UNIVERSITY OF FLORIDA
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Circular 1035

Florida Irrigation Systems[1]

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Introduction

Irrigation is extensively used for crop production in Florida. Currently, more than two million acres of cropland are irrigated. Florida's large irrigated acreage is due to low water-holding capacity soils and nonuniform rainfall distributions, despite large annual rainfall amounts. The high cash values of many crops grown, and the sensitivity of yield and quality to drought stress provide the economic incentives for irrigation.

Many different types of irrigation systems are used in Florida. This occurs because of the great variety of crops, the relative availability of water, diverse hydrological conditions, the costs of different systems, and the fact that all irrigation systems are not adaptable to all types of crops and crop production systems. Irrigation system selection is also affected by soil type. The deep sandy ridge soils require water to be transported in pipes and pressurized irrigation systems to be used, while the high water table flatwoods and muck soils permit the use of gravity-flow irrigation systems and open ditches. Microirrigation systems are becoming increasingly popular, especially in areas where periodic water shortages have occurred. Sprinkler systems may be required for irrigation for freeze protection, transplant establishment, crop cooling, and some field preparation procedures.

Irrigation systems can be grouped into four general classes, all of which are in use in Florida. The four classes are: (1) sprinkler, (2) surface, (3) subirrigation (seepage), and (4) microirrigation. Most Florida acreage (about 900,000 acres) is irrigated with seepage systems. Sprinkler systems rank second, irrigating almost 600,000 acres. Microirrigation systems (about 450,000 acres) are the newest and most rapidly increasing type of system. Only about 100,000 acres are surface (flood) irrigated.

Sprinkler irrigation systems

Sprinkler irrigation systems are systems in which water is applied by spraying it through the air from nozzles mounted on pressurized pipelines. Thus, water applications approximate rainfall, and systems are designed to apply water uniformly over the crop production area.

Sprinklers consist of nozzles mounted in a sprinkler body through which water is discharged under pressure. Nozzles may either rotate or be fixed.

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Rotating nozzles are typically impact-driven, gear-driven, or driven by the reaction as the jet of water is discharged. All of these methods use the energy of the flowing water to make the system operate. Individual sprinklers apply water to a circular or part-circle pattern created by the nozzle rotation. A typical impact sprinkler is shown in Fig. 1.

Figure 1. Typical impact-type rotation sprinkler.

Fixed (spray) nozzle systems use a rigidly-mounted nozzle which discharges against a deflector plate to distribute water (Fig. 2). Circular, part-circle, square, or

Figure 2. Typical fixed nozzle (spray) irrigation sprinkler.

rectangular water application patterns are possible, depending on the nozzle and deflector design.

Nozzle sizes for sprinkler irrigation vary widely. Sizes range from very small (1/8-inch or smaller) diameters which discharge only 1 to 2 gallons per minute (gpm) to very large (over 1-inch) diameters which discharge up to 1000 gpm.

Operating pressures also vary widely, ranging from only 10 pounds per square inch (psi) to over 100 psi. Larger nozzles usually require larger operating pressures to provide sufficient energy for proper water distribution.

Rotating nozzle sprinklers have much larger diameters of coverage than fixed nozzle sprinklers. As a result, they are most commonly used in large field systems where it is desirable to uniformly distribute water over large areas with as few sprinklers as possible. Spray nozzles are used in applications where the diameters of coverage are not as critical, such as small plot areas and in self propelled irrigation systems (center pivots and linear move systems) where the irrigation system travels over the area to be irrigated.

Many types of sprinkler irrigation systems are in use, ranging from small, portable manually-operated systems to large permanent, automatically-operated systems. Sprinkler systems are classified in the following sections of this circular, and typical applications of each class are discussed.

Multiple sprinkler systems

Multiple sprinkler systems use many small sprinklers with overlapping patterns. The amount of overlap is critical to achieve high uniformity of water application. Sprinklers are typically overlapped 50% to 60% of their diameters of coverage under low wind (less than 5 mph) conditions. Greater overlaps (and thus closer spacings) are required for higher wind speed conditions.

In multiple sprinkler systems, sprinklers are mounted on a lateral pipe or network of lateral pipes which carry water to the sprinklers. Water is supplied to the laterals from manifold (header) or main pipelines, depending on the system design. Multiple sprinkler systems are classified as portable, semi-permanent, or permanent based on whether the sprinklers and pipelines are moved from location-to-location between irrigation sets or whether the components are permanently buried in the field.

