CIR825

Irrigation of Lawns and Gardens[1]

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Normal rainfall in Florida ranges from 52 to approximately 60 inches per year. However, more than one-half of the annual total rain falls from June through September. During the winter and spring lack of rainfall may seriously affect lawn and garden growth without supplemental irrigation.

Often, droughts are thought of as long periods of time, such as months or years without rain, but Florida can experience drought conditions after only a few days without rain. This is a result of the very sandy soils in most of the state. Even during the rainy season, evapotranspiration (ET) rates may be high enough that irrigation of shallow rooted crops is required in order to avoid excessive water stress. Since the roots of most ornamental plants and grass are quite shallow, these plants are able to uptake the water stored in only the top 6 to 12 inches of the soil profile. Garden vegetables may develop deeper roots and be able to obtain water from depths of 18 to 24 inches. However, Florida's sandy soils have very low water holding capacities, and therefore the amount of water stored in the root zone, and available to the plant is very limited. Consequently, to avoid water stress, soil moisture must be replenished frequently by natural rainfall or supplemental irrigation.

Many irrigated lawns, with frequent, high levels of soil moisture content, would undergo stress from a sudden restriction of water or elimination of irrigation. Some changes in water management and scheduling of supplemental irrigation can improve the drought resistance of turf and should be included in lawn management. This process is called drought conditioning. The objective of drought conditioning is to grow a good quality lawn that will survive on little or no supplemental irrigation. It includes proper water application, good mowing practices, fertilization and pest control. Water management aspects for lawns are discussed Extension Publication ENH-63, "Let Your Lawn Tell You When to Water". Information on other aspects of drought conditioning is included in IFAS Extension Publication ENH-57, "Preparing Your Lawn for Drought".

WHAT CAN BE EXPECTED FROM HOME IRRIGATION SYSTEMS

A typical homeowner is often unaware of what is involved in the construction of a sprinkler or micro-irrigation system. Often, it is thought that in buying an irrigation system one is buying complete freedom from future watering problems. However,

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even with a well-designed system this may not be true. A well-designed, good quality system will significantly simplify watering, but it must be managed properly. Proper management includes proper operation as well as regular maintenance.

A good irrigation system may be expensive, but the investment should be repaid in time savings and landscape maintenance. An irrigation system should water a lawn and garden adequately and efficiently. This can be accomplished with proper design, properly selected good quality equipment, and good management, regardless of the size and complexity of the area which is irrigated. Major reasons for unsuccessful irrigation systems include: 1) poor spacing of sprinklers/emitters, 2) undersized pipes, and 3) poor management.

WHY DO YOU WANT YOUR SYSTEM PROPERLY DESIGNED?

Many home systems are not designed at all. An installer may walk over the lot and place markers at the approximate locations of proposed sprinkler sites. This is not a good beginning to achieve uniform and efficient water application.

A design should begin with a scaled map of the area which includes existing buildings, trees, shrubs, and sidewalks. The areas where water should not be applied (examples: walls, sidewalks) must be considered as well as areas where irrigation is desired. It is much easier to decide on paper where to put certain sprinklers by considering their areas of coverage, checking if sufficient overlapping exists, and making sure that all of the area is uniformly watered.

An existing water supply system must be examined to determine flow and pressure limitations. The number of sprinklers which can be operated at the same time should be calculated. Frequently, a system must be divided into zones. Each zone is designed to fit the water supply system by determining the most efficient way to connect sprinklers into groups. The pipes must be sized based on the water flow rate. Usually, several pipe sizes will be required within a single system. It is much easier to assure at the planning stage that the system will provide what is expected rather than to attempt to manage a poor installation.

The contractor should provide a detailed plan of the irrigation system and specifications of all necessary parts. The plan, including operational and maintenance procedures should be discussed with the future owner. An example of an irrigation plan and parts list is presented in Figure 1 and Figure 2.

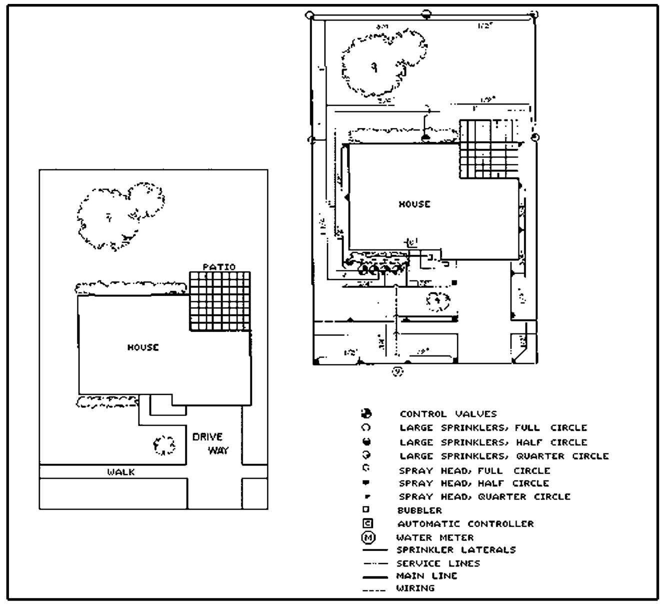

Fig. 1. A typical irrigation plan for a home lawn.

WATER SOURCES FOR HOME IRRIGATION SYSTEMS

There are several possible water sources for a home irrigation system. Water can be taken from a city water supply, private well or from an open water source such as a lake or pond. If a city water supply is used or a well with a pump already exists, the system should be designed for the flow rate and pressure available from the existing water source. If a well is to be drilled and a new pump is to be purchased for the system, the well and pump must be sized in the design process. For a surface water supply the pump must be also sized during the design process.

In Florida, well and pump permits from the local water management district are required in some cases. The local water management district should be contacted for specific information on permitting. In addition, some municipalities require permits and have restrictions on some wells.

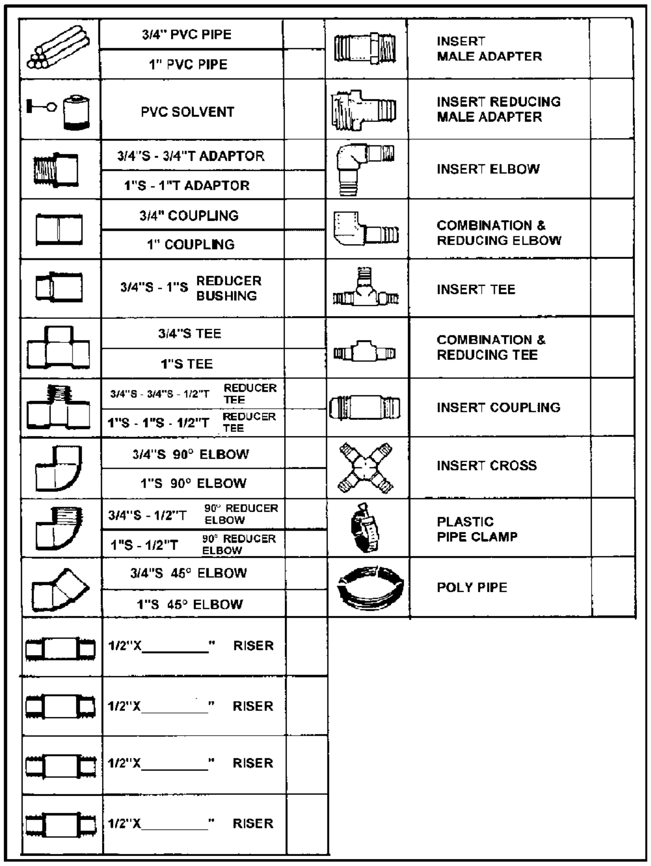

Fig. 2. Example of a parts list.

The water supply must provide the volume of water necessary to meet the irrigation requirements of the plants within each zone and within the maximum time allotted for irrigation of that zone. The flow rate of water available from the water source, the water application rate, and the time required for irrigation will determine the number of irrigation zones and the size of each zone. For example, if a lawn requires 1/2 inch of water every second day and two hours are required to apply this depth for each zone, the maximum number of zones will be 24 for a system which operates 24 hours per day. The practical number of zones would be much smaller. Some systems are operated only at night for no more than 8 hours/night. This amounts to 16 hours during two days. Therefore, if each zone operates for two hours, the maximum number of irrigation zones would be eight. A larger number of zones would not provide sufficient time to deliver 1/2 inch of water every two days to the irrigated area. The maximum number of zones for a given type of system can be determined using Equation 1 : The zone size can be determined from the available water flow rate.

