TRICKLE IRRIGATION

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A well designed trickle or drip irrigation system benefits the environment by conserving water and fertilizer and requires little labor to use. Water is applied either on the surface, next to the plant, or subsurface, near the root zone. In dry years, fewer weed seeds germinate between rows because there is less water available beyond the plant root zone. With drip irrigation there is less evaporation than with sprinklers. Evaporation losses from the soil surface are greatly reduced when drip irrigation is placed under plastic mulch.

It requires some expertise to install and operate a trickle system and consultation with a knowledgeable professional is wise. A poorly designed system can result in yield variability in the field due to areas of over or under watering and clogged lines. Trying to save money by cutting costs on initial equipment purchases will likely be more expensive in the long run. Any or all of these problems can completely offset the potential cost savings from using drip.

Considerations

Water source: Organic materials, such as plant materials, algae, small living organisms and inorganic sand, silt, and clay are likely to be of concern surface water such as a pond or stream. Well water is likely to have some sand, silt or clay particles, although not as much as most surface supplies. These particles can clog the small diameter emitters in the tape. Surface water might have contaminants from run-off, which can include diseases such as *Phytophthora* which has entered fields through irrigation water. Filters are used to remove particulate matter as discussed later.

Slope: A slope of 2% or less is the ideal for drip irrigation. Many fields in New England slopes greater than a 2%. A difference of 2.3 feet in elevation will change pressure by 1 psi, decreasing as elevation increases and visa versa. The length of lateral lines, the pump size, and pressure regulators are chosen based on the slope.

Soil: The soil type determines the soil wetting patterns. Soil wetting patterns in turn influence depth of the drip tape and the distance between emitters. The duration and frequency of irrigation are also determined by the soil type. Over watering can move fertilizer away from the root zone. On sands soils, water goes primarily downward rather than horizontally so emitters should be at relatively close spacing. Spacing between emitters can be greater in heavier soils there is considerable movement laterally. In sandy soils, irrigate more frequently, but run the water for a lesser amount of time. In heavier soils, irrigate less often, but run the water for a longer duration. In both cases, this should lessen the chance of leaching fertilizers away from the root zone.

Components

Drip tape should apply water uniformly throughout the crop root zone. The emitters should be close enough so that there is uniform wetting of the soil. As discussed above, the spacing of the emitters is affected by soil type. Drip tape should have a *coefficient of manufacturing variation* (CV) number which reveals how much variation in uniformity there is from one emitter to the next. A CV of 0.05 is considered excellent and a CV between 0.05 and 0.1 is acceptable. The rate of water delivery is a function of the size and spacing of the emitters and typically ranges from about 2.5 to 5.0 gallons per minute per 1,000 feet of tape.

The length of the drip lines is another important consideration. The length is determined by the pump size, the field size(s), and the slope of the land. Any one of these factors will influence wetting uniformity because the emitters will discharge water at different rates if there are changes in pressure along the line. Because of variation in water pressure, tape is rarely laid out longer than a length of 400 feet on fairly level land and less on slopes. Tape should run across the slope, but if this is not practical, it should run down hill so the pressure loss due to friction is counteracted by the gain as the elevation decreases. If the tape runs up hill, there is a double loss due to friction and increasing elevation.

The choice of tape thickness, measured in mils, is based on how long you want the tape to last and the expected highest water pressure in the lines. The longer the tape is expected to be in the ground, or the higher the pressure in the lines, the thicker the tape should be. Tape thickness is usually between 4 and 10 mil though thickness of up to 25 mil can be purchased. Tape can be reused for 2 to 3 years, but the labor costs of retrieving and cleaning the tape usually make this uneconomical for annual vegetable crops.

Placement of drip tape: There are three decisions to be made regarding placement of the drip tape: 1) the distance from the plant in the row, 2) whether to bury the tape or place it on the soil surface, and 3) the depth to bury the drip tape.

Whether the tape is laid on the surface or buried beneath the soil, there are a few general guidelines to follow. The tape should be placed as close to the plant as is practical for the specific crop. Twelve inches is the maximum distance away from the plant row - most tape is placed between 6 and 12 inches away. A little farther away is possible in soils that have good lateral movement or when other means of irrigation is used to germinate seed or establish seedlings. Tape is often laid between double rows of crops such as peppers. The soil will be wetter on the side of the crop where the tape is and there will be more roots there. Can be minimized by placing the tape close to the crop. The tape should be placed so that the emitters are pointed upward so that soil, silt and clay will settle away from the emitters after the water stops flowing.

Tape can be placed on top of the soil or a few inches below the surface. It is easy to install tape on the surface. It is easy to observe wetting patterns and to make repairs if needed. The disadvantages are that there is greater evaporation in the initial stages of the crop's growth and the tape is more likely to be damaged by production practices, wind, and animals. As tape is heated by the sun during the day, it expands and takes on a snake-like pattern in the row. This is particularly a problem with higher temperatures under plastic.

