

Introduction to Drip Irrigation

Advantages

A drip system produces healthy, fast-growing plants. In fact, improved crop yields were the primary force behind the development of drip irrigation for agriculture.

In traditional watering methods there is an extreme fluctuation in the water content, temperature, and aeration of the soil, resulting in plant stress. Drip watering keeps the moisture content of soil relatively constant and ensures that oxygen remains available to the root system.

For many gardeners, water conservation is the main reason for installing a drip system. When you water your garden, your purpose is to water plants rather than soil. Drip irrigation gives you the ability to put water exactly where it's needed and keep paths and areas between plants dry. This reduces both waste and weeding.

You can regulate precisely the amount of water used during irrigation so that nearly all of it remains in the root zone. Water lost to evaporation is negligible compared to overhead watering.

Traditional watering methods deliver water faster than most soils can absorb. If water exceeds the soil's percolation rate, it can only run off the surface, taking valuable topsoil and nutrients with it. On a slope, drip can be designed for minimum run-off and is often the only means of bringing a hillside into cultivation.

Another advantage of drip is that you can deliver equal amounts of water to plants over a wide area. This is very hard to accomplish with other methods of irrigation. It is now so well established that drip irrigation saves water that its use for narrow or sparse plantings is required by California law in new commercial and larger residential landscapes.

Drip irrigation is the slow and precise delivery of water to chosen plantings. It uses flexible polyethylene tubing with devices for dripping water (emitters) and low-volume sprays. The systems are easy to install, require no trenching, and the only tools needed are pruning shears and a punch.

Drip irrigation maintains near-perfect moisture levels in the root zone of plants, avoiding the too wet/too dry swings typical of overhead watering. Drip systems are controlled by hand or by an automatic timer, and can also be used to apply fertilizers directly to the roots of plants.

Drip systems irrigate all types of landscape: shrubs, trees, perennial beds, ground covers, annuals and lawns. Drip is the best choice to water roof gardens, containers on decks and patios, row crops and kitchen gardens, orchards, and vineyards. Systems range in size from a few hanging baskets to several thousand acres of crops.

A drip irrigation system is easy to install. Since no trenching is needed, you can install a system in an existing landscape with no damage to your plants' root systems. Tubing will be overgrown by ground cover, or it can be quickly concealed with mulch. Drip irrigation also allows you to water a large area from a small water source, since it uses water more slowly than other methods.

If you are installing drip to new plants, they will develop deep roots which are more resistant to dry spells.

However, the greatest advantage for the home gardener is time savings. The simple action of opening a valve replaces all the time spent watering by hand. With the addition of an automatic timer, you can go on vacation or cope with a busy schedule while your garden flourishes without you.

How To Use This Handbook

The following pages will help you design, purchase, and install a drip irrigation system tailored to your own garden. The last half of this catalog illustrates a selection of drip components and other products that we have found useful for home gardeners.

All the products shown here are proven, low-cost agricultural quality equipment suitable for use in home gardens. When a farmer installs and operates several acres of drip equipment, any weaknesses in design or manufacture become apparent pretty quickly.

If you don't find what you are looking for, call us. We carry a larger inventory of both drip and sprinkler equipment than this catalog represents, and will usually have the irrigation part you need. We encourage you to draw your garden on the graph paper in the back of the catalog and start laying plans for your drip system.

Landscape

Landscape plantings with various water needs are often mixed together in one garden. Ideally, each group of plants with similar needs is watered by a separate zone of the irrigation system, controlled by a valve.

In practice the number of zones you set up will also be influenced by the size of the garden. A small ornamental garden is often divided into only two zones—one requiring frequent, relatively shallow watering and the other infrequent, deeper water. A large landscape might require different zones for hedges, trees, a shade garden, perennial beds in full sun, an area of native plants and so on.

You've probably noticed that certain areas of your garden dry out faster than others, depending on exposure to sun and wind, differing soil drainage, and competition from tree roots for available water. A small garden where the plants have essentially similar water needs can be handled with a single zone. You can insert faster drippers or more drippers to take care of thirstier plants.

Hedges, perennial beds, and trees each lend themselves to different styles of drip layout. Dense plantings such as hedges, annual borders, and ground covers are typically watered

using emitter lines, tubing with pre-inserted drip emitters spaced at regular intervals. Irregular plantings such as shrubs and perennial beds are most often watered with individual drippers chosen for the needs of each plant.

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Small sprays attached to the drip system are also useful in mixed landscape. A common design is to water the ground cover between shrubs with sprays, while adding extra water near the base of each shrub with drip emitters. Another good use of sprays is to water small plants or ground cover growing among rocks or flagstones. For a summary of drip vs. microsprays see the comparison chart on page 7.

The best layout to water trees and large shrubs is to stake a tail of emitter line halfway between the trunk and canopy. Newly planted trees need at least two drippers directly on their root ball.

The flexibility of drip irrigation allows one to remove individual emitters from a system by replacing them with a "goof plug" or to add new emitters or lines to a system with little worry about

design. If a line is accidentally cut, it easily is repaired with a connector. It's a good idea to keep a few repair parts on hand just in case.