Assuming that the water source is providing 20 gpm which is 2400 gal during 2 hr, and knowing that each acre-inch of water is equivalent to 27,152 gal, the size of the zone can be calculated using Equation 2: If the zone is larger than .18 acre, more than 2 hours are required to apply 0.5 in of water or a larger flow rate from the water source is necessary.

$$\textit{Maximum number of zones} = \frac{(T \times R)}{D}$$

Where:

T = maximum time available for irrigation between cycles (hours)

R = irrigation application rate (inches /hour)

D = irrigation depth per application (inches)

Equation 1.

$$\frac{2{,}400\ gal}{27{,}152\ gal/acre-in \times 0.5\ in} = 0.18\ acre$$

Equation 2.

CONSTRUCTION AND DEVELOPMENT OF A WELL

An irrigation well should penetrate the water-bearing formations as deep as needed to provide the required flow rate while maintaining costs within economical limits. In general, for small uses like irrigation of lawns and gardens, wells will not need to be as deep as wells for larger agricultural applications. A 4-inch well usually will supply enough water for a lawn irrigation system.

Florida water management districts provide standards and criteria for construction, repair and abandonment of wells. All wells within a district must comply with these standards, regardless of whether a permit for the well is required.

Water levels in the well may fluctuate during different seasons. In addition, the water level is lower during pumping due to the drawdown effect. This level should be known to assure that the pump will be able to lift the water at all times. For more information on annual cycles and long-term trends in water levels the water management district should be contacted.

A new well should be tested to obtain the relationship between capacity (or discharge) and drawdown within the well. The testing procedure involves pumping the well at various capacities or discharge rates and measuring the drawdown in the well at each rate. Such information is necessary for the proper selection of a pump for a given well.

The contract for well drilling should include well development and testing, and it should be a written agreement between the prospective owner and the well driller. For more information on well drilling and development see IFAS Circular 803, "Water Wells for Irrigation Systems".

PUMP SELECTION

The pump selected for an irrigation system must be able to provide the necessary flow rate at the operating pressure required for each irrigation zone. This involves selecting a pump that can move the design flow rate of water from the drawdown level in the well or the low water level of a surface water supply to the level of the irrigation system, produce enough pressure to overcome friction losses in the system (from water flow through pipes, fittings, risers, valves, etc.), and provide the specified pressure for the sprinklers or emitters. Any significant changes in topography must also be accounted for as pressure losses or gains.

Each pump design is unique with respect to the flow rate (discharge) provided and the pressure (head) which may be developed. As the flow rate is restricted, the discharge pressure (head) increases. This relationship is generally expressed as a pump head-capacity curve. A typical set of pump curves is presented in Figure 3. In addition to the head-capacity curve, the relationships between the capacity and efficiency and capacity and required horsepower are presented in the same figure.

The three most common types of pumps which are used for irrigating lawns and gardens are: surface centrifugal pump, jet pump, and submersible centrifugal pump. These pumps are discussed briefly below. More information on pumps can be found in IFAS Circular 832, "Pumps for Florida Irrigation and Drainage Systems".

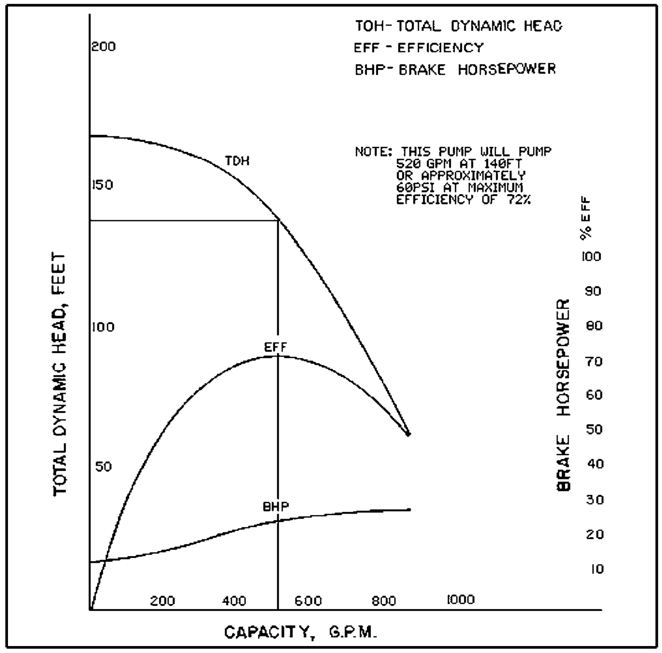

Fig. 3. A typical pump performance curve.

Surface Centrifugal Pumps

In centrifugal pumps energy is imparted to the fluid by the centrifugal action of an impeller. The velocity head imparted to the fluid by the impeller is converted into pressure head by means of a volute case (Figure 4).

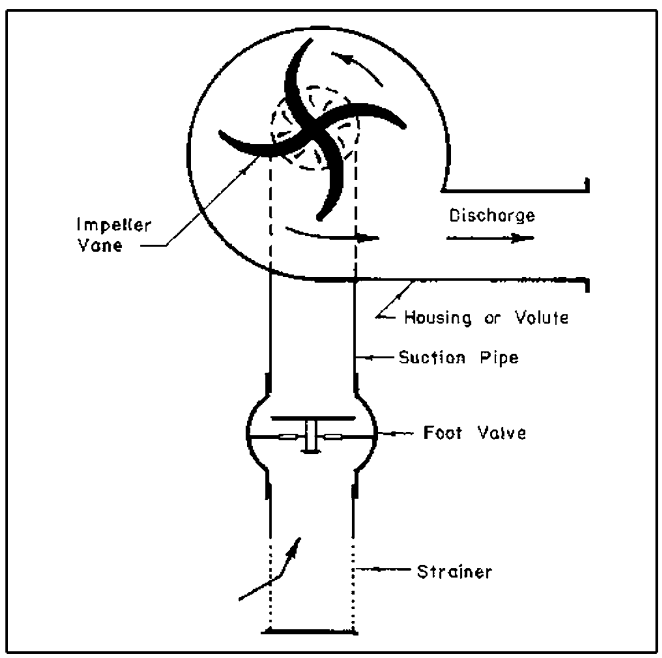

Fig. 4. Centrifugal pump.

Centrifugal pumps placed on the surface have limitations in the height to which they can lift water by suction. The practical lift for a centrifugal pump is approximately 15 to 20 feet. Therefore, if the water level with respect to the pump is deeper than this, due to drawdown or other causes, the water column may separate, resulting in a loss of pump prime. In these cases a different type of pump such as jet or submersible pump may be required.

Various sizes of centrifugal pumps provide discharges from just a few to several thousand gallons per minute (gpm) at pressures required for irrigation system operation. These pumps are usually designed to provide efficient operation over a wide range pump speed and discharge rates. Surface centrifugal pumps can also be offset from the well which in some cases may be convenient. However, most centrifugal pumps can lose their prime when turned off. A foot valve installed at the end of the suction pipe helps to maintain the suction pipe full of water during off cycles, such that pump prime is maintained.

Jet Pumps

A jet pump consists of a pump (usually centrifugal) and a jet or ejector assembly (Figure 5). The jet assembly can be located in the pump for shallow-well units or in the well for deep-well units. The pump forces a portion of the discharge water through the nozzle and venturi of the jet-assembly. The rest of the water pumped is supplied to the distribution system. The practical lift of this pump is approximately 22 feet for a shallow-well jet and up to 85 feet for a deep-well jet. The amount of water that must be provided to the jet increases as the level of the water surface in the well decreases. At a lift of 50 feet approximately 50% of the water pumped is provided to the jet. Jet pumps can produce a high capacity flow at low head. Their disadvantage is a low operating efficiency because of the need to recycle water to the jet.