How deep the tape should be buried in a given field is influenced by the crop, the soil type, the root pattern of the crop, soil wetting patterns, and the tilling practices used in the field. Drip tape is usually buried two to four inches deep, though with some root crops, the tape can be buried a little deeper. Water moves upward and laterally from the tape better in a loam soil than in a sandy soil, therefore, tape should be buried at shallower depths in sandy soils than loam soils. Buried tape is susceptible to damage from some insects such as wire worms.

Pumps: For a given area, trickle irrigation uses less water and at a slower rate than a sprinkler system. Therefore smaller pumps can usually be used. The required pump capacity is determined by the largest acreage to be irrigated at a given time, pressure loss due to friction and increases in elevation. Pump size can be determined when designing a system.

Filters: The choice of filter is based on the quality of the water passing through the system. A filter may be inexpensive initially, but be more costly in the long run when operating costs are considered. For example, when using dirty water, inexpensive filters tend to require frequent cleaning, increasing down time and labor. However, more expensive filters may operate for a longer period with out cleaning.

Screen filter: Screen filters are inexpensive and easy to install and work well if there are moderate to low contaminants in the water such as those coming from a well. Screen filters have a limited ability to store contaminants. If the water comes from a river or pond, the screens will probably have to be flushed often. This could result in considerable down time and labor.

Mesh screen sizes are between 20 and 200 mesh. The larger the number, the smaller the particle the screen will filter out. The screens are made from stainless steel, nylon, or polyester.

Sand filter: Sand filters are preferred over screen filters if the contaminant load is moderate to heavy. A sand filter can run longer than a screen filter before it needs to be cleaned by back flushing. This results in less down time and labor. The filters can be set up in pairs so that clean water from one filter is used to back flush the other filter or a disc filter can be used for this prupose.

The correct filter size is important. Under-sizing will increase pressure loss and there is considerable down time for cleaning. It is better to be too big than too small. The filter should be sized to handle the maximum amount of water flow anticipated for now and in the future.

The sand used should be of the correct type for trickle irrigation. It is made up of crushed, sharp edged silica or granite. The sand never needs replacing unless it is contaminated by oil or other chemicals. Sand filters can remove particles smaller than those that can be removed from a 200 mesh screen filter.

Disc filter: A disc filter consists of a series of discs that are stacked on top of each other. The discs are made up of microscopic grooves that serve as the filters. Equivalent mesh sizes are between 40 and 600 mesh. They require less water for cleaning than do sand filters.

Pipe/Mainlines: Mainlines can be metal pipe, PVC pipe or lay-flat hose. They deliver water from the pipe to the submains and laterals. Proper pipe diameter is a function of the pumping rate and distance the water must travel. Larger diameters can move greater volumes and have lower friction losses, but are more expensive than smaller pipes. The longer the pipe and the more elbows or junctions, the more loss due to friction, which then causes a gradual loss in pressure. A qualified designer can help determine the appropriate pipe size for the system.

Care should be taken when laying the pipe to prevent soil or debris from getting into the system and clogging the lines. The lines should be flushed before the tapes is connected to flush out any dirt that got into the lines during installation.

Check valves allow water to flow in one direction only. They are used to prevent water from flowing backward into a water source after the system is shut off. This is especially important to prevent injected fertilizer or pesticides from contaminating water supplies. They are required by law for systems with injectors. Vacuum-relief valves are installed to prevent soil from being sucked into the emitters when a vacuum is created after the system is shut-off.

Pressure regulators maintain the desired pressure as the water flows through the system. They are required to supply the appropriate pressure to tape and may be needed to protect filters and other components.

Running the System

The reason for using any irrigation system is to supply adequate moisture for the crop. This requires the replacement of water lost through the processes of evaporation from the soil and transpiration from the leaves (evapo-transpiration). Evapo-transpiration can be nearly zero during cool, calm and humid weather, but can exceed one-third of and inch per day when it is hot, windy and humidity is low. This loss can be measured with evaporation pans.

The need for irrigation can be determined by measuring soil moisture. Many growers do this by grabbing a handful of soil from the area of the root zone and making a judgment as to the need for irrigation or to determine if it is time to shut the system off. An experienced grower can do a good job of scheduling irrigation this way.

Instruments can be used to measure the moisture status of the soil. A tensiometer is a practical tool growers can use. A tensiometer is a plastic pipe with a ceramic cup at one end and a vacuum gauge at the other. The cup is wetted to saturation then the pipe is filled with water. The pipe is inserted into the ground at the root zone. A rule of thumb is to place the tensiometer about six inches from the drip tape at a depth of one-third the entire root zone. As the soil dries, moisture is pulled from the tensiometer through the ceramic cup. This creates a vacuum which is measured on a meter at the top of the tensiometer. When the tension rises to a certain reading, irrigation should begin, and it should stop when the gauge drops to a certain level. Some growers place tensiometers at two levels; one about six inches deep and another at about 12 to 18 inches. The upper unit indicates when soil moisture near the surface is being depleted (begin irrigating) and the lower one shows when the moisture has moved to the bottom of the root zone (stop irrigation). The appropriate gauge readings are based on soil type. These units work well in sandy to loam soils, but are not useful in clay soils. They can be purchased through several field equipment suppliers.