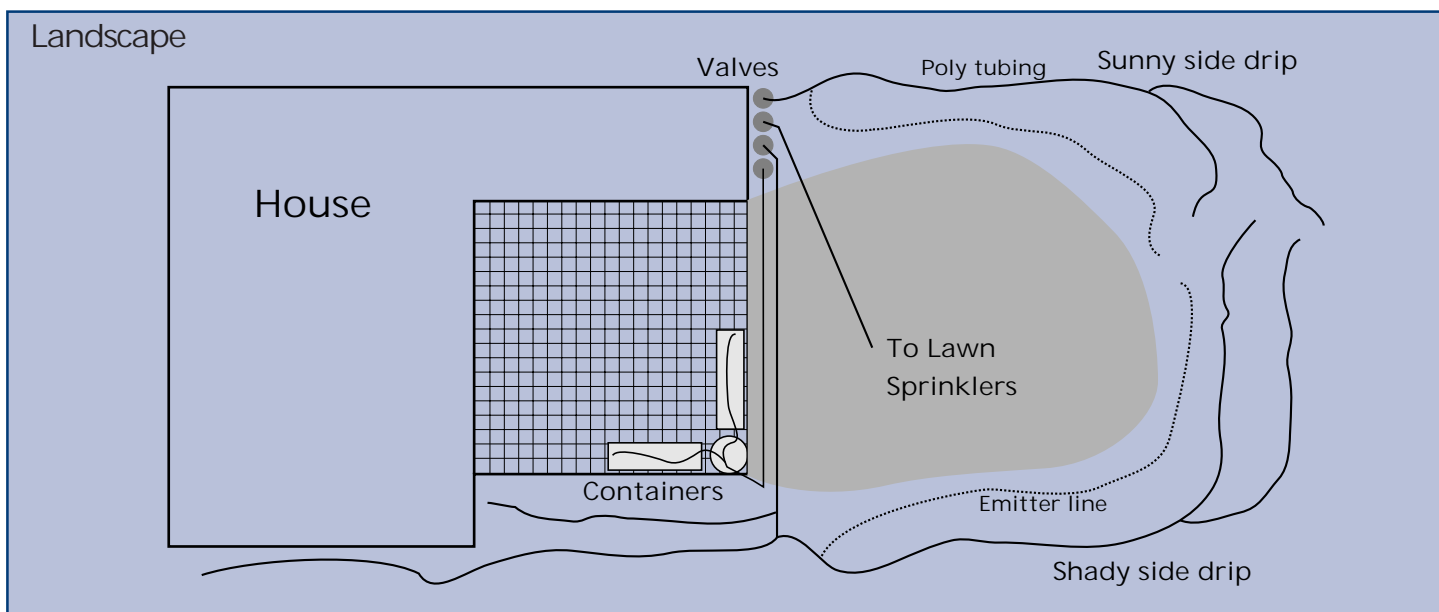
Containers

Plants in containers, which dry out faster than those in the ground, are prime candidates for an automatic drip system. Hand watering is very time consuming and the plants suffer immediately when watering is neglected.

A container drip system should always be zoned separately because its watering schedule is unique. Container plants need frequent waterings for only 2 to 5 minutes at a time.

In a container system, a 1/2" or 3/8" line is run below or behind the plants, under the railing, or under the deck itself. Smaller tubing (1/4") goes to each container. The 1/4" tubing is available in various colors to help hide it. It can also be run through the container's drainage hole.

All but the smallest containers need several emitters placed in them because their soil is so loose that water from each emitter moves downward without much sideways spread. The irrigation strategy is to place drip emitters 6" apart, or to attach small adjustable bubblers to spread the wa-



ter. Useful products from the catalog are mini-inline emitters, 1/4" emitter lines, shrubblers, and vortex sprays, all illustrated on pages 11-13. In containers less than 6" diameter, individual drip emitters will suffice.

A single 1/4" line can supply water to several containers. Add up the flow rates of the emitters that you are planning to use and compare with the maximum flow rates for the different types of 1/4" tubing (page 14). Emitters for containers can apply as little as 1/4 gallon per hour or as much as 10 gph.

Adjusting the number and size of emitters in a container drip system takes some experimenting, especially if the containers are of different sizes. Run the system and see which containers the water runs out of first. You either have to decrease the flow in these or increase the flow rate to the other containers on the system. This process will also help you set the run time for the system.

One product that increases both lateral spread and water retention in container soil mix is Broadleaf P-4 soil polymer, described on page 24.

Vegetables

Vegetables prosper when the surrounding soil is kept quite moist, but frequent overhead watering encourages rust, mildew, blossom damage, and disease. Closely spaced drip emitters can thoroughly water an area without wetting the plant leaves. In the rich soil of a well-prepared vegetable bed, drip irrigation produces spectacular growth and yields.

Rows and intensive beds are watered using emitter lines, with drippers 12" apart along the line. If plants are more widely spaced and deeply rooted (for example, tomatoes and squash), a single emitter can be placed at the base of each plant.