Portable Sprinkler Systems

Portable sprinkler systems are systems in which the sprinklers are mounted on movable lateral pipe sections which are transported from one location to another between irrigations (Fig. 3). The lateral pipes and

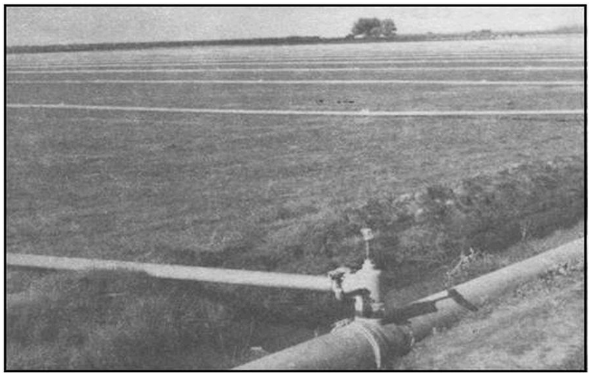

Figure 3. Portable sprinkler irrigation system with impact sprinklers installed on aluminum lateral pipelines.

sprinklers are set up on the soil surface and remain in place while irrigation occurs, then they are moved to a new location (zone, or set) and the process is repeated. These systems are typically designed with sufficient capacity to irrigate all zones in time to be returned to the first zone before plant water stress occurs. There are three types of portable sprinkler systems based on the method used to move the lateral pipes and sprinklers between irrigation: hand-moved, tractor-moved, and self-moved.

Hand-moved systems

Portable, hand-moved sprinkler systems are manually-moved from zone to zone. They consist of sprinklers mounted on portable aluminum lateral pipes, usually using short risers. Aluminum pipe is used because it is strong, light-weight, resistant to degradation by sunlight, and easily transported and connected with quick-connect couplings. Short risers are typically used because the laterals are not firmly anchored, and tall risers tend to lean or fall.

Laterals may be connected to portable aluminum manifold and mainline pipes, which may also be moved between sets. Buried PVC mainlines and manifolds are sometimes installed, and lateral connections are made through permanent hydrant valves which bring the water to the surface. These systems are sometimes called semi-permanent because the mainlines are permanently installed and only the laterals are portable.

Portable hand-moved sprinkler systems are widely used in Florida because they (1) have a low initial cost, (2) are flexible, easily adapted to various field shapes and sizes, and (3) can be moved with many Florida vegetable crops which are rotated from field-to-field to avoid disease problems or on rented land. A limitation to the use of portable hand-moved systems is the large labor requirements to move the pipe between zones. Because the pipes must be manually moved, these systems are not adaptable to tall crops such as corn, or other crops which would prohibit easily moving the system.

Tractor-moved systems

Portable tractor-moved sprinkler systems consist of sprinklers mounted on portable aluminum lateral pipes which are rigidly connected and mounted on wheels or skids. The laterals are towed between zones by pulling from the ends of the laterals with a tractor. These systems are more expensive than portable hand-moved systems, but have lower labor requirements. They are only used on short crops which are not disturbed by the skids or tractor traffic. These systems are most adaptable to larger land areas (longer lateral lengths) than hand-moved systems, or heavier soils than typical Florida sands so that less frequent moves are required. Therefore, portable tractor-moved sprinkler systems are not often used in Florida.

Self-moved systems

Portable self-moved sprinkler systems consist of sprinklers mounted on aluminum lateral pipes which are mounted above the soil surface on wheels (Fig. 4). They

also contain the mechanical components required to move the system, thus making these systems more expensive than hand or tractor-moved systems. There are 2 types of self-moved sprinkler systems, classified by the method of movement: (a) Side-wheel roll, and (b) Side-move sprinkler systems.

Figure 4. Side-wheel-roll sprinkler system irrigating cabbage transplants for establishment.

Side-wheel-roll sprinkler systems

These systems use laterals which serve as the axle for wheels located along the length of the lateral. This system is moved between sets by rotating the lateral pipe (axle). The lateral pipe is typically rotated by a chain drive system powered by a small gasoline-powered engine located near the center of the lateral. Sprinklers are kept in an upright position for effective operation by means of a weighted swivel coupling on each sprinkler.

Because the lateral pipe is mounted only 3-4 ft above the soil surface, this system is only adaptable to short crops. Few of these systems are used in Florida. The most common applications are for vegetables, short forage crops, and turf production.

Side-move sprinkler systems

These systems use a lateral pipe mounted on a short A-frame 4-5 ft above the soil surface. Each A-frame is supported by 2 wheels, which are typically powered by a chain-drive mechanism from a drive shaft that runs parallel to the to the lateral pipe along the length of the lateral. These systems are more expensive, but have no appreciable advantages over side-wheel-roll systems for Florida crop production systems. Thus, they are not commonly used in Florida.

Semi-permanent sprinkler systems

A semi-permanent sprinkler irrigation system (Fig. 5) is

a system which is set up and left in place throughout the crop growing season, after which it is manually removed and stored for the next growing season. Components of the system, such as the main

Figure 5. Semi-permanent sprinkler system with portable laterals fed from permanent underground pipelines.

or manifold pipelines are often permanently installed. A type of semi-permanent multiple sprinkler irrigation system used in Florida is the solid set system. Solid set systems are those in which the laterals and sprinklers cover the entire field to be irrigated, thus they do not need to be moved between irrigations.