Submersible Centrifugal Pumps

Submersible centrifugal pumps have one or more impellers mounted close together on a single vertical shaft, and the impellers and power unit (electric motor) are encased in a housing which is located below the water surface. Each impeller, its diffuser (guide vanes to the next impeller) and housing is called a stage (Figure 6).

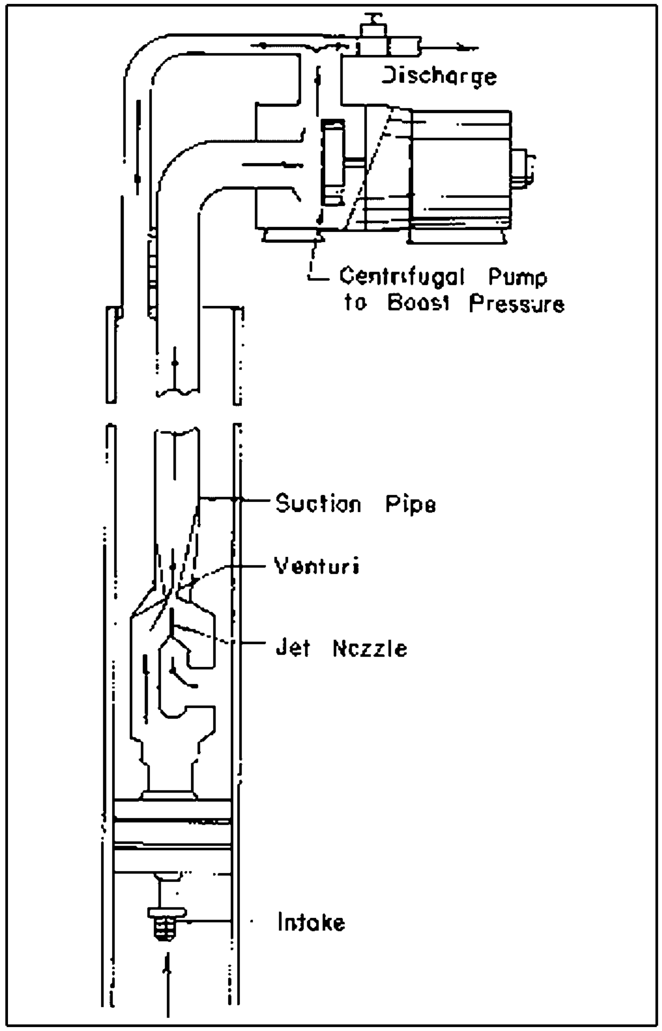

Fig. 5. Jet pump with jet asssembly in the well for deep well applications.

A 4-inch or larger well casing is required for submersible pumps. Any repair to the pump or motor requires removal from the well, making service difficult. Service requirements of these pumps and motors are generally minimal; however, in Florida, it may increase due to frequent lightning problems. Because submersible centrifugal pumps can lift water up to 1000 feet, they are adaptable for use in deep wells.

TESTING THE WATER SUPPLY

The water supply for an irrigation system should be tested. Testing involves determining the flow rates produced against different pressures. The assembly presented in Figure 7 is a tool which can be used to test a pump or municipal water supply line. If a flow meter is not available, a graduated bucket and a stop

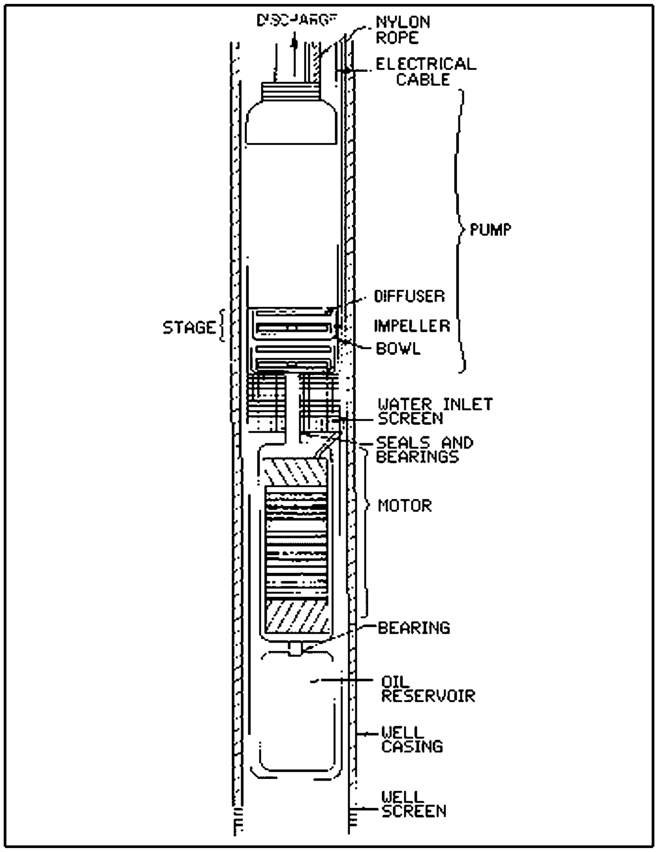

Fig. 6. Submersible multistage centrifugal pump.

watch can be used to determine the flow rate. A gate valve or ball valve may be used to vary the flow rate.

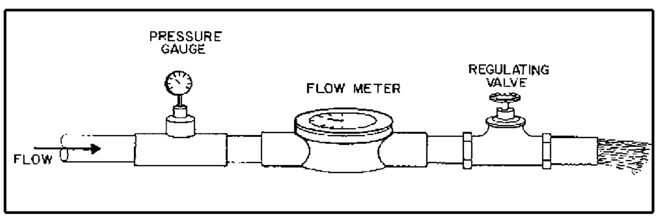

Fig. 7. An assembly to measure flow rate versus pressure from a water supply.

An initial pressure measurement should be made with the valve closed. Then, the flow rate should be gradually increased by opening the valve in small increments. The system should equilibrate for several minutes at each increment before recording the pressure and the flow rate. This process should be continued until the valve is fully open. It is important to note that the pressure read is not necessarily the pump pressure, but is the pressure of the system at the point of measurement. This should be as near the point where the irrigation system will be connected as possible.

A table similar to the example should be created.

By graphing these data, Figure 8 is produced. This is the calibration curve for the water supply. It allows the pressure to be determined for any given flow rate and vice versa. For example, if an irrigation system requires 9 gpm, only 22 psi will be available at this flow rate. Alternatively, if 35 psi is required at the entrance of the irrigation system for components to operate properly, than only 5 gpm is available at this point.

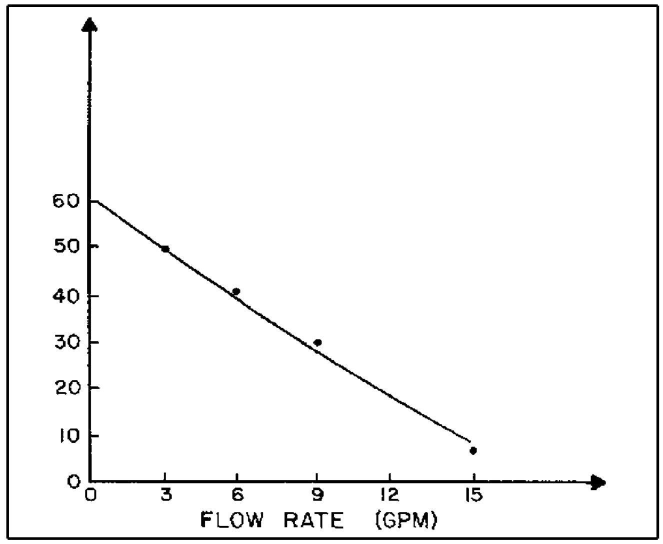

Fig. 8. Flow rate/pressure relationship for the irrigation system.

The pressure of municipal water supplies fluctuates during the day. During the times of low water demand, such as late night or very early morning hours, the water pressure is much higher. This time may be the best for operation of the irrigation system.