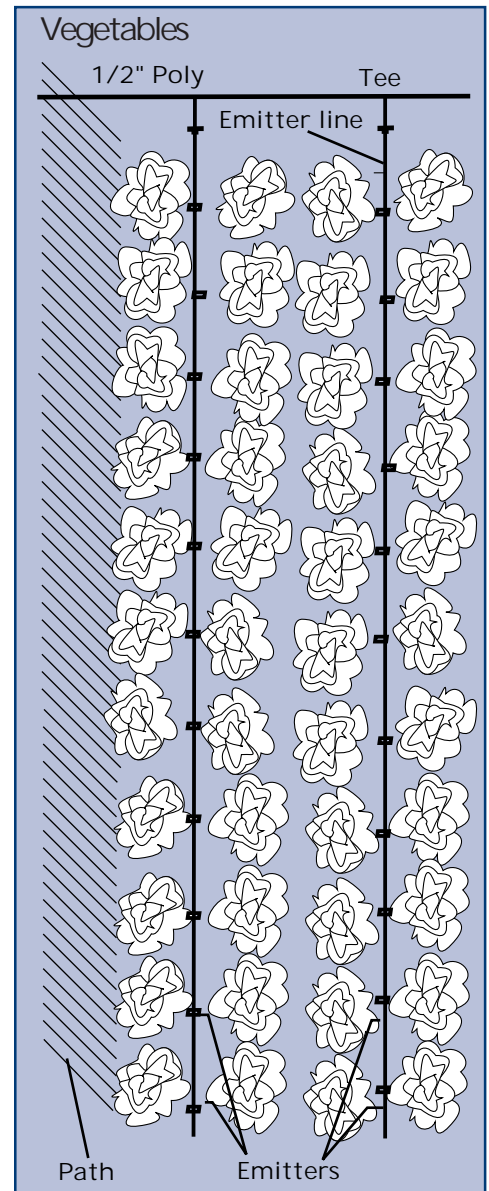
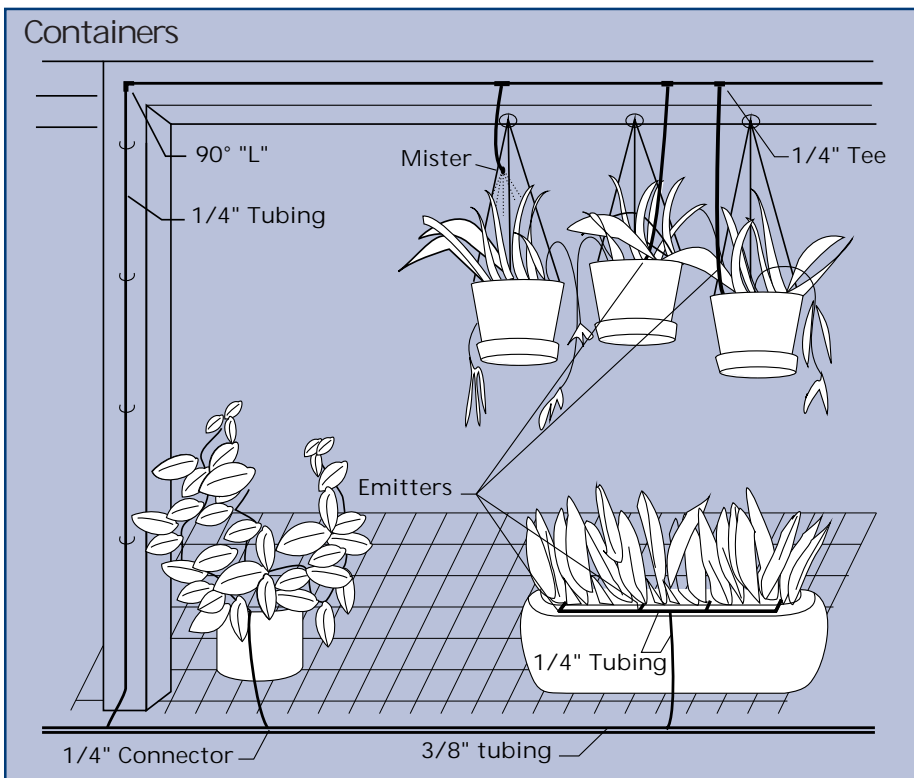
Root crops such as carrots, onions, and radishes can be planted two deep on each side of a single emitter line. With plants such as corn, strawberries, and peppers, one row on each side is preferable.

In intensive bed gardening, the system should be set up with parallel emitter lines 16" apart. If the bed is 4 feet wide, three lines will give

complete coverage. This system does not need to be changed when plantings change. Extra sprays and even individual emitters can be added for any plants that need extra water.

In the rich soil of a well-prepared vegetable bed, drip irrigation produces spectacular growth and yields.

If overhead water is needed, for instance when growing salad greens from seed in a hot climate, then half-circle jet sprays can be installed on poly tubing along the edges of the beds instead of using parallel emitter lines.



Lawns

Drip irrigation for lawn watering is finally moving out of the experimental stage. Five years of independent tests at the Center for Irrigation Technology comparing many products and installation methods in the extreme heat of California's Central Valley give us confidence in recommending this option. When properly installed with air vents and automatic flushing ends, subsurface emitter lines are proving very reliable.

The advantages over conventional lawn sprinklers include significant water savings, especially on hot or windy sites, and a surprising decline in turf diseases. Weed invasion may also be significantly reduced in healthy, dense turf since there is no topical moisture to encourage seed germination.

Subsurface lawn irrigation is particularly valuable on lawns where efficient sprinkler layout is difficult, such as steep slopes, long narrow strips, and odd shapes of all sorts.

A typical layout for a subsurface lawn system is shown below. Emitter lines are placed in parallel rows

4" to 6" below the soil. Spacing varies with soil type. In heavy clay soils, use 18" between lines, with emitters 18" apart on the lines. Tighter spacing is needed in lighter soils because the lateral water spread is not as great. The closest spacing ever needed is 12" between lines, with emitters 12" apart on the lines.

The lines are connected by headers on both ends. An automatic flush valve is attached to the header farthest from the water supply and is located in a valve box (see diagram). The flush valve allows any sediment to escape from the tubing each time the system starts up, and then closes down after it expels about 1 gallon of water.

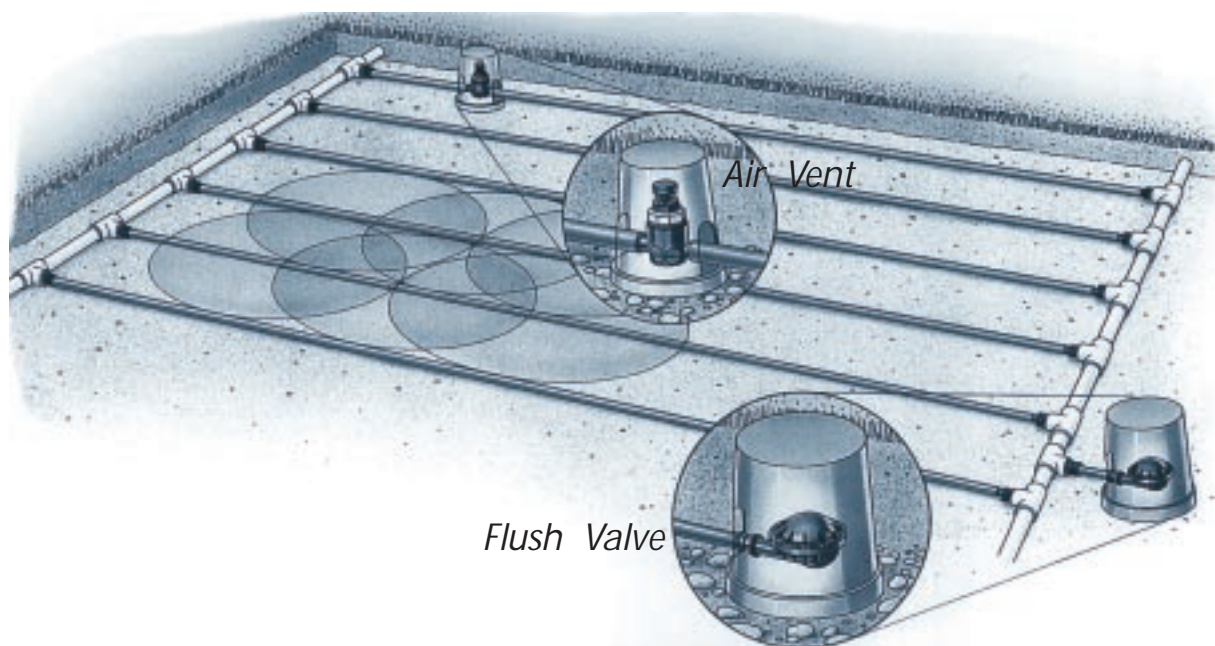
The air vent operates after the system has shut down and is draining. It permits air to replace water in the tubing and minimizes suction of sediment into the emitters. An air vent should be installed for each zone at the high point and can be buried in a valve box that has good drainage. If an anti-siphon valve is used to turn the system on and off, you may not need an additional air vent. (You can call the Urban Farmer Store to discuss your particular layout.)