The entire production area under a semi-permanent solid set system is not necessarily irrigated at once. In many cases, valves are used to control flow to individual laterals or zones. In other cases, such as when required for freeze protection, the entire field may be irrigated at once. In both cases, labor costs for system operation are low, because irrigations are controlled simply by opening and closing valves rather than by moving pipe.

Solid set, semi-permanent systems typically consist of sprinklers mounted on portable aluminum pipe. Because the entire production area is simultaneously covered with pipe and sprinklers, the initial system cost is much greater than the cost of a portable sprinkler system. Field traffic problems may also exist because the pipe remains in place on the soil surface during the irrigation season. In Florida, these irrigation systems are primarily used for vegetable and sod production.

Permanent sprinkler irrigation systems

There are two types of permanent irrigation systems: solid set and self-propelled irrigation systems. Both types are commonly used in Florida.

Solid set irrigation systems

Permanent solid set irrigation systems are systems which consist of permanently placed pipes and sprinklers. In Florida, lateral, manifold, and mainline pipes are typically buried, and only the sprinklers and risers extend above

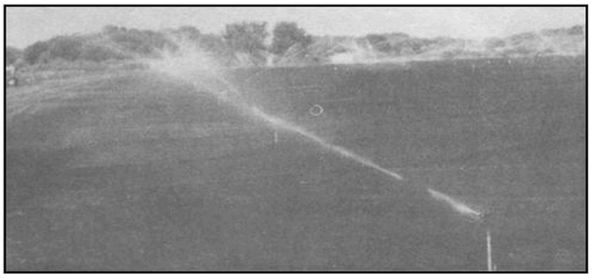

Figure 6. Pipelines are buried in permanent solid set sprinkler systems used for strawberry production.

the ground surface (Fig. 6). Because pipes and sprinklers are required to cover the entire production surface, permanent solid set systems are usually considerably more expensive than other types of irrigation systems. Therefore, permanent systems are typically used only on high cash value crops including citrus, strawberries, ornamental ferns, and other nursery crops.

As with semi-permanent solid set systems, the entire production area under a permanent solid set system is not necessarily irrigated at once. Valves are often used to control flow to individual zones. However, when required for freeze protection, plant establishment, or crop cooling, the entire field may be irrigated at once. In both cases, labor costs for system operation are low because water delivery to a zone is controlled by simple opening and closing valves rather than by moving pipe.

Self-propelled sprinkler irrigation systems

Self-propelled irrigation systems are those which operate under their own power. During irrigation, they move slowly and continuously across the field as it is being irrigated. There are two types of self-propelled multiple sprinkler irrigation systems which are being manufactured: center pivot and lateral-move systems.

Center pivot irrigation systems

These systems consist of sprinklers which are mounted on a lateral pipe which is supported approximately

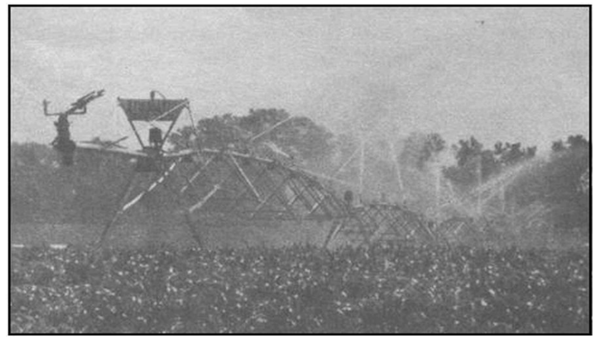

Figure 7. Center pivot irrigation laterals are supported by large A-frames with drive wheels for self-propelled operation.

10-12 ft above the ground by large A-frames (Fig. 7). The lateral is fixed to a pivot point at one end. Water is supplied at the pivot point. In most systems, the lateral rotates around the pivot point and irrigates a circular or part-circle area in the center of a square block of land (Fig. 8).

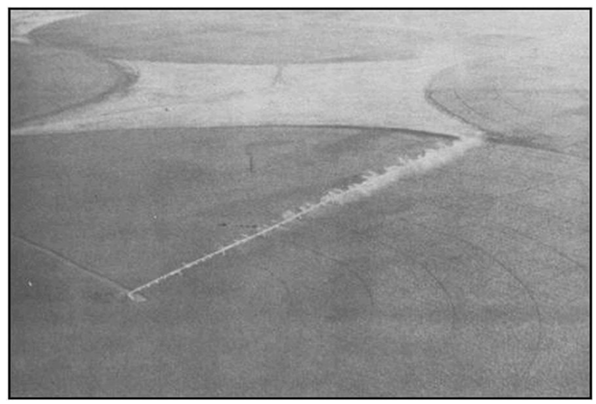

Figure 8. Center pivots irrigate circular (or part-circle) land areas.