If the water is supplied by a pump, Figure 8 should be similar to the pump curve provided by the pump manufacturer. However, even if the manufacturers pump curve is available, it is advisable to run this test to examine the pump performance, which may differ with particular conditions of installation. A specific pump may not be as efficient as presented on the manufactures curve usually due to installation. For efficient pump performance well casing diameter should be at least one nominal pipe size larger than the pump size for a submersible pump. This allows for clearance during installation and free water flow into the pump. However, due to the additional cost, frequently, a 4-inch pump is placed in a 4-inch casing in small irrigation systems. Pump performance may change and it decreases with wear, especially if the pump has been used for a period of time.

WATER QUALITY FOR IRRIGATION

Water quality of the water source may affect the design of the irrigation system. In general, water quality problems can be classified as physical, biological and chemical. Physical problems relate to mineral particles of sand, silt, and clay present in the water source. Chemical problems are associated with high levels of soluble salts, calcium, magnesium, bicarbonate, iron or manganese which can precipitate from the water causing clogging or undesirable staining, or low pH (acidic water) which can corrode metal parts. In shallow wells and surface waters in Florida, biological problems are quite often encountered. The presence of various microorganisms, algae, and fungi can create maintenance problems in irrigation systems.

If the water for a home irrigation system is from a municipal line, then water quality should not be a major problem. This water has already been treated for human consumption under requirements which are more restrictive than those for irrigation water. All bacteria, part of the iron, manganese and other potential problem causing minerals have already been removed. Filtration may still be necessary for some systems, but the type of selected filters may be much simpler.

Filtration and sometimes water treatment may be necessary depending on the type of irrigation system used and the water source (well, pond, river or canal). Sprinklers can be damaged by physical contaminants such as sand and silt. Also, flows may be restricted in lines or sprinklers by chemical precipitation of calcium carbonate ($CaCO_3$) or by a buildup of biological slimes associated with sulfur or iron. Other chemicals or elements in the water may cause aesthetic problems. The presence of iron and/or manganese can create staining problems of walls and sidewalks when the water is allowed to come in contact with them.

Poor quality water can create more problems in micro-irrigation than in sprinkler irrigation. In micro-irrigation water is delivered to the plants through emitters which use small orifices or long flow paths with small diameters. These small openings are necessary to deliver the small flow rates characteristic of these systems. Water quality management is generally necessary in the management of micro-irrigation systems. Clogging of emitters may result from physical, chemical and biological contaminants.

In general, water to be used in a micro-irrigation system will require filtration and often additional treatment. Even with city water a 200 mesh filter is recommended. Careful evaluation of irrigation water and adequate water quality testing can help to determine which of the preventive methods will be most effective and reduce future maintenance problems.

Clogging problems will vary with and within the sources of irrigation water. Generally, the water sources can be grouped into surface water, shallow wells and deep wells. These are in addition to the city or other public water supplies.

An irrigation system using surface water will be prone to biological and physical clogging. However, chemical precipitation is normally not a major problem in systems using surface water supplies. Chemical precipi-tation is more common with the groundwater supplies.

Physical clogging relates to mineral particles of sand, silt and clay which can aggregate in lines and are large enough to clog the emitters. In the limerock Floridan aquifer small particles of lime scale are frequently encountered and may be pumped through the system as well. Physical clogging can be associated with all of the aforementioned water sources. Therefore, filtration is recommended and is generally necessary. It is recommended that strainers be used in the sprinkler irrigation systems and finer filtration (depending on the emitters used) in micro-irrigation.

Chemical precipitants in the irrigation system are often due to naturally occurring compounds. Waters containing high levels of soluble salts, calcium, magnesium, bicarbonates, iron or manganese can all be associated with chemical precipitation. Chemical precipitation is usually found in irrigation systems using groundwater. Chemical treatment such as acid injection may be required to prevent clogging of systems using water which has a high potential of chemical precipitation.

Biological clogging due to algae cells and filaments, their residues, and iron and sulfur complexes are the major problems associated with surface water and some groundwater sources, especially with micro- irrigation systems. Residues of decomposing algae can accumulate in lines, emitters and micro-sprinklers. This residue, consisting of ruptured cells which forms soft non-sticky deposits, can collect iron and support the growth of iron bacteria or other slime-forming bacteria. These growths may clog systems or restrict flows, necessitating periodic treatment such as chlorination.

Different filtration methods for micro-irrigation systems are discussed in IFAS Fact Sheets AE-61, "Screen Filters in Trickle Irrigation Systems" and AE-57, "Media Filters in Trickle Irrigation Systems".

SPRINKLERS

A sprinkler is an assembly which is attached to the pipe system and used to disperse water over a lawn, flower bed or garden area. There is a wide variety of types and styles of sprinklers. They range from quite simple to relatively complex devices. It is important to select the correct sprinkler for a given application. Precipitation rate, operating pressure, and diameter of coverage are very important in the design and selection process. Sprinklers can generally be classified as spray heads, or rotary sprinklers.

Spray Heads

A spray head has a fixed nozzle with an orifice which results in water distribution in the form of a fine spray. The extremely wide variety of nozzles can facilitate different applications. The nozzle can be easily removed and replaced. In general a 15-30 psi pressure is required for operating spray heads. Spray heads can be classified into bed spray head, lawn spray heads and shrub spray heads. Bed and shrub spray heads are usually stationary, where lawn sprays can be either stationary or pop-up types.

A bed spray head emits a small, flat or extremely low-angle spray. The distance of coverage ranges from 18 inches to 5 feet depending upon the spray head design and the system operating pressure. Bed spray heads are used in small restricted bed areas and narrow planter boxes (Figure 9a).

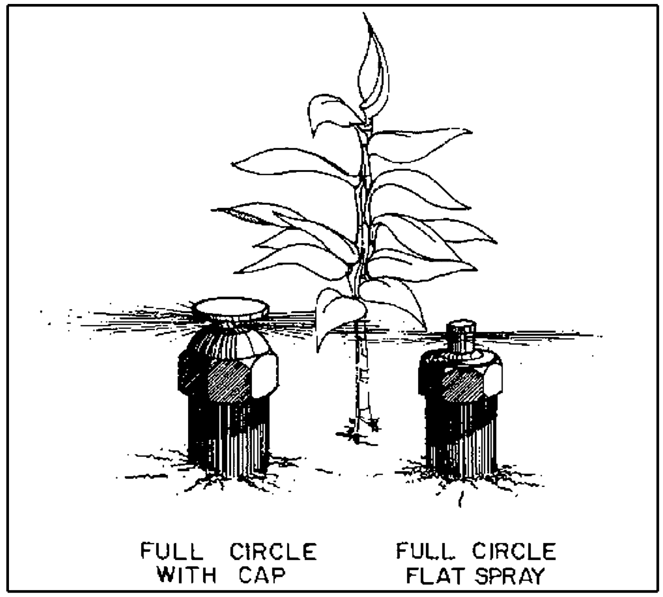

Fig. 9a. Bed spray heads.

Stationary or surface lawn spray heads are short mushroom-shaped sprinklers without moving parts (Figure 9b). Stationary lawn spray heads are usually used in areas where minimum initial installation cost is a major factor. They are used in small areas where rotary sprinklers are too large. They are also selected in areas where blowing sand could damage the mechanism of a sprinkler with moving parts.

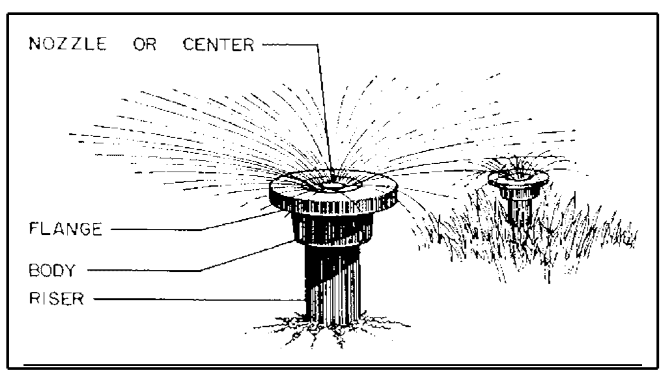

Fig. 9b. Stationary lawn spray.

