away from above-ground pests. However, plugging issues are very difficult to detect on buried drip and this is the biggest reason that many growers give for leaving their drip tubing above ground. If the tubing is going to be removed after one season, as is often done in row crops, the drip tape or tubing is almost always buried. Often drip tubing is suspended from trellis wires in vineyards and orchards. The only reason for this is to protect the tubing from cultural operations.

The deeper drip tape is buried the more horsepower it takes to install, yet the more it will be protected. A draw-back is that it is sometimes difficult to get the water from the drip tape to rise to the soil surface to germinate seeded crops. Lighter textured (sandy) soils will have the greatest challenges getting water to the soil surface. If the tape is placed a little deeper, it is possible to do multi-year installations of buried drip and plant, cultivate, spray and harvest over the top of the drip tape without damaging it. To do this it is important to remember exactly where the drip tape is in each row. Tractors equipped with GPS systems that are repeatable from year to year can make this much easier.

Sometimes buried drip tape will have problems with plant roots growing directly into the emitters and plugging them (called root intrusion). This can be managed by injecting herbicides or acids in the lines to discourage roots immediately in and around the buried drip emitter without harming the plants. Many growers believe that root intrusion problems can be avoided by avoiding water stress or deficit irrigation situations.

Filtration System Selection

Filtration is an absolute necessity with drip irrigation. With very dirty water the water is often pre-screened to prevent rapid plugging of the main filtration system. These include settling ponds, cyclone sand separators, and overflow screens. There are three major types of main filtration systems: screen, sand media, and disk filters.

Simple screen filters are the least expensive. However, in order to get the degree of filtration needed very fine screens must be used and unless the water source is very clean they will become plugged quickly. As a screen filter gets plugged and as the pressure differential across the screen increases larger more malleable particles can be "extruded" through the smaller screen holes and make it through to plug emitters on down the line. There are self-cleaning screen filtration systems that can be purchased, but these can be expensive.

Sand media (media tanks) are probably the most common method used in agricultural applications. These are simply tanks of sand that the water flows down over. The small bits of debris get caught in the sand as it flows through. Sand media tanks have a larger filtering area in the three-dimensional space through the sand and therefore don't plug as readily as screens. They also have a large variety of pore spaces and will filter more of the finer particles than a screen or disc filter. When the sand media is getting plugged (usually indicated by a high pressure difference across the sand filter) clean water is run backwards through the filter which “boils” the sand up and floats the filtered particles up and they are discharged from the system. There must be at least two tanks so that one can supply clean water while the other is back flushing.

Disk filters are series of flat, circular, plastic disks with small grooves in them that are stacked on top of each other in a cylindrical filter. The water is forced to go through the gaps between the disks and the suspended particles are left behind. When the filter is plugged, clean water is back-flushed through the system which pushes the disks apart and washes out the filtered particles.

Fertigation/Chemigation Components

Most agricultural producers are going to want to have their drip irrigation system set up for fertigation or chemigation (applying fertilizers, pesticides, or herbicides through the irrigation system). Chemigation requires a large tank to hold the chemicals that are to be injected (usually in liquid form), a pump and an injection port that mixes the chemicals with the water. Several protections are also required to protect the water source, and the environment in case of spills or problems.

For chemigation the following must be installed on the water line in order from the pump; a vacuum relief valve, a low pressure drain, a low pressure switch (this shuts the chemical injection pump off if the water pump stops), a functional check valve (back-flow prevention device) and the chemical injection port where the chemical is mixed with the water. The following must be installed on the chemical injection line in order from the chemical storage tank; a normally closed solenoid operated valve that is interlocked with the water pump (if the water pump shuts off, it closes), a “metering” chemical injection pump, a normally closed injection line check valve, and the injection port.
See a competent irrigation designer to get this system designed correctly and according to state law.

Other Drip System Requirements

Air Vents/Vacuum Release valves should be installed at all of the high points in the system to allow air our of the lines when they are filling, and to allow air back in to avoid a vacuum condition inside the tubing that might draw soil into the emitters and plug them.

Pressure regulators may need to be used. Drip systems are normally designed for low pressure operation. If the pressure is higher than the designed operating pressure then the system will blow apart, leak, or otherwise not work correctly.

The system should be designed so that the ends of the drip lines can be opened to allow debris to be flushed out of the lines with the water. The lines should at least be flushed out in the spring and in the fall. The lines may need to be flushed more often depending on the quality of the water and the filtration system.

Determining Drip Application Rate

To know what the application rate is, the dripper flow rate (usually measured in gallons per hour), the dripper spacing along the tubing, and the distance between drip lines must be known. You can calculate it here, or you can do it yourself using the equation:

$$ApRt = 231.1\frac{EmitterFlow}{RowSpc \cdot EmitterSpc}$$

where:
ApRt = Application Rate (inches per hour),
EmitterFlow = Emitter flow rate (gallons per hour),
RowSpc = Spacing between rows (inches), and
EmitterSpc = Spacing between emitters (inches).