Most center pivot systems are equipped with a large diameter end gun. The end gun operation is normally limited to a 180-degree arc, and its application is directed to areas beyond the lateral pipeline. This extends the effective diameter of the irrigation lateral. In many systems, the end gun is operated only in the corners of the square field, thus increasing the acreage that can be irrigated.

Some center pivot systems are equipped with corner units which operate only in the corners of a square field to irrigate most of the square. Corner units typically consist of one additional tower and section of lateral pipeline which are extended for irrigation of the corners of the field and retracted along the sides of the field.

Because of the laterals travel over the area to be irrigated, center pivots can effectively use low pressure spray nozzles to distribute water. When spray nozzles are used, pumping costs are reduced, however, application rates are high because the water is applied near the lateral rather than being distributed over a wide area. The high application rates can cause runoff from soils with low infiltration rates. This is normally not a problem in Florida because of the high infiltration rates of typically sandy soils. Thus low pressure center pivot systems equipped with spray nozzles are often used in Florida.

Because of the height of the lateral, Center pivot systems are adaptable to most crops, including tall crops like corn. The cost of a center pivot system per acre irrigated decreases with increasing size up to the common size of 160 acres. Thus center pivots are often used to irrigate large acreages of lower cash value crops such as field crops. They are also adaptable to both small and large acreages of high cash value crops, but irrigation schedules are not as flexible as solid set system schedules. For example, 24 to 48 hours may be required to complete one revolution of a center pivot system, and this time may be excessive for shallow-rooted vegetable crops grown on sandy soils.

Center pivot systems are more expensive than portable systems, but less expensive than permanent solid set systems. Because they are self propelled, irrigations are easily scheduled and adjusted, and labor costs are low.

Center pivot systems are widely used for field crop production throughout the world. They are used for field crops in north Florida, and for sod, forage crops, pasture, and waste disposal throughout Florida.

Lateral-move irrigation systems

Lateral-move irrigation systems are similar to center pivot systems with the exception that the A-frame supported lateral pipe travels in a lateral (linear)

direction rather than pivoting around a central point (Fig. 9). Thus, lateral-move systems are better adapted to rectangular land areas than center pivots.

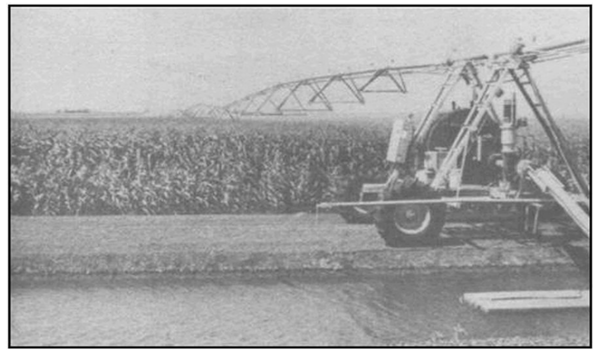

Figure 9. Lateral-move irrigation systems irrigate rectangular land areas. The pumping station travels with the lateral.

Because lateral-move systems do not rotate about a fixed pivot point, they must drag a large flexible hose, use a permanent underground pipeline with risers modified for automatic operation or use an open ditch for the water supply. The hose-drag units are the most common. The open ditch systems require a pump to travel with the lateral pipe to pressurize the water. Lined ditches would be required in the deep sandy soil areas of Florida, but unlined ditches could be used in the flatwoods soil areas where high water tables exist. Permanent underground pipe systems with automatic couplers are more technically complicated and expensive than the other methods of supplying water to a lateral-move irrigation system.

Lateral-move irrigation systems are more expensive than center pivots. Thus, these systems are primarily used in areas where the value of land dictates the use of systems which are adapted to rectangular land areas, and for irrigation of very large land areas so that the cost per acre is lower. Lateral-move systems are not commonly used in Florida.

Single sprinkler (gun) irrigation systems

Gun sprinklers are very large sprinklers which operate at high pressures (Fig. 10). Nozzle sizes commonly range to over 1-inch in diameter. Pressures required for proper operation typically range from 80 to 120 psi, with 100 psi being very common. While flow rates may range up to 1000 gpm for very large guns, rates from 500 to 600 gpm are very common for large field scale guns. Typically only one or two guns are used in a gun irrigation system.

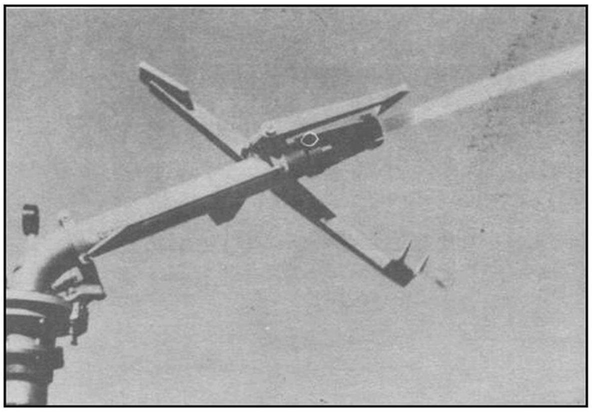

Figure 10. Gun sprinklers use large diameter nozzles to discharge high flow rates at high pressures.