Emitter lines can be placed under the soil in several ways: by hand trenching; with a mechanical trencher that cuts a narrow slot; or with a pipe-pulling vibratory plow. Another possibility when you're undertaking extensive soil amendment is to lay the tubing before the final 4" of soil is spread. Site conditions will usually suggest the most economical approach.

An advantage of drip for lawns is the good control you have over the amount of water that different areas receive. For instance, if a berm, a slope, and flat areas of turf are irrigated on the same valve, you can place tubing close together on the berm to increase the precipitation rate and use normal spacing for the flat areas, with greater distance between lines as you approach the bottom of the slope. Emitter lines next to walkways and patios should be located no more than 4" from the hard edge to prevent dry strips.

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Lawns



Orchards

Drip irrigation is widely used in commercial orchards. Slow, deep waterings and precision control encourage tree growth without the oversaturation and weeds that flood or sprinkler irrigation can bring. Equal amounts of water can be delivered to each tree.

The changing water needs of growing trees can be easily met if you size your piping to the trees' mature water needs. Saplings can start with one emitter at the base of each tree, and emitters can be added as needed. The drawings below illustrate some common layouts:

1. Run lines down rows of trees and place emitters at base of each tree.
2. Run lines along rows about 3 feet on either side of trees to encourage balanced root growth.
3. "Tee off" each line with a loop around each tree to water the entire circumference of the root zone.
4. Use sprays with sandy soil if cultivation methods allow. One or two jet sprays on stands can cover the entire root zone of a tree.

Vineyards

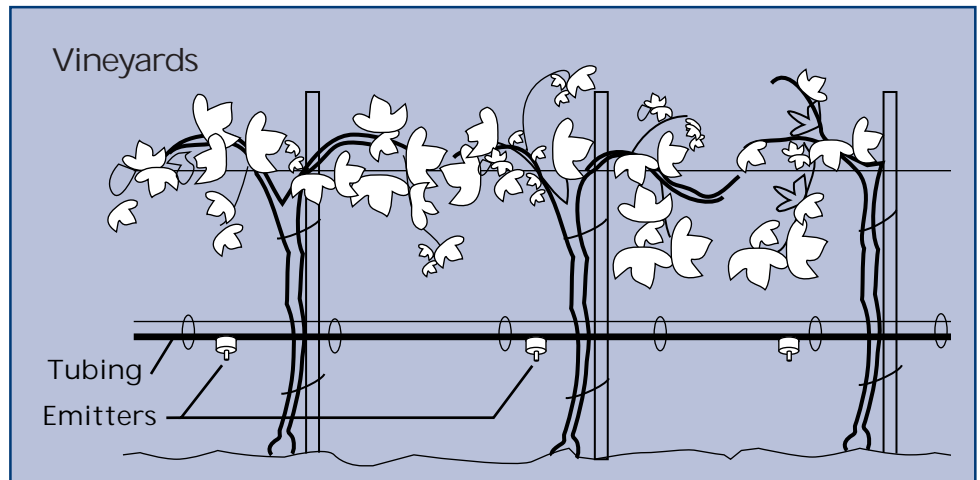
Even the largest and most old-fashioned wine-grape growers have converted to drip irrigation, and for good reason: Drip irrigation provides excellent water management, reduces runoff and erosion on slopes, discourages harmful mold, and produces better fruit.

The preferred method of installation is to tie tubing to a wire suspended about 18" off the ground attached to the grape stakes. At this height, the tubing doesn't interfere with weeding.

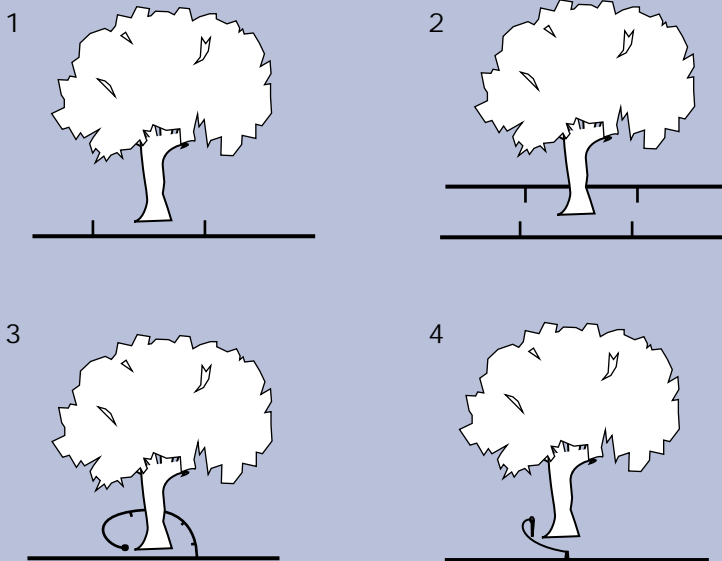
Once tied on, the tubing is allowed to unwind for a few days so that when the emitters are punched into the

bottom of the tubing, they stay pointed down. The drip will then fall where intended instead of running along the tubing. Since vineyard rows are often long and on uneven terrain, pressure-compensating emitters should be used.

