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Drip Irrigation for Commercial Vegetable and Fruit Production

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Drip irrigation is a highly efficient irrigation method well suited to many fruit and vegetable row crops. Drip tubing or tape discharges water to the soil through emitters positioned close to the plant. The drip tubing can be placed uncovered on the soil surface, under plastic mulch, buried in the soil, or suspended above the ground (e.g., on a trellis system). Water application rate is relatively low and irrigations are usually frequent. Properly designed and maintained drip-irrigation systems can have benefits that help increase the profitability of crop production.

Advantages

Reduced Water Use: One important advantage for growers with limited or expensive water is the water savings that a well-designed and managed drip system provides. Drip irrigation can minimize runoff, deep-percolation, and evaporation. Irrigation application uniformity is improved and application occurs directly to the plant's roots. Drip irrigation allows for frequent, efficient irrigation that works well for establishing crops and for shallow rooted crops.

Decreased Weed and Disease Pressure: Since the inter-row and non-cropped field edges are not watered with a drip system, weed growth is limited in comparison to sprinkler and flood irrigation. Drip irrigation keeps water off the plant canopy, thus reducing foliar disease development on many plants. Both of these benefits can lead to reduced pesticide use, leading to chemical and labor savings.

Lower Pumping Needs than Sprinklers: Drip irrigation uses a lower water pressure (35-40 psi for most systems) than sprinkler irrigation (50-80 psi). Additionally, lower flowrates are possible due to higher irrigation efficiencies. These factors reduce pumping costs when operated properly.

Uninterrupted Field Operations: In general, traffic rows should remain dry, allowing access to conduct field operations during or soon after watering. This simplifies timing of tillage, application of pesticides, harvesting, and other field operations.

Fertilizer Application: Precise fertilizer application is possible through the drip irrigation system due to high irrigation application uniformity and irrigation efficiency. Additionally, soluble nutrient losses are reduced due to decreased deep percolation and surface runoff. This reduces fertilizer costs and/or improves crop yields.

Adaptable: Drip systems are suitable for uneven topography and oddly shaped fields. For some fields this is an advantage over surface irrigation due to high land leveling costs and issues caused by disturbing soil profiles. It also has some advantages over sprinkler irrigation on small and odd shaped fields because the poorest uniformity with sprinkler irrigation occurs at field edges due to a lack of proper application overlap from sprinklers.

 

Figure 1. Commercial pepper field with drip irrigation and plastic mulch and farmers market grower with drip tubing on ground

Disadvantages

Cost: Initial investment in a drip system typically ranges from $1,200 to $2,000 per acre. Additionally, there is specialized equipment needed to install and remove the drip tape. Some parts of the system last 30 years or more (filter, pump, delivery line, etc.), but drip tape or drip tubing lasts 1 to about 10 years. For some annual crops, less expensive thin wall drip tape is used and discarded each year. Replacing drip tape each year can cost about $400 per acre depending on emitter spacing, wall thickness, and row spacing. Thicker-walled drip tape or tubing is used in perennial crops and is left in place for several years. While costs are high, the decision to use drip systems should be to increase profitability through better crop quality and yields.

Need for Clean Water*:* Debris and sediments in irrigation water can easily plug small emitters. It is important to use filtered water in order to avoid clogging. Depending on the water source, multiple filtration systems, such as a settling pond combined with a media filter and/or other with inline filters, may be needed. Additionally, bacteria/algae growth and mineral deposition from irrigation water can plug emitters. These conditions can be prevented with disinfectants such as chlorine to control biological growth and acid to dissolve chemical precipitates and buildup.

Leak repair*:* Drip tape can easily be damaged by equipment, insects, rodents, or even by deer stepping on it. Leaks need to be fixed in order to keep the system running efficiently. In general, leak repair parts are inexpensive but can be costly in labor. Farmers may need to control rodents and insects to protect drip tape. Some farmers have found that using 6 to 8 mil. (1 mil. is 1/1000 of an inch) wall thickness helps reduce leaks on tubing that is replaced each year. Drip tape installed for multi-year use generally has a thicker wall, such as 10 to 15 mil. Drip tubing with a wall thickness of 50 to 70 mil. is suitable for many years of use above or below the ground with less potential for leaks.