Gun irrigation systems require large energy inputs per unit of water delivered because of their high operating pressures. They also have relatively high labor requirements, both to move the portable guns between sets and to set up the self-propelled (travelling) guns. Despite these limitations, gun systems are popular in Florida. They are flexible, that is, they allow irrigation of oddly-shaped fields, they are available in a range of sizes to permit irrigation of small to relatively large (up to 90 acres per gun) areas, and they are easily transported between fields. Guns also have relatively low initial costs as compared to permanent or portable solid set irrigation systems, and they require less labor than portable multi-sprinkler systems.

Portable gun systems

Figure 11. Portable gun system for field crop irrigation in north Florida.

Portable gun irrigation systems (Fig. 11) are widely used in Florida. Guns may be moved by hand, but due to their size, they are typically towed with tractors.

Hand-moved portable guns

Hand-moved portable guns have larger labor requirements than other types of guns because they must be manually moved between sets, and a gun is a relatively large item of equipment. Hand-moved guns are most adaptable to relatively small acreages. They are commonly used to irrigate small fields of vegetables, melons, and tobacco, especially in north Florida. Water for hand-moved portable guns is typically supplied by either portable aluminum pipe or large diameter flexible hoses.

Tractor-moved portable guns

Tractor-moved guns are mounted on skids or wheels to facilitate moving them between sets. Less labor is required, thus permitting them to be used on larger acreages than hand-moved guns.

Self-propelled (traveling) gun systems

Traveling guns are widely used in Florida. These are self-propelled irrigation systems. Two types of traveling gun systems are in common use. They both use the same types of guns for water distribution, but they are different with respect to the way the guns are moved through the field. With both systems the guns are mounted on carts or trailers that are slowly and continuously moved through the field as the guns operate. The rate of water application and total depth applied depend on the flow rate from the gun, the diameter of coverage, and the speed at which the gun travels.

Cable-tow traveling guns

Figure 12. A cable-tow traveling gun pulls itself through the field by winding up a cable anchored at the edge of the field.

Cable-tow systems automatically tow a large gun through the field by winding up a cable (Fig. 12). The gun is mounted on a cart which also contains a cable reel and winch. The cable is stretched across the field in the desired direction of travel, and the end of the cable is firmly anchored at the end of the travel lane. As water flows to the gun, an impeller drive unit or water piston is used to power the winch. Thus, the cable-tow traveling gun pulls itself across the field by winding up the cable. The speed of travel is adjustable from only a few feet per minute (fpm) to 10 or more fpm. Water is supplied to the gun by a collapsible, flexible hose that is also towed by the system. A travel lane approximately 10 ft wide is required for this type of traveling gun because the flexible hose loops behind the cart.

Because they are set up to irrigate long travel lanes, cable-tow systems require much less labor than portable guns. Travel lane lengths of up to 1320 ft are typical. A typical 500 gpm cable-tow traveling gun can irrigate up to 80 acres.

Despite the high cost of gun operation, cable-tow systems are commonly used to irrigate field crops, vegetables, melons, and citrus in Florida. They are widely used throughout the state, although their high operating costs have caused some systems to be replaced by more energy-efficient microirrigation systems, especially for perennial crops such as citrus.

Hose-reel traveling guns

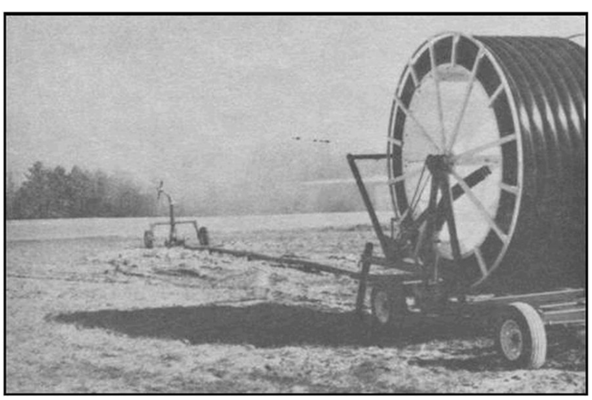

Figure 13. A hose-reel traveling gun winds up the hose on a large reel to move the gun during irrigation.

A hose-reel traveling gun uses a large reel unit to wind up the hose and retract the gun (Fig. 13). The hose is semi-rigid and does not collapse on the reel, so that water can be continuously pumped through it during operation. The hose and gun are laid out in the desired direction of travel. The reel is then used to retract the hose and gun at slow speeds, irrigating as the gun is retracted.