A typical layout involves a rigid PVC supply line underground at the ends of the rows, flexible PVC with a hose-thread filter to bring water for each row above ground, and then 1/2" poly tubing along each row. Each vine is watered with one, or better yet, two emitters. Lateral lines can be over 1000' long depending on emitter size and vine spacing.



Trees



A fertilizer injector is a useful addition to your drip system. It lets you deliver nutrients directly to the root zone, producing maximum growth. No outside power is required—existing water pressure in your drip system does the work for you. An automatic fertilizer injector is also used to treat mineral deposits and algae growth if you have these problems with your water supply.

Planning

To aid planning and design, all systems should be sketched to scale on graph paper. (You can use the inside back cover of this catalog.) Draw a plan of your yard or garden indicating areas of ground cover, flower and vegetable beds, lawns, and patios. Note on your drawing the location of hedges, shrubs, trees, and also retaining walls and driveways that will act as barriers to your piping.

Take an overall look at the area to be watered. Notice if the area slopes, how steeply it slopes and in which direction. Also note areas of shade from trees or the house, and areas where tree roots will compete for moisture with your plantings. This is the time to divide your garden into zones to be watered separately (see Landscape, page 2). Then decide whether each area is best watered with drippers or microsprays.

Draw a plan of your yard or garden indicating areas of ground cover, flower and vegetable beds, lawns, and patios.

The next step is to compare the flow rate from your water source to the flow that each proposed zone will need. Most zones in home systems use less water than the faucet (hose bibb) is capable of delivering, and

they can run as a single unit. If, however, a zone needs more than the hose bibb is able to deliver at one time, it can be divided into as many smaller zones as necessary.

To determine the hose bibb's flow rate, run the water at full force into a measured bucket and time how long it takes to fill. If, for example, a 5-gallon bucket takes 30 seconds to fill, then the flow is 10 gallons per minute (gpm), or 600 gallons per hour (gph). Figure that maximum usable flow is 75 percent of the flow rate into the bucket—in this example 7.5 gpm or 450 gph. This is the largest zone that the source can supply at one time.

Finally, mark on your drawing the tubing and emitters for each zone and make up a list of materials, including fittings, that you need for the project.

Emitter Placement

The most important factors are the size of the root zone and type of soil. Make sure that you are watering more than 50% of the root zone. Refer to the chart below for guidelines. Shallow roots require closer emitter spacing than deep roots because the system run time will be shorter, giving less lateral spread from each emitter.

Water moves downwards in soil due to gravity and from particle to particle in all directions due to capillary

action. In coarse sandy soil, gravity affects water movement more than capillary action. In finer soils such as clay, capillary action is much stronger, so water will tend to spread before penetrating very deep. An emitter in sandy soil may suffice for an area 16" in diameter, while the same emitter in clay soil may wet an area 24" or more in diameter.

...irrigating new plantings, you need at least one dripper directly on each root ball.

A field test is useful. Slowly drip water from a garden hose on the soil to be irrigated. After half an hour, check to see how deep and wide the water has spread. Be sure to dig down into the soil away from the obvious wet area on the surface to see the extent of coverage.

Drip emitters are typically available in flow rates of 1/2, 1, or 2 gallons per hour. Factors that influence the choice of flow rate include: (1) different rates are used to give different amounts of water to plants on the same system; (2) sandy soil takes a fast drip rate, while a 2 gph dripper in clay soil produces a puddle of water and may result in dirty water getting back into the drip tubing; (3) choosing slower drippers allows you to use more in a single zone, and allows longer runs of tubing.

SELECTION, NUMBER & SPACING OF EMITTERS

	Flow Rate (gph)	Number of Emitters	Placement of Emitters
Low shrubs (2-3')	1.0	1-2	at plant
Shrubs and trees (3-5')	1.0	2	6-12" either side
Shrubs and trees (5-10')	2.0	2-3	2' from trunk
Shrubs and trees (10-20')	2.0	3-4	3' apart
Trees (over 20')	2.0	6 or more	4' apart
Flower beds	1.0	1	at plant
Ground cover	1.0	1	at plant
Vegetables, closely spaced	0.5-1.0	1	every 12"
Vegetables, widely spaced	1.0-2.0	one per plant	at plant

When irrigating new plantings, you need at least one dripper directly on each root ball. Water doesn't move well from surrounding soil into the growing medium in which container-grown plants are raised, and they are particularly vulnerable to drying out because of their small root zone. On a slope, put drippers on the uphill side of the plants that you are watering.

Sizing your components

After you have determined the number, output, and placement of emitters, mark them on your sketch. Draw in the lines to connect the emitters, noting the length of tubing and connectors needed.

Add up the flow of each dripper to arrive at the total flow of the zone. Once you have determined the total flow, select the appropriate filter, pressure regulator, and tubing. For systems using 180 gph or less, a head assembly such as the **hose bibb head assembly** illustrated on page 8 is sufficient. Even on a small system a Y-filter may be preferable because it is so much easier to clean.

Add up the flow of each dripper to arrive at the total flow of the zone.

Tubing should be sized to keep pressure loss within acceptable limits so that each emitter is able to put out its expected flow. Pressure ranges for each emitter type are given on page 11 in the parts catalog. You'll notice that pressure compensating emitters provide a constant flow rate over a wide range of pressures.

Pressure is always lost to friction as water flows through tubing. Friction is greater at high flow rates and in smaller tubing. 1/2-inch tubing can be used for flows up to 320 gph. 3/8" tubing, sometimes preferable for its low profile and extra flexibility, will carry up to 100 gph. Check the

catalog pages for recommended flows of other tubing sizes and maximum line length for different emitter lines.

