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Drip Irrigation Basics

Drip systems are a common method of irrigating vegetable crops, particularly in small- to medium-sized growing spaces. They allow for the application of water directly to the plant root zone at a rate that can be absorbed by the soil without runoff. This publication explains how to install a drip irrigation system suitable for small-acreage fruit and vegetable production in the Great Plains. It addresses the needs of urban farms, large home gardens, and community or communal gardens.

System Considerations

Drip (trickle) irrigation originated in England in the 1940s. It continues to grow in popularity with the adoption of plasticulture and greater awareness of the need for water conservation. In addition to saving water, drip irrigation provides consistent soil moisture and optimizes plant growth. Applying water with precision at the emitter location rather than across the entire growing area reduces weeds between rows and limits the spread of soilborne plant pathogens by not wetting the entire plant (Figure 1). It also allows for fertigation, the injection of fertilizers into irrigation water (Figure 2).

A disadvantage of drip irrigation is that water must be filtered — even city water carries particles that can clog emitters. Maintenance of low-pressure (drip tape) systems can be high because rodents, mowers, and other types of equipment can damage the system. Once installed drip irrigation systems should be monitored for leaks. Because water is applied directly to the soil, system malfunctions may not be detected until the crop is stressed.

With an understanding of basic drip irrigation system requirements, installation and use is fairly simple. Drip irrigation systems fall into two main categories: high pressure or low pressure. In

Figure 1. Drip tape running beside pak choi provides water directly to the root zone.

Figure 2. A venturi-type injector introduces fertilizer into the irrigation water.

high-pressure drip systems, pressure-compensating emitters regulate water flow at each emitter. In low-pressure systems pressure regulators are located at the start of the system or connection point. The water dispersed at each emitter depends on the pressure maintained in the drip tape. In subsurface drip irrigation systems, emitter lines are installed permanently 10 to 15 inches underground so they require less maintenance throughout the growing season. This publication focuses on the design and installation of surface drip irrigation systems, which are commonly used for vegetable production in the Great Plains.

Crop Water Use

Water is the most important molecule for plant survival, growth, and development. Water maintains the physical structure (turgidity) of plant cells and is necessary for photosynthesis. Plant nutrients are typically taken up in water, and some (for example, calcium) require proper water flow for internal transport. Water moves through the plant by a process known as transpiration, which is regulated by the leaf stomata. Transpiration rates are dependent on leaf temperature as well as the difference in the relative humidity within the leaf (typically >99%) and the air directly surrounding the leaf.

The supply of water to the root zone should be based on crop species needs and growth stage as depth of the root system will vary based on these factors. Young transplants should be watered frequently (daily to every two days), while larger more established vegetable crops can be watered 1 to 2 times per week, depending on temperature and rainfall. Soil type and composition have a tremendous effect on irrigation frequency and volume needs. The distribution of water from a drip emitter varies based on the soil type (Figure 3). Sandy soils need to be watered more frequently than soils with high clay or loam content, which may require less frequent irrigation but for longer times.

Principles of Water Movement

Knowing how water pressure and volume affect the performance of sprinklers and emitters is critical to the design of successful irrigation systems. Enough pressure must be maintained throughout the system for it to operate properly. Understanding basic principles also helps with maintenance and troubleshooting.

Water pressure refers to the force that water applies to a physical object that contains it (a pipe, for example) and is expressed in pounds per square inch (psi). When the pipe is full and force is applied, pressure builds. In surface and well irrigation systems, force is applied by a water pump. In municipal water delivery systems, the force may be gravity. Water pressure is applied due to the height of the water tower. Pressure only builds to a certain level and is regulated by the incoming water pressure (40 to 75 psi) or running pump (>80 psi). In low-pressure drip systems (10 to 15 psi), the psi is set by the pressure regulator. As long as system components can sustain water volume at that particular pressure, moving water to various irrigation systems and greenhouses should not be a problem.

Water volume is measured in gallons per minute (gpm) or gallons per hour (gph). This value reflects the amount/rate of water moving through the irrigation system at any given time. If the proper volume of water is not being delivered to the system, it cannot pressurize to the appropriate level. A major advantage of drip/trickle irrigation is a dramatic reduction in the volume or rate of water required. For example, an overhead irrigation system covering a 24- by 200-foot high tunnel might require 30 to