Hose-reel systems require less labor than cable-tow systems because they are easier to set up for operation. A typically 500 gpm hose-reel traveling gun can irrigate up to 90 acres. However, these systems are more expensive than cable-tow systems.

Hose-reel systems are used for the same crops as cable-tow gun systems. In addition, there is some use of hose-reel systems for the establishment of transplanted vegetable crops. The smaller cart on which the hose-reel gun is mounted permits use in row crops without the need for a wide travel lane to tow the hose behind the gun.

Surface irrigation systems

Surface irrigation systems are those in which water is applied on the soil surface and is distributed across the surface by the soil hydraulic characteristics or by flooding the entire area to be irrigated. Surface irrigation is primarily applicable on heavier clay and loam soils which have finer textural classifications and lower hydraulic conductivities than typical Florida sandy soils. Where such heavy soils exist in Florida (primarily in north Florida, near Georgia and Alabama), irrigation is not generally practiced because of the high water-holding capacities of these soils and Florida's large annual rainfall. Thus, except for rice flood irrigation systems and citrus crown flood systems, surface irrigation is not commonly used in Florida.

Level systems

Level surface irrigation systems are those in which the soil surface is essentially level and the water moves across the surface primarily due to the difference in water depths. These systems are irrigated by apply water at high rates across the soil surface to wet the surface as quickly as possible, and then continuing to apply water at reduced rates while infiltration occurs simultaneously across the entire field being irrigated. The water is applied and then allowed to stand and infiltrate until all of that applied has infiltrated. Normally several inches (2 to 6 inches) are applied per irrigation.

Level furrows

Level furrows are used in row crop production systems. Crops are planted on beds and water is directed into the furrows, normally into each or every other furrow. Water is typically applied by siphon tubes from open ditches or by gates or valves from gated aluminum pipes.

Figure 14. Field ditches are flooded with water for crown flood irrigation of citrus.

In Florida, a type of level furrow irrigation system is used to irrigate bedded citrus on flatwoods (high water table) soils. This "crown flood" irrigated citrus is irrigated by allowing water inflow to large furrows between the citrus beds (Fig. 14), allowing the water to stand in the furrows for 8 to 24 hours, and then draining the furrows by pumping the water to the next citrus grove. In these systems, water is applied through large diameter conduits from a large manifold or header ditch.

Level borders

Borders are typically rectangular blocks of land bordered by soil ridges (levees or borders) 1 to 2 ft high. The borders retain the water applied within the area to be irrigated. Water is typically applied by large gates from open ditches, portable gated pipe or valves from underground pipelines. Less frequently, siphon tubes are used in open ditches.

Rice irrigation systems are the only level border surface irrigation system used in Florida (Fig. 15). Levees (borders) maintain water depths in each paddy (border) within about 1 inch of the average depth. Water levels are maintained above the soil surface to flood the area for weed control. Water levels in each paddy are maintained by drop structures or weirs which are set at the required water elevation. Runoff from each paddy flows into the next downstream paddy.

Figure 15. Rice production systems are flooded for irrigation, weed control and to prevent oxidation of muck soils.

Basins

Basins are small border areas, primarily used for permanent crops such as orchards or vineyards, but also used for some ornamental crops. Basins may encompass only one or several trees or other plants. Irrigation may be applied by risers from underground pipelines into individual basins, or by any of the other methods discussed for level border systems.

Graded systems

Graded surface irrigation systems are those in which the field slope is large enough that it significantly influences the way that water must be be managed to obtain uniform water applications. Graded systems are typically irrigated by initially applying water at high rates to wet the entire surface, then reducing the application rate or pulsing the applications to closely approximate the soil infiltration rate. Large amounts of runoff may occur if slopes are steep.

Land smoothing is typically required to obtain high efficiencies from graded surface irrigation systems. Other techniques used to obtain high irrigation efficiencies are tailwater recovery (re-use or recycling), cablegation (an automated flow rate cut-back irrigation method), and surge irrigation (where several separate pulses of water rather than continuous applications are used).

Graded furrows

Graded furrows are irrigated with the same equipment as level furrows. In order to obtain uniform water applications along the furrow without excessive runoff, cut-back irrigation is practiced. In cut-back irrigation, the flow rate is reduced to the rate required for infiltration after the water reaches the distant end of the furrow.

Contour Furrows

A contour furrow has a gradient to allow runoff from rainfall to flow nonerosively from the field site. Irrigation management is similar to the management of graded furrows. However, more labor is typically required to avoid erosion and nonuniform water application which might occur if furrows overflow during irrigation.

Corrugations

Corrugations are small furrows which are formed when small grain seeds are drill-planted. Management of the irrigation of corrugated fields is similar to the management of graded furrows. However, irrigation of corrugated fields is more difficult and labor-intensive than that of conventional furrows because it is difficult to prevent these small furrows from overflowing.