Plastic disposal*:* The annual replacement of some types of drip tape results in significant plastic disposal into the landfill, incurring disposal costs and causing environmental concern. Additionally, taking up the drip tape adds to labor costs. Drip tape buried deeper than about 5 inches is harder to retrieve. If the tape is in the tillage layer it gets torn-up and incorporated into the soil. The tape does not harm the soil, but can be a nuisance.

Labor costs: The installation and removal of drip tape requires concentrated labor efforts. However, the total irrigation labor costs may be less, because of the automation capabilities of a drip system.

Components of a Drip System

Drip systems have several basic parts, and multiple options are available for each component. A typical system includes the water source, pumping system, filtration, pressure regulators, chemical injectors, distribution network, and drip tape. A short video, https://www.youtube.com/watch?v=it8EJw7cGnk, shows the components of a drip irrigation system used to irrigate an onion crop. These components are detailed below. Drip tape, tube, and emitters vary in their specifications and the distribution system must match the supply requirements of the tape.

Water Sources and Distribution*:* Water for drip irrigation can be from surface (canal, creek, pond), groundwater (well), and/or potable sources. Generally, existing sources of irrigation water are suitable for drip irrigation. Drip irrigation requires an on-demand and sometimes nearly continuous supply of water. If the source of water is not continuous, such as a periodic water delivery schedule, then an on-farm reservoir with adequate volume may be needed to supply the drip irrigation system. Water diversion from surface supplies or from a reservoir usually requires screening in addition to the filtration system downstream of the pump. Water filtration is required to prevent clogging of drip emitters. Well water may also need to be filtered but not as extensively as surface water. Potable water is high quality, clean water but is usually more expensive than other sources and may have limited availability. Culinary or potable water is also more likely to have restrictions for agricultural use than other sources. Depending on the location of the field and the water source, a surface or buried pipe distribution system may be needed.

Pumping System**:** Drip irrigation systems require pressurized water. Pressurized irrigation lines and potable water do not require a pumping system, but other water sources do. The size of pump must match the supply requirements of the drip system. If a pump from sprinkler irrigation system is used for a new drip system, the impeller can often be trimmed to reduce the pressure (preferable) or alternatively the water pressure can be controlled with pressure reduction valves

Figure 2. Pump for commercial drip irrigation system.

Filtration: Since drip-irrigation water passes through small emitters, the size of particles in the water must be smaller (recommended 4 times smaller) than the size of the emitter in order to prevent clogging. A 200-mesh screen equivalent is sufficient for most systems. Filter mesh value is inversely related to the size of screen openings. This means a 200-mesh filter stops smaller particles than a 100-mesh filter. There are several different filtration options and all can be used alone or in conjunction with another filter. Clogging will quickly occur if the incorrect filter is used. Unless your water source is culinary, never operate a drip system without a filter system as clogged emitters can cause irreparable damage. Placing chemical injection systems upstream of the filtration systems prevents possible chemical precipitates from clogging emitters. Injected disinfectants are used to control bacteria in filters. One exception may be to prevent discharge of chemicals during back-flushing of media filters.

- <u>*Media filters*</u> are an excellent choice for large-scale commercial vegetable and fruit production using groundwater to irrigate. They are heavy, large, and are often installed in sets of two or more. They are more expensive than some filter options but are highly effective at cleaning poor-quality water, even at high flow rates. Media filters catch debris in sand or crushed rock inside the filter and water is cleaned as it moves through the media. At least two filters allows one to backflow and wash while the other(s) is filtering water for the drip system.

Figure 3. Media filters (four silver tanks).