Depending on the area to be covered, different spray patterns can be selected. Spray heads can be purchased in coverage patterns of 360°, 180°, 90° or less. They can also have different geometries of coverage, such as circles or rectangles. Because of these versatile patterns, spray heads are ideal for small, odd-shaped areas.

Pop-up lawn spray heads are those which raise the nozzle above the surrounding grass during operation then drop down to the level of the ground when not in use (Figure 9c). The pop-up feature minimizes the need for trimming the grass around the heads and at the same time improves water distribution since the head is high above the grass when in operation. Pop-up spray heads are usually spring-operated and require a certain pressure level to operate the pop-up mechanism. Operation of the pop-up mechanism may be a problem where the water contains large amounts of sulfur, iron or alkalines. These minerals are often present in Florida's well water and they can cause failure to pop-up moving parts by promoting chemical deposits or bacterial slime growths. A pop-up mechanism can also be damaged by sand pumped through the system.

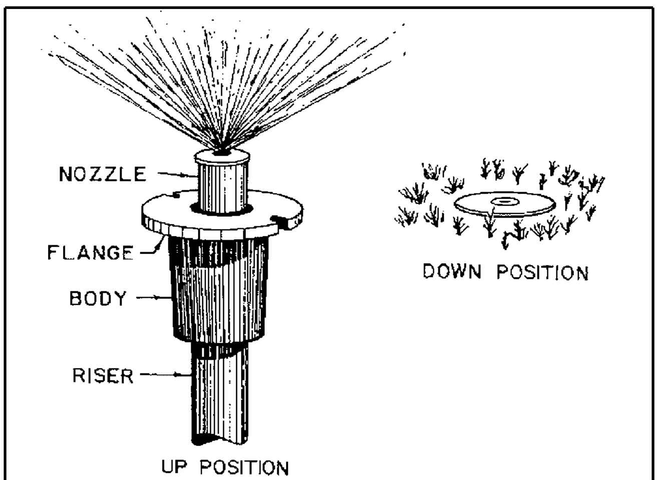

Fig. 9c. Pop-up spray head.

Average precipitation of spray nozzles is relatively high, approximately 1 in/hr. These nozzles are used for rapid watering of lawns. However, use on steep slopes and heavy (clayey) soils may result in runoff. Therefore all irrigated areas of the system should be examined for proper selection and location of nozzles to avoid runoff.

Other nozzles include shrub sprays which are usually specially made nozzles mounted directly on permanent risers above the foliage of the shrub. Generally, they are smaller in size than the nozzle produced for pop-up lawn sprinklers. These nozzles are used to apply water to all planted areas where the height of the riser will depend on the application and characteristics of the sprayer nozzle.

Rotary Sprinklers

Rotary sprinklers are designed to disperse water in an arching stream-type spray pattern. Due to the rotation of the sprinkler, a circular area is irrigated. Small rotary sprinklers usually use one nozzle, while large sprinklers frequently use two nozzles to accomplish uniform distribution (Figure 9d). The pattern of coverage for a rotary sprinkler can be a full circle or a part circle. Rotary sprinklers are generally used for applying water to larger areas and require operating pressures of 25 to 80 psi.

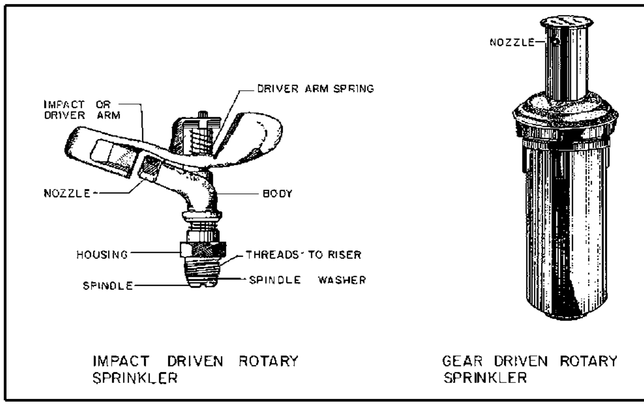

Fig. 9d. Rotary sprinkler.

Stationary and pop-up types are available in both impact and gear driven models. Gear driven models are usually more expensive but they provide a constant speed of rotation which increases uniformity of water application. In addition, the rotating mechanism is usually well protected and often does not come in contact with water. This protection extends the life of the sprinkler.

Nozzles

The nozzle is that part of a sprinkler which actually distributes the water. It is the discharge opening or orifice used on a sprinkler to control the volume of discharge, distribution pattern, diameter and droplet size. The volume of discharge from the sprinkler is primarily a function of nozzle size and pressure. Wetted diameter is a function of nozzle size and pressure, but it is also greatly affected by the type of sprinkler.

Generally, specifications of different nozzles are provided by the manufacturer. However, if this information is not available, the discharge volume of a particular sprinkler can be estimated from the size of the nozzle and the operating pressure (Table 1).

MICRO-IRRIGATION

In micro-irrigation systems water is distributed through emitters which are placed along the water delivery pipe. Water is applied in the form of drops, tiny streams, or miniature sprays. This type of irrigation system operates under relatively low pressures (6-30 psi) and can deliver water, nutrients and other chemicals directly into the root zone of the plant. Micro-irrigation can be managed to apply small quantities of water and/or chemicals to precisely match evapotranspiration and nutrient demands.

Micro-irrigation emitters use small orifices or long flow paths with small diameters to deliver low flow rates of water typical of this type of irrigation system. Several different types of emitters are presented in Figure 9e .

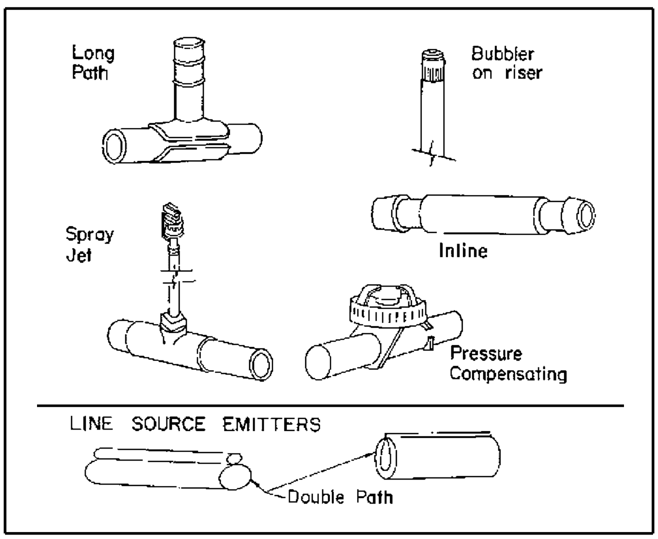

Fig. 9e. Types of emitters.

The discharge rate of an emitter must be considered in the selection process to insure that the device can supply the required amount of water within a reasonable time. For example, a homeowner may have some trees with a daily water requirement of 40 gallons per day and only 2.5 hours available for irrigation time. Then, the minimum discharge rate to each tree must be 16 (40/2.5) gallons per hour (gph). Emitters associated with micro-irrigation systems typically have discharge rates which vary from 0.5 to 2.0 gph for drip-type emitters up to 5 to 35 gph for the spray and mini-sprinkler type emitters. Therefore, in the above example, eight 2.0 gph drip emitters, two 8.0 gph, or one 16.0 gph spray or mini-sprinkler would have to be used for each tree.

Micro-irrigation systems are very suitable for irrigation of trees, shrubs, flower beds and all kinds of small, restricted areas. They are not practical for irrigation of large lawn areas, because water does not distribute very well in the lateral direction in Florida's typical sandy soils. This poor lateral movement requires a very close spacing for drip-type emitters to provide a uniform distribution of water. More information on micro-irrigation systems can be found in IFAS publication AE-24, "Principles of Micro Irrigation".