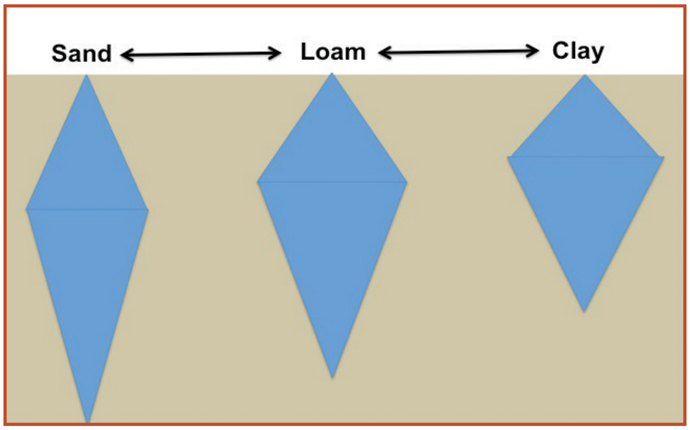

Figure 3. Distribution of water in various soil types. High concentrations of clay lead to wider distribution, and greater amounts of sand lead to narrow water distribution.

40 gpm, compared to a drip system that might only require 4.

Low-Pressure Drip Systems

Low-pressure drip systems are the type most commonly used for annual vegetable production. Components are inexpensive and simple to set up and tear down during the growing season. Low-pressure systems use drip tape, or T-tape, which has emitters installed at various spacings (4, 12, and 18 inches) along the drip line (Figure 4).

Figure 4. Drip tape is used in low-pressure drip systems. Pre-installed emitters are available with various spacings.

Emitters are not pressure compensating and rely on a pressure regulator to control water flow by maintaining a specific and constant pressure. Most drip tapes run at 6 to 20 psi (10 to 12 psi is typical). This is dependent on the emitter and thickness of the drip tape. When buying components, select the correct regulator for the drip tape to ensure accurate operation. One major advantage of drip tape is that it can be installed in long rows (>500 feet) and deliver the same amount of water throughout the entire run. Drip tape can be reused for 1 to 2 years if stored in a rodent-free environment, but is prone to leaks during the second year of use. Drip tape is connected into header (distribution) lines with simple connectors and terminates at an end cap.

High-Pressure Drip Systems

High-pressure drip systems use pressure-compensating emitters. This means that the water pressure of the supply line can vary between 30 to 50 psi. This type of system provides consistent water delivery at each emitter, regardless of its location on the drip tube. High-pressure systems are useful for high tunnels or permanent beds where similar lengths of drip tube are used every year. Emitters are pre-installed into poly tubing or may be added during system assembly (Figure 5). Because they run at higher pressure than the low-pressure drip tape, drip tubing is much thicker and can be reused. In fruit production systems, drip tubing may remain permanently once installed. It is less prone to damage from rodents and leaks throughout the course of the growing season. High-pressure systems offer advantages over drip tape, but there are disadvantages. Pressure-compensating emitters typically have higher flow volume and require shorter run lengths (<250 feet) to deliver water consistently. They are also much more expensive. Drip tubing costs three to seven times as much as drip tape per linear foot. Similar to drip tape, drip tubing is attached to header lines with simple connectors or adapters. These can be used to attach a garden hose directly to the line as well.

Drip System Design

Drip irrigation system components include:

- A source of pressurized water filtered of dirt and other aggregates.
- An infrastructure (typically underground piping) that delivers water to individual fields or growing areas.
- A header line that distributes water to the drip tube or tape.
- The drip tape or tube that delivers water to each plant or row of plants.

Designing an irrigation system requires planning to determine where water will be used on the farm and the volume of water needed. Water pumps should be chosen based on the volume and rate of water to be used during a given irrigation event. Calculations for determining the gpm required for a given production field or area are given on page 7.

Combinations of high-pressure and low-pressure drip can be used as long as distribution piping is run at high pressure and individual pressure regulators

Figure 5. High-pressure drip system emitters can be (A) preinstalled at the factory or (B) installed during assembly.

(10 to 12 psi) are located at the beginning of header pipes for low-pressure drip systems in the field. A mixed system requires more individual pressure regulators but provides greater flexibility. It allows for the use of garden hoses to water in transplants, fill tanks, and wash equipment, as well as overhead irrigation when needed (Figure 6).

Water Source and Filtration

Water source is an important consideration when purchasing land to grow fruits and vegetables (Table 1). Surface water used for irrigation should be filtered. Typically, sand or disk filters are used for primary filtration (Figure 7) with screen filters positioned at header lines or near the drip system for added protection. Well water is ideal for drip systems because it is inexpensive and does not require primary filtration. Screen filters are recommended. Water should be tested for pathogens and to determine water pH and salinity.

Pumping Water

Water pumps may be consideration for surface (pond, river, creek, etc.) irrigation. Groundwater pumps are installed in a well, and municipal water is delivered at high enough pressure (40 to 75 psi) for drip systems. A major advantage of electric pump systems (groundwater or surface) is that a pressure tank can be installed to regulate pressure and provide water whenever needed. Conversely, systems that use gas, propane, or diesel-powered pumps can only deliver water when the pump is running. This can be a concern when low volumes of water are needed frequently, such as in high-tunnel production or small acreage plots.