A gypsum block is less commonly used by growers. It measures the soil moisture by measuring electrical resistance. After the gypsum is saturated with water, it is embedded in the soil. Soil water moves in and out of the gypsum block as the soil is wetted or dried through irrigation or rain. The gypsum dissolves and moves with the water. As the concentration of the gypsum changes, the electrical resistance changes. The block needs to be replaced after all the gypsum dissolves.

An important point to remember with drip irrigation is that the water is applied near the plant and that there is very little available moisture outside of the root zone. The root zone of a specific crop is much closer to the plant under a drip system than with other types of irrigation or where there is significant rainfall during the growing season. Soil moisture should be measured in the root zone, *not in the furrows away from the plant.* During periods of warm weather, the moisture in the root zone can be rapidly depleted even though there is sufficient moisture next to the plant.

Fertigation

Fertigation is the injection of chemical fertilizer into irrigation water. Nitrogen and potassium are available in liquid or soluble solid form and can be applied through a drip system. Phosphorus, if needed, is usually broadcast at the beginning of the season.

By using a fertilizer injector, trickle irrigation can be used effectively to apply N during to growing crops. The need for supplemental N can be determined using the pre-sidedress soil nitrate test (PSNT) as it is with other application methods. Samples for the PSNT should be take from under the plastic, if used. The best way is to use a soil sampler which will punch a small hole in the plastic and remove a core of soil. **Be sure to avoid cutting the irrigation tape when sampling under plastic.**

With conventional topdressing or sidedressing, it is common to apply all the N in one or two applications. With trickle irrigation, it is convenient to apply small amounts of N weekly or even daily, which is desirable from an N management standpoint. For example, if you want to apply about 50 lb N per acre, you can inject a little over seven lb N per acre per week for seven weeks, or about one lb per day if you prefer. Small weekly applications provide for more efficient crop use of N than one or two larger applications. Daily application offers little advantage over weekly application, but may be necessary if the injector cannot inject a week's worth of N during the appropriate irrigation run time. To do this, dissolve the desired amount of fertilizer for the area to be covered at one time in a bucket or barrel. In the example above, mix seven lb of N for each acre to be covered at one time in water. Use enough water so that it will take about 20 minutes to complete the injection. If injection occurs more rapidly, the application may not be uniform. On the other hand, a longer injection time may result in excess water. To prevent leaching, the irrigation system should not be run longer than necessary to effectively wet the root zone of the crop. This will distribute the material throughout the rooting area. Excess water will leach some of the N below the root zone. If there is not enough time to inject all the fertilizer needed for the week in one injection, then smaller, daily injections are preferable. Before injecting fertilizer, the entire system should be filled with water and at full operating pressure. When all the fertilizer has been injected, the system should be run long enough to flush all fertilizer from the lines. If fertilizer is left in the lines, clogging may occur due to chemical precipitates or growth of bacterial slimes.

Water problems

There is a potential for certain fertilizer materials to react with chemicals in irrigation water. If the water pH is below 7.0, there is little potential for problems, but at pH 8.0 and above, the risk is high. At levels above 40 to 50 ppm, calcium and magnesium are likely to react with phosphorus, if present in the fertilizer, causing precipitation of phosphates. If fertilizer containing calcium is added to water with concentrations of bicarbonates above 2 meq/liter, calcium carbonate may precipitate. Sulfates in fertilizers can react with calcium in the water resulting in the precipitation of gypsum. These precipitates can clog emitters.

Phosphorus- and sulfate-containing fertilizers, if needed should be applied before planting because we are not concerned about these leaching. Nitrogen is the element that is most appropriate for injection into trickle irrigation water. Calcium nitrate has the potential to cause clogging if the water pH and bicarbonate levels are high as noted above. If calcium nitrate causes clogging, potassium nitrate or urea can be used as an alternative N source.

Water testing labs can analyze water for pH, calcium, magnesium and bicarbonates. You can also perform a simple test: Mix fertilizer into a container of irrigation water at the same concentration it will be after injection into the trickle system. Cover the mixture to exclude dust and let it sit for at least the length of time it will be in the system before it reaches the soil. If the water becomes cloudy or a precipitate collects on the bottom of the container, you can expect this to happen in the irrigation system with the likelihood of clogging. If it is necessary to lower the water pH, acid can be injected into the irrigation water. This requires special handling precautions and special injection equipment. Be sure to carefully follow directions to avoid personal injury or damage to crops or equipment.