Graded borders

Graded borders retain irrigation water within the border areas because the ridges constructed are typically 1 to 2 ft tall. However, if rapid surface wetting followed by reduced (cut-back) flow rates are not used, the uniformity of water application will be reduced. If cut-back irrigation is not accurately practiced, excess water will accumulate and infiltrate at the lower ends of the borders, and thus the efficiency of these systems will be reduced.

Flooding

The term "flooding" is used to describe three distinctly different types of irrigation practices: (1) in many parts of the world, flooding refers to the irrigation of heavy soils where furrows, corrugations, or borders do not exist to direct water uniformly across the surface, (2) this term is also widely used to describe the practice of inundating the soil surface in rice production systems, and (3) in Florida, the term "crown flood" is used to refer to a citrus irrigation method that was previously discussed in the "level furrow" section of this publication.

Flooding is often practiced where water supplies are plentiful and inexpensive, so that irrigation efficiency is not the major concern, although irrigation efficiencies can be relatively high, depending on soil properties and whether tailwater is re-used. In Florida, both rice and citrus are irrigated with flood irrigation systems. Rice is produced on high water table organic soils which must also be flooded for another purpose, to prevent oxidation and loss of the organic soil. When citrus is produced using the crown flood method, runoff water is typically used to irrigate another citrus grove in a large management area, thus the overall efficiency of water use is high.

Subirrigation (seepage) systems

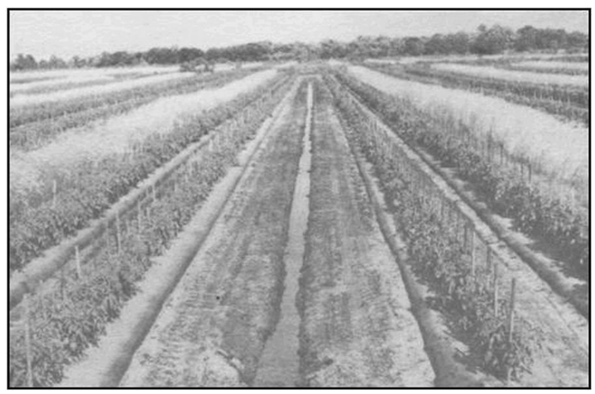

Figure 16. Seepage irrigation of sandy soils uses water furrows to distribute water for tomato production.

Subirrigation (seepage) systems are those in which water is supplied at rates high enough to establish and maintain a water table just beneath the crop root zone. Irrigation then occurs by capillary movement of water into the crop root zone. This method of irrigation is limited to use on sandy (Fig. 16) and muck (Fig. 17) soils with high hydraulic conductivities in the surface soil layers, but with restrictive subsurface layers and existing high water tables. Large quantities of water must also be available to raise the water tables in addition to providing water for crop evapotranspiration (ET).

Figure 17. Muck soils are seepage irrigation with widely spaced surface ditches for sugarcane production.

Water is typically applied from a parallel network of open field ditches (water furrows) or underground pipe (drain tiles), called laterals. Open ditches are more common because underground pipe systems are more expensive, and they are sometimes clogged by bacterial activity, chemical precipitation, and other causes. The ditches are also required for surface drainage during large rainfall events. Recently, subsurface drip irrigation systems have been developed for water table control (Fig. 18). Although they are more expensive and have higher maintenance requirements than open ditches, they conserve water by avoiding runoff and standing water in ditches, and they allow more precise water table control through the network of underground pipelines. Thus, these systems are primarily being installed in areas where water shortages exist.

Lateral ditches are typically spaced from 12 to 60 ft apart on sandy soils, depending on the soil hydraulic conductivity and on irrigation, drainage, cultural, and field equipment requirements. On muck soils, ditches are often wider spaced, typically from 100 to 200 ft, because of the greater conductivity of these soils.

Constant water table systems

Constant water table systems are systems in which irrigation water is applied continuously (except during, or in anticipation of rainfall) to maintain a water table at the height required for optimum crop growth. Water is continuously pumped into ditches or water furrows, and water levels are typically controlled with flashboard riser structures at the downstream end of the irrigated field. Flow rates are often adjusted as a function of stage of crop growth, time of year, and in some cases, even time of day. Diurnal field water tables typically fluctuate only a few inches in response to changes in ET rates during the day.

Constant water table seepage systems are used to irrigate large acreages of vegetables and sugarcane, and some citrus in Florida. Depending on field slope, soil properties, ET rates, and management practices, runoff often occurs from the fields. Irrigation efficiencies are lowest when runoff water is discharged from the irrigated field. Efficiencies are highest when runoff is recycled or applied to other irrigated fields and when application rates are matched to changes in water requirements during each day.