A typical small-acreage fruit or vegetable farm (1 to 5 acres) can use a small, motorized pump that moves approximately 50 gpm at 75 to 80 psi (Figure 8A). For very small-acreage growers with less than 1 acre, it is important not to use a pump that is too large or incapable of maintaining water movement

Figure 6. High pressure (50 psi) is maintained to distribute water with a pressure regulator (right) installed at the beginning of the header pipe. A garden hose thread connector at the end of the "T" allows for watering and overhead irrigation.

	Examples	Primary Filter	Screen Filter	Typical Volume	Cost	Winter
Surface	Pond, creek	Yes	Yes	High	Med	No
Groundwater	Well	No	Yes	Varies	Low	Yes
Municipal	City, County	No	Yes	Very Low	High	Yes

Table 1. Considerations for water sources when using drip irrigation

Figure 7. A sand filter (foreground) filters creek water delivered with a gas-powered pump (background).

Figure 8. (A) A gas-powered 10 hp pump is covered to reduce wear from environmental damage and keep the engine cool during operation. (B) Belowground 3-inch PVC piping distributes water to various production fields.

due to the low volume. Water will need to be distributed throughout the farm acreage. This can be done using underground PVC piping (Figure 8B) or with lay-flat hoses for aboveground water transport. For help selecting proper pumps, consult a dealer who specializes in these products.

The Header Pipe

The “header” is the pipe that distributes water to the drip tapes or tubes. Typically, it is polyethylene tubing (orchard pipe) or made from lay-flat hose for larger acreages (Figure 9). Header size is determined by the total volume/rate of water required by the system in that area. For small areas such as high tunnels, a pipe ¾-inch in diameter is sufficient. Larger fields may require a 1- to 2-inch header pipe.

Installing Drip Tape/Tubes

Install drip tape with emitters facing up to keep dirt from moving into emitters when the system shuts off. Drip tape should be offset 2 to 4 inches from the center. Avoid placing it in the middle of the row to make planting easier and to save time when posts or stakes are used for plants such as tomatoes or peppers.

If installing drip tape by hand, use a modified sawhorse or a similar apparatus to unroll the tape

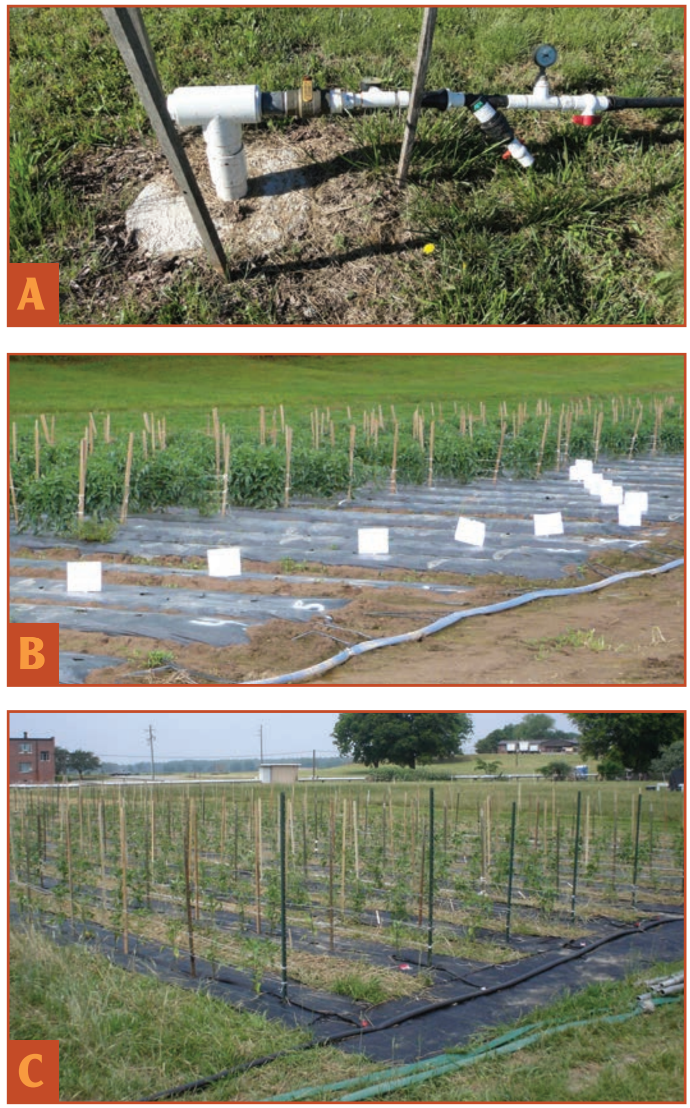

Figure 9. (A) Header pipe with (left to right) 1-inch pressure regulator, screen filter, pressure gauge, and valve connected to 1-inch poly piping. (B) Header pipe made from 2-inch lay-flat hose runs perpendicular to rows and distributes water to drip tape in a low-pressure drip system. (C) Header pipe made from 1-inch poly pipe, also known as orchard pipe installed with fabric mulch to reduce weeds and grass growth under the pipe.