Elevation change is another factor that leads to pressure variations. If the tubing runs downhill, pressure increases by .433 psi per vertical foot. An equal amount of pressure is lost when the system runs uphill. If the difference between high and low points of the system is no more than 25 vertical feet and pressure-compensating emitters are used, then the pressure variation is acceptable.

On a hilly site with greater elevation changes, the main problem is that the pressure starts to strain the tubing and fittings. Our solution is to start with a 20 psi pressure regulator at the top of the slope, and install an extra 20 psi pressure regulator every 25 feet down. We run tubing with emitters across the slope with a single supply line down the slope.

If you do not use pressure-compensating emitters, more attention must be paid to keeping line-pressure values within acceptable limits. The maximum flow rates mentioned above for 3/8" and 1/2" tubing should be reduced by a third, to 66 gph and 210 gph respectively, and the maximum elevation change should be 10 feet.

This is as much engineering as most home drip systems require. Higher flow rates can be handled by larger poly tubing or buried PVC pipe with risers for different areas. Once the tubing is laid out, extra drippers to water new plantings can be easily added. If expansion takes you over your usable flow rate, dividing the system into two or more parts is a simple solution. But no matter how large or small your system, a scale drawing is crucial in determining your needs.

Here are some factors to consider when deciding between drippers or sprays for a particular area

DRIPPERS

- can be completely hidden by mulch, protected from view and from damage
- need a large number to water an area of ground cover or an annual flower bed
- give precise placement of water
- minimum water loss by evaporation
- in most landscapes, the coverage provided by a drip system will improve as the plants mature. As roots grow deeper, the duration of watering lengthens, and each dripper will irrigate a wider area
- maintenance of a drip system requires careful, if infrequent, inspection

MICRO SPRAYS

- cannot be completely hidden; vulnerable to disturbance by children and pets
- can be placed 5-8 feet apart so less tubing is needed; easier to cultivate around the system
- not as precise as drippers—not good for planters on decks, for instance. Can increase weed growth
- lose 20–30% of their water to evaporation
- coverage from sprays can deteriorate as the plants grow, blocking the spray patterns
- sprays can also be blocked by weed growth
- if problems develop with a spray system they are more easily seen

The head assembly is the connection between the source of water and the drip irrigation system. At the least, it includes a backflow preventer, filter, and pressure regulator.

Hose bibb head assembly

1. A vacuum breaker, the simplest backflow preventer, connects to the hose bibb.
 2. An in-line screen filter attaches to the vacuum breaker to keep rust and other water impurities from clogging the emitters.
 3. A hose-thread preset pressure regulator installs after the filter to reduce pressure in the lines to 25 psi.
 4. A hose thread to compression fitting connects the assembly to your tubing.
- These items cost about \$15 and can be installed in two minutes.

The most common addition to the basic head assembly is a fertilizer injector, which allows you to feed your plants while you water. Drip systems pose special problems with the usual methods of fertilizing, which rely on overhead water to dissolve and spread the nutrients. An injector allows you to apply fertilizer with the same accuracy as your watering system. All injectors should be installed downstream from a backflow preventer (no one wants to drink fertilizer!).

Pipe-thread head assembly

1. Most pipe-threaded systems start with an electric anti-siphon valve wired to a timer.
2. The Y-filter screws directly into the valve.
3. A pipe-threaded pressure regulator screws onto the filter.
4. A pipe-thread to tubing adapter connects to your lines.

All pipe-threaded joints require 3 wraps of teflon tape before you screw them together. The Add-It fertilizer injector (page 18) is recommended for a pipe-threaded system. Install it between the valve and Y-filter. The pipe fittings required vary with the size of the injector—call if you'd like help ordering them.