BUBBLERS

A bubbler head is designed to flood or soak a restricted area where even a small spray might be objectionable. Because bubblers operate under low pressure and cover very small areas adjacent to the plant, they are often included as a micro-irrigation device. All types of bubblers operate under relatively low pressures (1-10 psi). However, their flow rates are relatively high (approximately 60 gph) when compared with other micro-irrigation emitters. Due to these characteristics the orifices of bubblers are relatively large and less prone to clogging. Bubblers are used in small pockets in "living patios" or for special plants which should not have water applied to the foliage (Figure 9f). The "spider" type of bubbler distributes water over a slightly larger area by several small flowing streams (Figure 9g) and is useful under extremely dense foliage. Distribution of water from the bubbler is determined by the distribution characteristics of the soil. Lateral movement of water in sandy (light) soils is small compared to more clayey (heavy) type soils. Since the water is applied at the high flow rate, it ponds around the plant. Due to this ponding, the distribution of water in the root zone is improved for a sandy soil, as compared with the drip emitters. For clayey soils, water intake rates are low; therefore, to reduce runoff losses, it may be necessary to construct small containment dams around the bubbler.

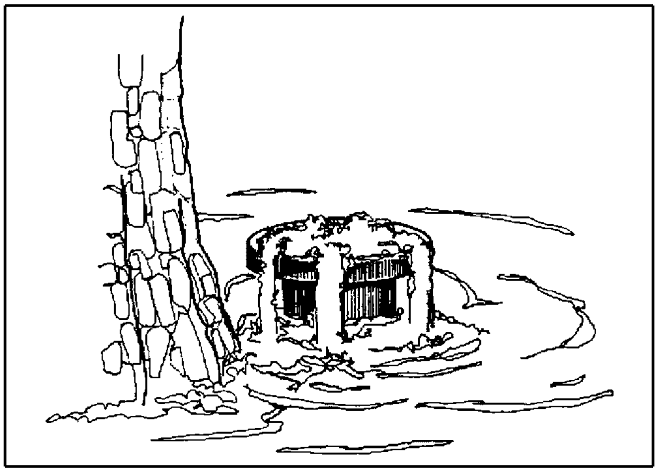

Fig. 9f. Bubbler (flood type).

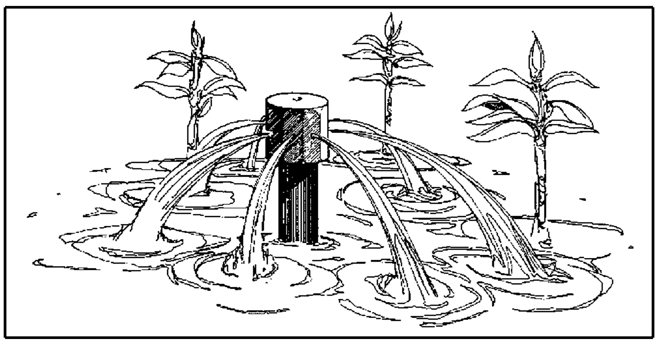

Fig. 9g. Bubbler (spider type).

VALVES AND CONTROLLERS

Valves

Valves are devices which are used for controlling the flow of water in an irrigation system. There is a wide variety of different types of valves which are used for many different purposes. Valves can be simple and manually operated or more complex with automatic operation.

A common type of manual valve is a gate valve which is usually used as the main shut-off valve (Figure 10a) because of its low head loss when fully open and slow closing characteristics. Opening of the system too quickly may result in water surge and water hammer causing damage to pipes and fittings.

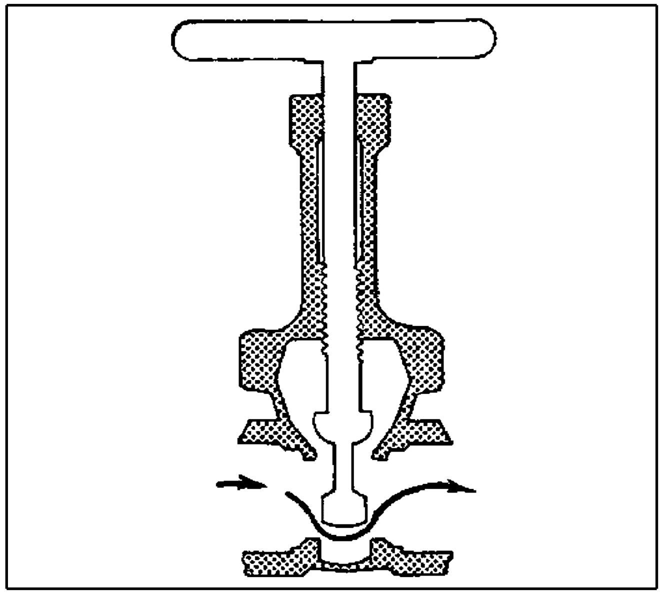

Fig. 10a. Gate valve.

Manual control valves such as globe valves (Figure 10b) are sometimes used for flow regulation into a zone. Their design results in significant pressure loss. Ball valves (Figure 10c) are sometimes used as on/off valves for different zones of sprinklers. However, they should be used with caution, since their quick operation may result in water hammer.

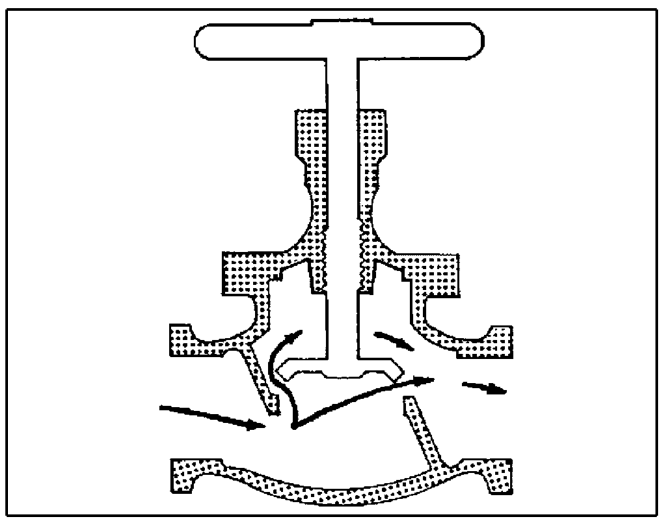

Fig. 10b. Glove valve.

Irrigation systems with automatic control use automatic valves for opening and closing of different irrigation zones. Automatic valves can be classified into two major groups: electrical valves and hydraulic valves. Small irrigation systems for lawns and gardens almost exclusively use electric types of valves. It is very important to match the output of the controller with the requirements of the type of valves

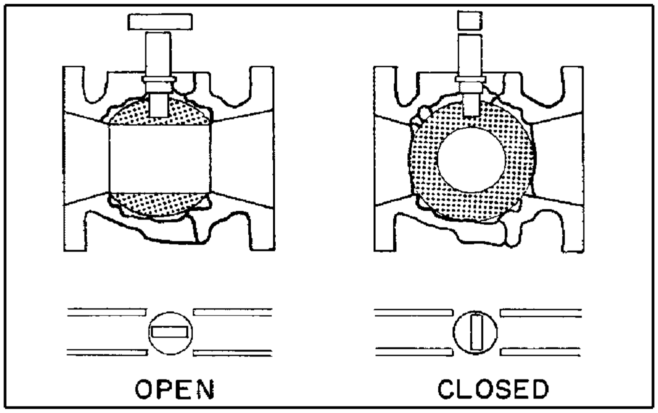

Fig. 10c. Ball valve.

used in the irrigation system. For safety reasons 24 volts AC should be used for electrical solenoid irrigation valves. Power is transmitted to the valves through underground wires (for electric valves) or control tubing (for hydraulic valves).

The other major distinction among automatic valves is the position which a valve assumes if the power from the control mechanism is interrupted. Some valves close when power is not supplied and they are called "normally closed." Other types of valves remain open under no power conditions and are called "normally open".

The other type of valve frequently used in all irrigation systems is a check valve. Check valves are used to allow water to flow in only one direction (Figure 10d). These simple valves are useful for restricting backflow of water from the irrigation system to the water source.

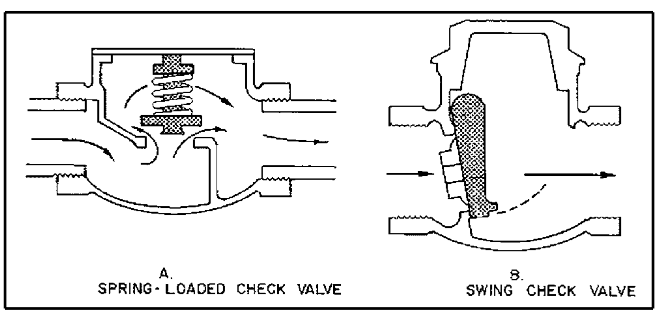

Fig. 10d. Two types of check valves.