– *Screen filters* are also commonly used on small acreage production operations and can be used as backup filters downstream of a primary filter system. Screen filters work best with water that is already somewhat clean, such as groundwater. They are as effective at removing particles from the water as a media filter but cannot filter at the same scale. Regular cleaning is critical and is required more often than for media filters. Screen filters are typically equipped with a flush valve that makes filter cleaning easy. Using a large screen filter before a small screen filter will help to decrease the frequency of cleaning required.
– *Disk filters* are composed of stacks of doughnut-shaped disks. Water moves from outside the disks to the inside, being cleaned in the process. A disk filter's cleaning capacity is higher than for screen filters but lower than for media filters. Filter cleaning is more involved than for media or screen filters. To clean disk filters, the disks need to be separated and washed with pressurized water.

Pressure Regulators and Gauges: Drip tape cannot withstand high pressures. For most systems, the recommended operating pressure is 8 to 15 psi once the water reaches the drip tape. High water pressure can burst open the tape, requiring it to be replaced. In order to achieve this low and constant pressure, a pressure regulator should be installed in-line. Pressure gauges are installed to monitor the water pressure and make sure the pressure regulator is operating as expected. Gauges can be installed anywhere along the system, including using portable ones that can be temporarily installed at the end of the drip tape to measure pressure at the end of the line.

Figure 4. Water delivery line with combination pressure regulating and on-off control valve.

***Chemigation**:* Injectors allow the introduction of fertilizers, pesticides, or anti-clogging chemicals directly into the irrigation water. Fertilizer application in this way is particularly useful when plastic mulch is used over the top of the irrigation line and access to the soil is limited. Chemigation delivers chemicals directly to the root zone of the plants. This allows for precision application, resulting in increased efficiency (use less material) and can increase pesticide application safety. Chemicals for system maintenance can be used to kill algae or dissolve precipitates that clog emitters. Verify the product injected is water soluble to prevent chemical precipitation that will lead to clogging of emitters.

When injecting material into the irrigation line, a backflow-prevention device must be used to prevent contamination to the main water supply. Different types of injectors are available, and the best injector for a given system depends on the type of chemical injected. When injecting fertilizer, the most important consideration is to ensure that the injector has a high enough flow rate to apply the desired amount of fertilizer in a reasonable timeframe. An injector with a capacity of 1 gallon per minute (gpm) is suitable for fertilizer injection into systems for zones of less than 10 acres. Maintaining an exact injection rate is not as important for fertilizer application compared to other chemicals, as long as continuous injection is not used. When injecting anti-clogging chemicals, a very low injection rate is used that must be highly accurate. To accurately apply low rates (often just 1 to 10 ppm) a different type of injector from the high-flow type for fertilizer application is used. Follow all safety precautions.

Pesticide injection can be accomplished with either high or low flow types. In addition to deciding between high-flow/low-accuracy and low-flow/high-accuracy injectors, the type of power available affects your choice of injectors. Injectors can run via electricity, small engines, or even the water pressure of the irrigation system.

***Distribution systems**:* Once the water has been pumped, filtered, regulated, and delivered to the field, it is delivered into a header/manifold line to which individual drip lines are connected. A valve (manual or automated) is usually installed between the distribution pipeline and the header/manifold. A header line can be flexible poly pipe, PVC, or vinyl lay-flat hose. The header line and connectors are gathered and stored over the winter each year for re-use the following spring.

Figure 5. Flexible pvc header line with manual connectors drip tape.

Drip Tape/Tubing: There are many different considerations and options when selecting drip tape. Emitter spacing, flow rate, wall thickness, and diameter vary depending on the selected type. Understanding each of these parameters is important for selecting the right tape for your field.

Figure 6. Lay-flat 3-inch manifold connected to 17 mm diameter, 6 mil. wall thickness, drip line.

Drip tape (or tubing), is made with thin polyethylene with small, regularly placed emitters to allow for slow water discharge. Emitter spacing suitable for vegetable production varies from 4 to 18 inches. Desirable emitter spacing depends on the crop being grown and the soil. Onions, with small root zones and close spacing benefit from 4 to 8 inch spacing. Tomatoes, with greater spacing and larger root zones grow well with 12 inch spacing. Soil type also plays into deciding on emitter spacing. Sandy soils or cracking soils require closer spacing than loam or clay-loam soils due to different water movement patterns in the soil. Drip tape is installed with the emitters facing up to prevent clogging when sediment settles to the bottom of the tape.