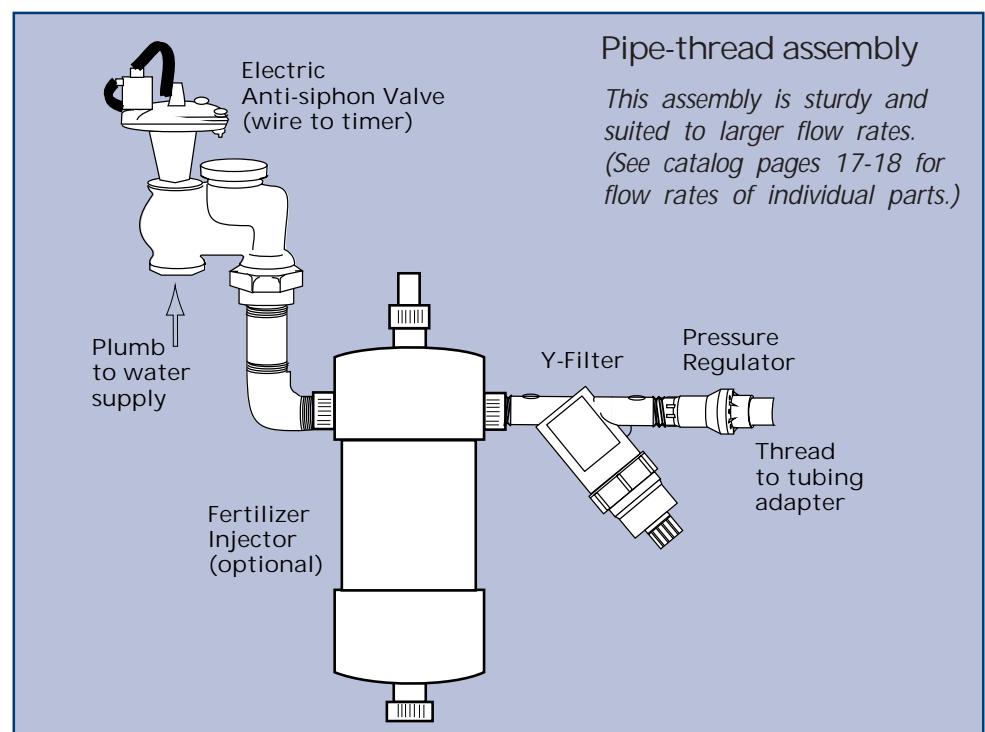
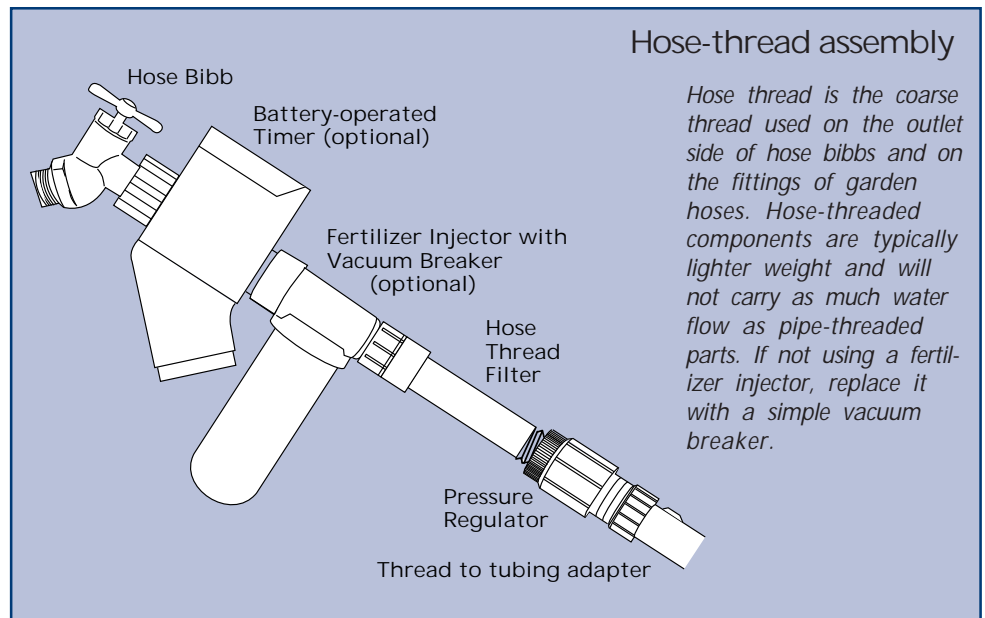
An alternative set-up is to install a filter and an adjustable pressure regulator on the supply line leading to more than one automatic valve, with each valve controlling a separate circuit. Be sure that the casing of the filter is strong enough to take full, constant water pressure (we recommend the Amiad filter, page 17), and use a brass adjustable pressure regulator.

A standard vacuum breaker will be useless if installed on the supply line to one or more valves, because the plastic float inside it becomes stuck to its seat

when the device is left under constant pressure. Rather, a vacuum breaker must be placed *after each valve*. We can supply backflow preventers to go on a constant pressure line, if necessary.

Lines and Fittings

Polyethylene tubing is run from the source of water to the plant, where the emitter is attached. Emitter line (poly tubing with pre-installed emitters) is used where a continuous band of water is needed.



Poly tubing has many advantages. It is resistant to ultra-violet damage from the sun, giving it a life of 15-25 years. It is light, flexible, and easy to move. Its fittings require no glue or clamps. It has “memory”—when emitters are inserted, it seals around their barbs. With both compression and barbed fittings, the tubing is pushed into place, and its elasticity and memory hold it secure. A barbed fitting fits inside the tubing; a compression fitting fits over it.

Fittings are available to make sharp turns (elbows), branch lines (tees), and to make the transition between different sizes of tubing. At the end of each line is an end cap with provision for flushing the line. Couplings allow you to extend lines or replace damaged sections.

As lines are laid out, the tubing may have to be secured until it takes shape. This can be done with stakes designed for this purpose. Leaving a little slack in the lines will allow for expansion and contraction from temperature changes, and will help prevent emitters from moving out of position.

Emitters

Once the lines are in place and flushed, the emitters can be installed. Simply make a hole in the tubing with

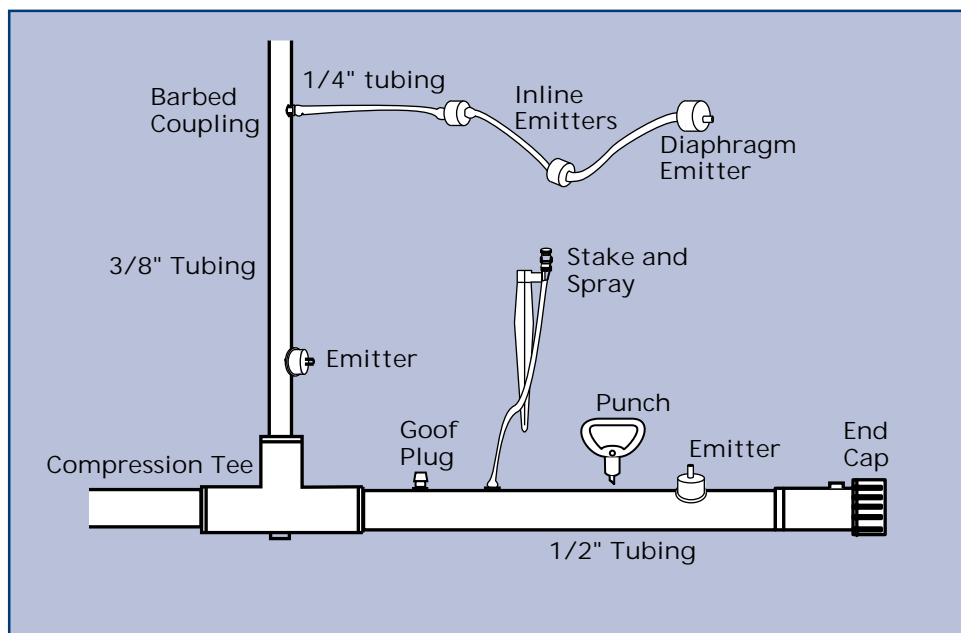
a hole punch, then pop the barbed end of the emitter into the hole. If you punch a hole in the wrong place, it can be fixed with a goof plug.