Various valves are discussed in detail in IFAS Circular 824, "Valves for Irrigation Systems". A reader interested in valve construction, applications, advantages and disadvantages should consult the above publication.

Controllers

Controllers can be simple on/off timer switches which operate one or more remote automatic valves, or they may be sophisticated computers with many stations and variable programming. Sophisticated controllers can control many valves, allowing for operation at any time of day or night, with individual scheduling for each valve. Some controllers allow for programming of various irrigation schedules for up to two weeks.

A controller may include a soil moisture measuring device. This type of arrangement allows for automatic irrigation scheduling in response to predetermined moisture status in the plant root zone.

Price ranges of controllers will vary widely with the complexity of the device. However, for most home systems controllers will range from $50 - $200.

BACKFLOW PREVENTION

Irrigation systems which use municipal water supplies and irrigation systems in which chemicals are injected require backflow prevention systems. The specifications for backflow prevention systems are given by state law, a city ordinance, or other codes. It is important to make sure that the system is in agreement with the backflow prevention requirements of the local municipality. Generally, a reduced pressure principle device is required if chemicals are injected into the irrigation system and the water supply is municipal water. For irrigation wells, a combination of check valve, low pressure drain and a vacuum breaker may be sufficient. A detailed description of these requirements can be found in IFAS Extension Bulletin 217, " Backflow Prevention Requirements For Florida Irrigation Systems " and IFAS Extension Bulletin 248 "Backflow Prevention Requirements For Irrigation Systems Using Municipal Water Supplies".

SOME RULES OF GOOD DESIGN

Good sprinkler systems should water the area completely, uniformly, and in accordance with the wishes of the owner. A comprehensive plan of the area to exact scale is necessary. The first step is to decide on the type of sprinkler heads to be used. The system should be designed for complete coverage. Sprinklers should be selected on the basis of the type of area to be covered (ground cover, shrubs, lawn), the water flow rate and pressure available, soil infiltration characteristics and the scope of the area to be covered. The sprinklers must be fitted to the area and carefully placed within the maximum recommended spacing (this is usually 50-60% of the diameter of coverage). If it is possible, triangular spacing of sprinklers should be selected over rectangular since it provides better coverage. Full circle and part circle coverage patterns also should be selected where appropriate. In many residential areas there is not enough space to establish a typical rectangular or triangular pattern for sprinklers. In such cases it is best to select the sprinklers for the bordered areas such as buildings, sidewalks, walls and patios first and then fill the middle areas with sprinklers so that uniformity of application will be sufficient.

For micro-irrigation systems it is important to provide required lower pressure by using appropriate pressure regulators. It is important to make sure that the spacing of the emitters will provide sufficient distribution of water in the lateral direction resulting in uniform water application. For more information a reader should consult IFAS publication AE-24, "Principles of Micro-Irrigation".

REFINEMENT OF THE SYSTEM

An irrigation system should be designed with separate zones for different vegetation with different water requirements or different root depths. For example, flower beds should be watered separately from lawn areas. This requires additional pipe, fittings, sprinkler heads and valves. This type of refinement for watering will increase the initial cost of the system, but it will often result in a savings of water and the possibility of supplying different amounts of water for different plants.

It is important to keep in mind that for uniformity reasons, sprinklers with different application rates and different watering patterns should be placed in separate zones. If full-circle sprinklers are in the same zone with half-circle sprinklers, the nozzles for the half-circle sprinklers should be selected so that the flow rate is half of the flow rate from the full-circle sprinklers. In addition, spray heads, rotary sprinklers and micro-systems should be installed in separate zones since they usually have different pressure requirements, different application rates, and different required times of operation.

Root zone characteristics vary from turf to shrubs to trees. Therefore, it may be necessary to place zones according to plants with similar root zones to avoid over-or under-irrigation of dissimilar plants within the same zone.

IMPORTANCE OF SPRINKLER OVERLAPPING

Most sprinklers have a decreasing application rate from the sprinkler head out to the maximum diameter of throw (Figure 11a). This occurs because the area to be covered increases as distance from the sprinkler increases. Because of this pattern it is necessary that sprinklers overlap in order to achieve a uniform application. Usually there is a plateau in the sprinkler distribution pattern before the descent begins. Generally, the larger this plateau, the further apart sprinklers can be placed. However, a safe rule of thumb is to make sure that the last droplets of one sprinkler reach the adjacent sprinkler. This is a 50% overlap of wetting patterns.

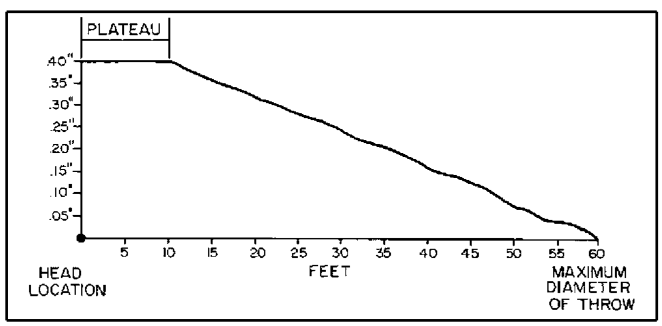

Fig.11a. Typical distribution curve for a sprinkler head.

Quite often a typical distribution curve for a particular sprinkler is supplied by the sprinkler manufacturer. To measure the distribution pattern, collect water along the radius of the pattern in several locations (Figure 11b) and the application depths can be easily determined. By using a stopwatch and measuring the time required to apply a certain depth, application rates can be determined as well. This will help in management of the system. Proper overlapping of the sprinklers will provide increased uniformity in water distribution (Figure 11c) over irrigated areas. Poor uniformity will result in some areas being over-irrigated and some areas being under-irrigated which could result in plant stress.

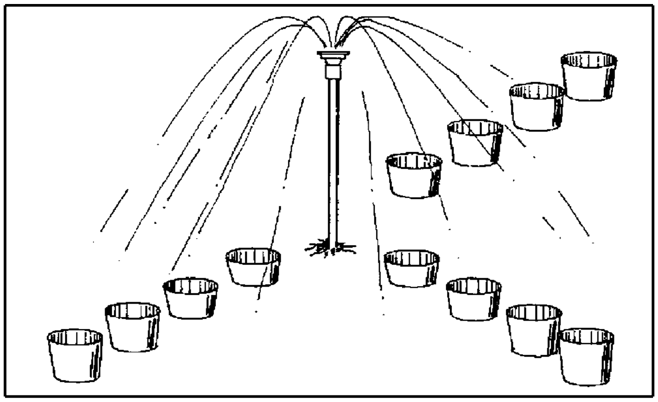

Fig. 11b. Determination of sprinkler distribution pattern using catch cans.

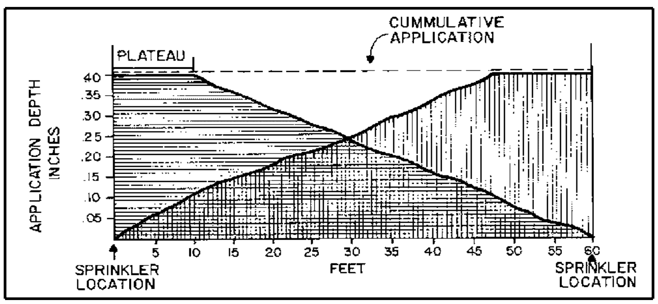

Fig. 11c. Effect of sprinkler overlapping.