Flow rate can be expressed in gallons per hour (gph) per 100 feet of tape (gal/hr./100 ft.) or by single emitter emission rate in gph. Without adequate filtration, lower flow drip (i.e., < 0.25 gph/emitter) tapes are more prone to clogging than higher flow drip tape. Pressure compensating emitters provide better irrigation uniformity on sloping fields or when drip lines are long.

Drip tape wall thickness ranges from 4 to 25 mil. (1 mil. is 1/1,000 of an inch). Thin tape (4 to 8 mil.) is meant to be used for 1 year and then discarded. Thicker drip tape can be used for more than 1 year. Tape cost is related to wall thickness and diameter with price per foot increasing with wall thickness.

Drip tape diameters range from 5/8 inch to 1 3/8 inch, with 5/8 and 7/8 inch being most common. The selection of drip tape diameter and emitter flowrate is based on economics and field dimensions.

Drip tubing (as opposed to tape) wall thickness ranges from 50 to 70 mil. depending on diameter. Drip tubing is well suited to irrigation of perennial crops (i.e., asparagus, grapes, raspberries, etc.), small areas where the tubing can be removed each year for tillage and planting, or buried in fields that require only shallow cultivation and tillage. Drip tubing can be buried using GPS- (global positioning systems) guided equipment and then row tillage and planting can occur over the buried tube lines using GPS-guided equipment and planters.

It is best to rely on manufacturer information and tables concerning drip tape or tubing specifications. Manufacturers provide information about emitter discharge at different pressures, uniformity of emitter discharge, allowable length of run, and filtration requirements. In most field applications, low emitter discharge rates are used to accommodate longer drip line runs (fewer manifolds and lower costs). It is critical to know the drip system's application rate (i.e., inches per hour) to schedule irrigation and determine operation times. To schedule irrigations, you can calculate water use from crop ET estimates or measured soil moisture. Either way you will determine an application depth per irrigation. The time required for the application is based on your drip line application rate. The following formula is used to calculate the drip system application rate.

Drip Irrigation Application Rate (based on the flow per emitter in gallons per hour, or gph):

Rate (in/hr) = 1.6 times emitter discharge rate (gph) divided by emitter coverage area (ft^2)

Note: emitter coverage area is calculated as the emitter spacing times the line spacing).

Example: 1.6 x 0.5 gph / (1 ft x 2.5 ft) = 0.32 in/hr.

See the USU fruit and vegetable irrigation guides listed at the end of this document for detailed irrigation scheduling information by crop.

Table 1 provides examples of water application rates based on emitter flow rate and drip line spacing. Emitter flow rates around 0.2 gph per foot are typical of drip tape used in fields. It is best to do specific calculations and then use the table to check if the calculations appear correct. While drip systems have good application uniformity and minimize water loss, they are not 100 percent efficient. A typical irrigation efficiency would range from 85 to 90 percent to account for non-uniformity of application and leakage or other losses. Gross irrigation is equal to net irrigation divided by application efficiency (i.e., 1 inch divided by 85% (or 0.85) equals 1.18 inches).

Table 1. Application rates and minutes of irrigation to apply 1 inch of water.

Irrigation Application Rates and Time		Drip Tubing/Tape Emitter Flow Rate (gallon per hour per foot)				
		0.2	**0.5**	**0.6**	**0.9**	**1**
		Application Rate (Inches/hour)				
Drip Tubing Row Spacing (inches)	**12**	0.32	0.80	0.96	1.44	1.60
	18	0.21	0.53	0.64	0.96	1.07
	24	0.16	0.40	0.48	0.72	0.80
	30	0.13	0.32	0.38	0.58	0.64
	36	0.11	0.27	0.32	0.48	0.53
		Minutes to Apply 1 Inch				
	12	187	75	62	42	37
	18	281	112	94	62	56
	24	374	150	125	83	75
	30	468	187	156	104	94
	36	561	224	187	125	112