(Figure 10A). A stationary roll can be difficult to unwind, resulting in folds and kinks that prevent proper water distribution (Figure 11). One or two well-placed landscape staples (8 inches) can be used to hold the drip tape in place before applying mulch (Figure 10D).

Plasticulture systems use drip tape installed by a plastic layer or combination bed-shaper/plastic layer (Figure 10B). Place the roll of drip tape on the bed shaper so that emitters face up. Do not allow the machine to stretch the tape too much during installation. Weakening the tape during installation can lead to leaks during the growing season.

To terminate the line (low-pressure systems), fold the end of the drip tape three times and slide a small section of drip tape (about 2 inches long) over the end so it stays folded when pressurized (Figure 12). Finally, attach the drip line to the header line using a simple reverse-threaded connector. The drip tape/tube will be pushed onto the barb of the connector and then a reverse-threaded collar is twisted to lock in the drip line (Figure 10C). Use a punch tool that is properly sized for the connectors to attach them to the header line. Install pre-manufactured end caps to terminate the line of drip tubing (high-pressure systems; Figure 10D). Connectors vary, but most feature a reverse-threaded locking collar that compresses the wall of the header pipe and creates a watertight seal.

Soil Moisture Monitoring

Soil moisture should be monitored daily to maintain proper growing conditions. Several devices are available to aid in daily decision-making, but nothing beats personal experience with the crop and soil type. A tensiometer (Figure 13) is the most accurate for measuring soil moisture, but there are a number of good soil-moisture sensors. Tensiometers do not require power or batteries but need weekly maintenance and may not work as effectively in sandy soils. Water must be kept in the column inside the tube pumped weekly to prevent air bubbles from reducing accuracy. The tensiometer should be installed 4 to 8 inches below the ground and also at 12 to 15 inches below ground to gain a better understanding of soil moisture. A number of electric

Figure 10. (A) A simple system for unrolling drip tape without kinks that can be used by a single installer. (B) A bed-shaper installs drip tape and plastic mulch. (C) Drip tape is connected to the header pipe with simple PVC connectors that have reverse-threaded locking collars(D). Drip tubing is terminated with a premanufactured cap.

Figure 12. (A) Fold the drip tape three times and hold securely. Crease and bend the folded end lengthwise to make it easier to place the sleeve over the end. (B) Slide the sleeve (~2-inch piece of drip tape) over the end until it is completely covered (C) to keep it from unfolding when pressurized.

Figure 11. Drip tape (low-pressure systems) is prone to kinks if not installed properly.

soil moisture sensors are available that can be used to monitor soil conditions when using electric solenoid valves in automatic watering systems.

Automatic irrigation systems and soil conditions should be checked manually to make sure they are working properly. A soil probe is an easy and accurate way to check soil moisture. Or you can press soil together in your hands to observe stickiness and how well it clumps together.

Calculating Water Needs

Total water volume usage can be calculated using the total row length of drip tape/tubing, the emitter spacing and gpm of each. Water usage is specific to the drip tape and is provided by the manufacturer (Figure 14A). The following example shows how to determine the amount of water required to irrigate a 24- by 200-foot high tunnel with four rows of drip tape (800 feet total) for 2 hours (Figure 14C). It assumes emitters are spaced every 4 inches, using 60 gph per 100 feet of tape (equal to 1 gpm per 100

Figure 13. A tensiometer can be used to monitor soil moisture.

feet). In this case, the tape uses 8 gpm to run the irrigation system:

(800 feet of tape /100 feet) x 1 gpm/100 feet = 8 gpm

Multiply the run time by the system flow rate to determine total usage: 8 gpm x 120 minutes = 960 gallons of water per 2-hour irrigation event.

This information is useful for tank watering (Figure 14B) and when designing ponds and water catchment systems. Similar calculations can be used to determine the amount of water needed in a given week, month, or growing season. Keep in mind that this does not account for water to fill the piping, which also should be included in the estimate.

Figure 14. (A) A roll of drip tape includes details for calculating water use and determining system pressure requirements. (B) Tank watering is possible because of the low water volume required by the drip system. A small electric pump is placed into the tank and powered by a generator. (C) Low-pressure drip tape and plastic mulch help maintain consistent soil moisture for high-tunnel tomatoes and peppers.

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