SYSTEM MANAGEMENT

Irrigation management involves maintenance of the system as well as scheduling irrigations. Maintenance involves cleaning, repairing, and replacing components as necessary to maintain an efficient and properly operating system. Sprinkler systems generally require less maintenance than micro-irrigation systems. Periodic visual inspection of sprinkler heads and their operation is usually sufficient. Once a year the nozzles may be checked with an appropriately sized drill bit for change in size due the wear or clogging. Micro-irrigation requires more maintenance. More details on micro-irrigation maintenance are given in IFAS Bulletin 245 "Micro-Irrigation on Mulched Bed Systems: Components, System Capacities and Management". In addition to routine maintenance, the system should be checked for clogging and uniformity of water application. The procedure is described in IFAS Bulletin 195 "Field Evaluation of Trickle Irrigation Systems: Uniformity of Water Application".

Irrigation scheduling involves a decision-making process of when to irrigate and how much to apply or how long the system should be operated. The scheduler must decide on the objective of the irrigation and the type of information required to accomplish scheduling. Objectives may involve drought stress avoidance, frost protection, or crop cooling. This publication discusses only drought stress

avoidance. The decision process can be influenced by several factors and requires careful examination of the available information.

SCHEDULING TO AVOID DROUGHT STRESS

Drought stress can be controlled by irrigation. Scheduling the time and amount of application will depend on the availability of water as well as the soil water status, allowable depletion, and water use rate. Table 2 provides monthly potential evapotranspiration (ETp) levels for north and south Florida during each month. Figure 12 shows the division of Florida into two regions (North and South). For turf, the actual evapotranspiration rate is near the value of ETp, and Table 2 can be used to approximate turf water requirements. For other plants, the actual ET rate will vary, but it is directly related to ETp. In this case, ET_p must be multiplied by a crop coefficient for a given plant and growth stage. Thus, Table 2 cannot be used directly.

Soil Water Status

Moisture available to the plant is influenced by the available water holding capacity (AWHC) of the soil. The AWHC is defined as the amount of water that can be held by the soil between the permanent wilting point and field capacity of the soil. Permanent wilting point is the soil water content where plant is no longer able to extract water. Field capacity refers to the water content of the soil after it has been fully wetted, and excess water has drained.

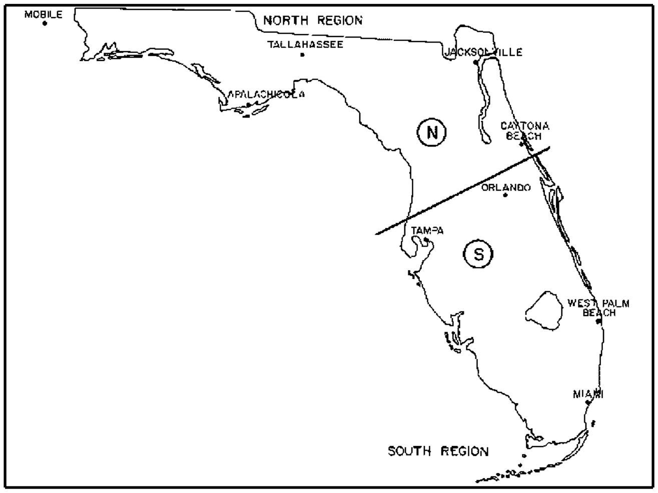

Fig. 12. North and south evapotranspiration regions of Florida.

Additional soil information necessary to the irrigation scheduler includes the available water in the soil at the time of irrigation. The available water is that amount of water contained in the soil at the time of interest within the AWHC range. This property may be monitored with soil water sensors. One type of sensor, called a tensiometer is very applicable to sandy soils. Additional information can be obtained from IFAS Circular 487, "Tensiometers for Soil Moisture Measurement and Irrigation Scheduling" and 532, "Measurement of Soil Water For Irrigation Management".

The soil water properties are dependent upon the soil type and texture. Sandy soils have low water-holding capacities (0.5 to 1.0 inches of water per foot depth of soil) as compared to the water-holding capacities of loam or clay soils (2.0 to 3.0 inches of water per foot depth of soil). Therefore, more frequent, smaller amounts of irrigation are required on a sandy soil to avoid movement of water below the plant root zone. For example, if a soil has a AWHC of 1-inch of water per foot depth of soil, and a plant root zone is limited to a 1-foot root depth, the maximum depth of water that can be held in this root zone is 1-inch. If irrigation exceeds this amount, the additional water will percolate downward out of the root zone and will be unavailable to the plant.

Allowable Depletion

The allowable depletion is the level of water depletion which will be allowed before irrigation will be applied. The level of allowable depletion will vary with the plant characteristics as well as the irrigation system characteristics and capacities.

Plants sensitive to water stress may be irrigated at 20 to 30 percent depletion levels (80 to 70 percent of available water remaining in the soil). However, most plants will be irrigated in the 40 to 60 percent depletion range.

Irrigation system design may be such that the time required to complete the cycle of irrigation for all zones will not allow the irrigation of the same zone before 50% depletion occurs. If drought sensitive plants are being grown and the irrigation is designed at 30% depletion this system will not be sufficient. An irrigation system with a larger capacity is required for these plants.

Water Use Rate

The plant water use rate may be obtained directly or estimated. However, it is very difficult to obtain direct information, and therefore, most water use data are estimated. Estimation methods can involve the use of field sensors, measured pan evaporation data, published data, or broadcast information.

SCHEDULING BY THE ACCOUNTING METHOD

After compilation of soil, plant, and climatic data, the irrigation scheduler must design a program which meets the needs of the plants. One type of scheduling program utilizes an accounting procedure (see IFAS Circular 431, "Irrigate by the Accounting Method") to record inputs and outputs of water to and from the irrigated area.

Example: A homeowner located in Orlando has a lawn irrigated with a sprinkler system. The system delivers water at a rate of 0.5 inches per hour. The lawn has an 12-inch root zone and is on a sandy soil with an available water holding capacity of 0.9 inches of water per foot depth of soil. It is April and the turf requires 0.15 inches of water per day to meet the environmental demand for water. What type of scheduling program will meet the needs of this situation?

1. Establish a level of allowable depletion, say 50%.

2. Determine the available water holding capacity (AWHC) of the root zone (Equation 3):

3. Number of days between irrigations (Equation 4):

   Irrigation depths of 0.45 inches will then be applied every 3 days if rainfall does not occur. However, no irrigation system is 100% efficient due to wind, evaporation and runoff. Assuming an efficiency of 75%, the irrigation depth applied must be 0.60 (0.45/0.75) inches in order to deliver .45 inches of water to the root zone. Water amounts greater than this will move out of the root zone and will be unavailable to the plant. If the profile is allowed to fully deplete, 1.2 inches of water should be applied every 6 days. However this would result in plant stress and is not recommended.

4. Operation time (Equation 5):

$$12\ in.\ root\ zone \times \frac{0.9\ in.\ H_2O}{ft.\ of\ soil} \times \frac{1\ ft.}{12\ in.} = 0.9\ in.\ of\ available\ water$$

Equation 3.

$$\frac{0.9\ inches\ available \times 0.50\ depletion\ level}{0.15\ inches\ of\ demand\ per\ day} = 3\ days\ between\ irrigations$$

Equation 4.

$$\frac{0.60\ inches\ to\ apply}{0.5\ inches\ per\ hour} = 1.2\ hours\ (72\ minutes)$$

Equation 5.

As a final note, if the homeowner could only irrigate one day a week, then 7 * (0.15 inches/.75) = 1.4 inches of water must be applied at once to provide water for the entire week. However, part of the water will be wasted. Applying 1.4 inches of water delivers 1.05 inches (weekly requirement) to the soil due to an application efficiency of 60%. Therefore, since this soil can hold only 0.9 inches of available water in the root zone, 0.15 inches of water will be wasted.

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Table 1.

Pressure (psi*)	Flow Rate (gpm**)
60	0
50	3
30	6
20	10
5	15
* psi: pounds per square inch	
** gpm: gallons per minute	
Note: Your numbers in both columns will differ from the numbers in this example	

Table 2.

Table 2. Potential evapotranspiration (ETp) levels for two regions of Florida, north and south (Figure 12).

Month	North Region ETp (in/day)	South Region ETp (in/day)
1	0.07	0.09
2	0.10	0.12
3	0.13	0.15
4	0.17	0.19
5	0.19	0.20
6	0.19	0.19
7	0.18	0.19
8	0.17	0.17
9	0.15	0.16
10	0.12	0.14