Irrigation Design

A successful drip irrigation system requires careful planning, accounts for field topography, drip tape flow specifications, and field layout. Drip line spacing can be one line per row or bed with multiple rows of crop (spacing can range from 2.5 feet to 6 feet or more). Some producers use a double drip line (one on each side of crop row) for a single row of widely spaced crops like watermelon or squash. The spacing and number of drip lines is a complex integrated function of soil hydraulic properties, grower experience, enterprise economics, and farmer preference. For complex systems, consult an irrigation engineer or irrigation system consultant who has been trained and certified to properly design drip irrigation systems.

Due to inefficiencies in the system, plan on slightly over-sizing the system (supply 110-120% of plant needs). Crop needs vary greatly but an average water need for vegetable crops is 1.5 inches of water each week. See the Additional Reading section at the end of this document for a list of crop-specific irrigation recommendations for Utah.

Drip irrigation systems may be divided into zones. A zone is an area that is irrigated separately from other areas. In designing zones consider water supply, system capacity, field topography, field size, maximum length of drip tape laterals, and filter capacity. Manufacturer's recommended maximum values for drip tape length are generally between 400 to 600 feet, but can be over 1,000 feet with low flowrates and pressure compensating emitters and proper drip tape diameter. If tape is used in excess of recommended length, uneven application occurs. Strive to keep zones approximately the same size to maximize efficiency.

Maintenance

Prevention is the best way to keep your system working well. Be sure to use the appropriate filter for your irrigation water source and regularly clean it as needed. Drip lines and manifolds should be flushed periodically to remove settled debris by opening the ends of header line and/or drip tape. Injecting a cleaning compound, such as chlorine gas or sodium hyprochlorite can also clean the line. Periodic injections of sulfuric or phosphoric acid is used to prevent scaling from hard water. Care should be taken to apply the right amount and the use the correct injector type. As long as the chlorine is applied correctly, the amount of chlorine is so low that no damage to the crop results. Routinely check drip lines for leakage and repair leaks promptly. Use all chemicals as directed. Carefully follow all safety precautions when using chemical injects to prevent human harm. Chlorine gas is harmful and can react with other chemicals.

National Drip Irrigation Supply Sources (listed alphabetically) – An internet search can help find local drip irrigation equipment designers, installers, and suppliers.

BWI-Springfield,
Springfield, MO
www.bwicompanies.com

Hummert International
Topeka, KS
www.hummert.com

Hydro-Gardens,
Colorado Springs, CO
www.hydro-gardens.com

Irrigation-Mart, Inc.,
Ruston, LA
www.irrigation-mart.com

Irrometer Company, Inc.,
Riverside, CA
www.irrometer.com

Jain Irrigation, Inc.,
Watertown, NY
www.jainsusa.com

Netafim USA,
Fresno, CA
www.netafim-usa.com

Rain Bird Corporation: Agricultural Irrigation Resources,
Glendora, CA
www.rainbird.com/ag/index.htm

Rain-Flo Irrigation,
East Earl, PA
www.rainfloirrigation.com

Schumacher Irrigation, Inc.,
Platte Center, NE
www.schumacherirrigation.com

Spring Brook Supply,
Holland, MI
www.springbrookirrigation.com

The Toro Company,
Riverside, CA
Sprinkler and Drip Irrigation Planning & Installation Guide
www.toro.com/sprinklers/guides.html

Trickl-eez Company,
St. Joseph, MI
www.trickl-eez.com

WeatherMatic Company,
Garland, TX
Automated Water Management Systems
www.weathermatic.com

Additional Reading

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http://www.protos.ngo/sites/default/files/library_assets/423.2_BUR_E8_avoiding_common.pdf

USU Fruit and Vegetable Irrigation Guides

- Apple
- Cherry
- Melon
- Onion
- Peach
- Pepper and Tomato
- Raspberry and Blackberry
- Squash and Pumpkin
- Strawberry

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