There are four ways to install emitters. The most common method is to place the emitter directly on the line. This way you only have to punch the hole and pop in the emitter.

Another way is to install a connector into the line, run 1/4" tubing to the place where the water is desired, and push the emitter into the end of the tubing. A third way is to place the emitter on the tubing and use 1/8" or 1/4" tubing to transport the water to the base of each plant. Finally, you can cut 1/4" tubing and insert an in-line emitter that drips and also allows water to pass through to the next emitter.

To install a spray, first punch a hole in the main line and insert a 1/4" connector. A short length of 1/4" tubing then leads from the connector to a stake. The spray screws directly into the stake and can be raised with an extender if it is blocked by plants.

Some misters are supplied already attached to a spike which pushes into the soil, and a barb to which you attach 1/4" tubing to supply water. Others are designed to be attached directly to tubing above the plants—in a greenhouse or above a hanging basket, for example.



Assembly Tips

1. Start the installation at the water source, working out to the laterals.
2. Be aware of the type of thread in your fittings. Forcing a hose-thread fitting onto a pipe-thread fitting can strip threads and cause leaks.
3. When pipe-thread connections are made, wrap threads with three layers of Teflon tape before connecting.
4. Check the correct direction of flow on valves and head assembly parts. All pipe-thread components have an arrow on them that points in the direction of water flow. Hose-thread parts are even more foolproof: all inlets are female and all outlets are male, which makes correct installation natural when the parts are screwed onto a hose bibb.
5. Do not tighten plastic hose thread fittings with a wrench. If you need to use a wrench on plastic pipe-thread fittings, be very gentle.
6. If you want to use your hose bibb to connect a garden hose & a drip system, use a hose Y shut-off. This turns one hose bibb into two, each with its own shut-off.
7. Be careful to keep dirt out of the tubing during assembly. After laying out the lines, open the ends and let water run through to flush them.
8. Letting the tubing sit in the sun will make it easier to manipulate. Dipping the end of the tubing into hot water makes it easier to connect the fittings.
9. Do not force the tubing too far into compression fittings, as this may interfere with water flow (1" into the fitting is enough).
10. When installing pipe under a sidewalk, let water dig for you. Attach a garden hose to a stiff piece of pipe and work the pipe under the structure.
11. When you punch a hole for an emitter or connector, hold the punch at a right angle to the tubing. This makes a round hole which will seal tightly around the barb of the emitter.

Scheduling

The object of each watering is to bring the moisture in the root zone up to a satisfactory level. Once the desired moisture content is reached, no more water should be applied. Too much water cuts off necessary oxygen and washes nutrients out of the reach of the roots. Before the soil has dried out too much the system should be run again. In this way the plants can be maintained in near optimal conditions.

The development of drip irrigation...led to successful and trouble free systems

Many factors affect how much water should be applied in any one period of time. Among these are: soil type, root depth, air temperature, humidity, and the plant's maturity. With drip irrigation it is possible to take all of these factors into account to provide ideal growing conditions for your plants.

The chart below lists times and intervals for watering different plants. Keep in mind that both are greatly affected by the factors mentioned above. The most important of those factors are depth of the root zone and soil composition. The deeper the roots and the finer the soil, the longer the watering time must be, but you can reduce the frequency of watering. A fine soil such as clay cannot absorb water very quickly, but will hold the moisture for a longer period of time.

Shallow root zones and sandy soil types will require frequent waterings of a shorter duration. Observe plant and soil moisture conditions, consult local experts (agricultural extension agents, nursery personnel), and adjust watering times and intervals to maximize growth and minimize water use.

In a system with mixed plantings, such as in most landscaping designs, some compromises may have to be made between plants that require

occasional deep watering and those that prefer frequent shallow watering. This can be partly accomplished by using emitters of higher output on the deep rooted plants. If this is not practical because of other factors, a compromise can be reached by doing shallow waterings on a frequent basis as well as occasional deep waterings.

Maintenance

Occasional maintenance should be carried out on all drip irrigation systems. Inspect the flow from each emitter, flush lines by unscrewing the end caps and turning the water on, and clean the filter. The development of drip irrigation products—now in their third decade—has led to successful and trouble-free systems for both the farmer and the homeowner. The design of a system using filtration and quality emitters will make maintenance a simple yearly task. Visual inspection of the system is the best way to observe performance, and can be done in minutes while gardening.

We suggest that you plan a complete inspection of your system at the beginning of each season. This may be all that you need to do unless there is much foot traffic or animal damage.

The other time to check your system carefully is after any new planting or garden maintenance that may have damaged the tubing.

If you are having trouble with your system, conduct the standard maintenance procedures first. If the problem is a single emitter, replace it. If it is more widespread, look for a break in the lines. If the problem cannot be determined by observation, it may be a result of inadequate water supply or faulty system design. Feel free to call the Urban Farmer Store for assistance.

Goof plugs can be used to plug holes from which emitters have been removed. They are very simple to use, and are indispensable when doing repair work or changing your pattern of plantings. Likewise, couplings come in very handy when any repair needs to be done on a damaged section of line. Simply cut out the damaged section and install a new piece using the couplings to connect the two pieces together.

Goof plugs and couplings should be ordered with all systems. If they are not needed in the initial installation, they will form the backbone of your repair kit.

WATERING SCHEDULE GUIDELINES

Type of Plant	Time (in hours)	Intervals (in days)
Low shrubs (2 - 3')	2	3
Shrubs and trees (3 - 5')	3	4
Shrubs and trees (5 - 10')	4	5
Shrubs and trees (10 - 20')	5	6
Trees (20' or over)	6	7
Flower beds	1	2
Ground covers	1	2
Vegetables - close spacing	.5-1	2
Vegetables - wide spacing	1.5	2
Potted plants	1-10 min.	1