Fluctuating water table systems

Fluctuating water table seepage irrigation systems are systems in which water tables are permitted to fluctuate on a daily basis as water is only applied intermittently in an effort to reduce runoff. These systems shut off irrigation pumps when water tables are high and runoff begins to occur. Pumps are restarted when water tables drop to critical levels or during peak ET times of the day.

Fluctuating water table systems are less frequently used than constant water table systems because higher levels of management are required, the potential for leaching crop nutrients is increased, and yield reductions occur when water tables fluctuate excessively.

Microirrigation systems

Microirrigation systems are those which use low flow rate emitting devices (emitters to place water on the soil surface near the plants being irrigated or below the surface directly into the plant root zone. Microirrigation systems are characterized by the use of small diameter, flexible plastic lateral pipes and operation at low pressures. Normally only a fraction of the crop root zone is irrigated, and frequent, small irrigations, which keep the irrigated zone near field capacity, are practiced. Chemicals, especially fertilizers and cleaning agents, are often applied through microirrigation systems.

The term "microirrigation" is a general term which includes several specific types of systems, including drip, spray (or microsprinkler), bubbler, line source perforated pipes or seepage hoses, or other similar types of systems. With microirrigation, the levels of management, water treatment, and filtration generally exceed those associated with other types of irrigation systems.

Drip

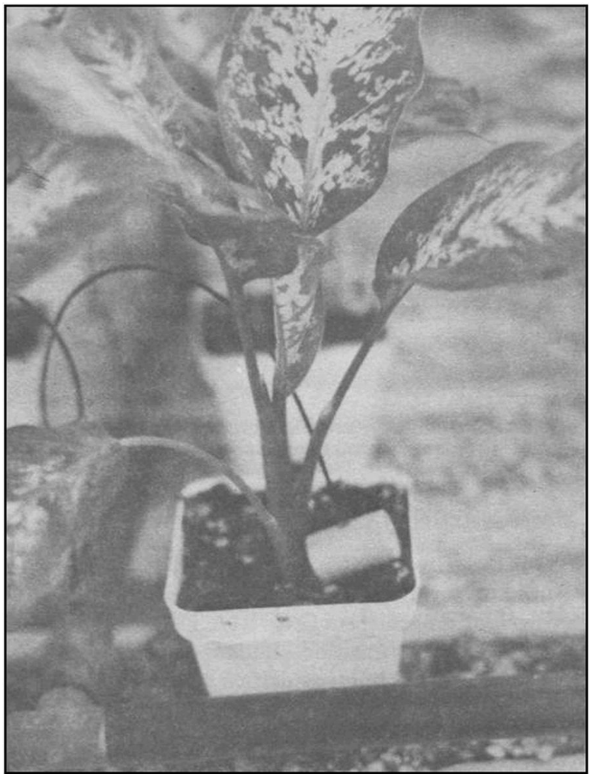

Figure 19. Spaghetti tube drip emitters are used to apply water to each individual container in this ornamental nursery.

Drip types of microirrigation systems apply water from discrete point source emitters attached to or molded into lateral pipes (Fig. 19). Emitter discharges are in the form of small streams or individual drops, with flow rates ranging from 0.3 to 2 gph, but most commonly being 1 gph. Operating pressures typically range from 6 to 30 psi.

In Florida, drip irrigation systems are primarily used in vegetable (especially tomato and pepper), ornamental (container nurseries), and fruit crop (citrus) production systems. Because of system costs, they are not used in agronomic (field) crops.

Emitters are typically placed on or slightly below the soil surface or under the plastic mulch in mulched vegetable production systems. Because drip emitters rely on the soil hydraulic properties to distribute water, and typical Florida sandy soils limit lateral unsaturated water movement, spray (or microsprinkler) emitters have become more popular in those tree crop production systems where it is desirable to irrigate a significant fraction of the tree root zone with relatively few emitters.

Spray (microsprinkler)

Spray or microsprinkler types of microirrigation systems, like drip systems, emit water at discrete points. However, emitters typically have flow rates much greater than drip emitters. Flow rates normally range from 8 to 30 gph, with 15 to 20 gph emitters being very common. Spray emitters distribute water by spraying it through the air over diameters of 5 to 25 ft, depending on the crop being irrigated. Emitters are typically mounted on short (6 to 12-inch) risers above the ground surface to improve distribution patterns.

Figure 20. Spray (microsprinkler) emitters irrigate a large fraction of the tree root zone in this citrus production system.

Spray emitters are most commonly used in citrus microirrigation systems (Fig. 20). In citrus, the advantage of distributing water over a large diameter as compared to the much smaller diameter of drip emitters has been demonstrated to increase yields. The larger flow rates and orifice sizes also reduce filtration requirements and clogging problems.

Both spinners and fixed deflectors are used to distribute the water from spray emitters. The fixed deflector type are more often used because the moving parts in spinner emitters sometimes fail to function under field conditions.

Bubbler

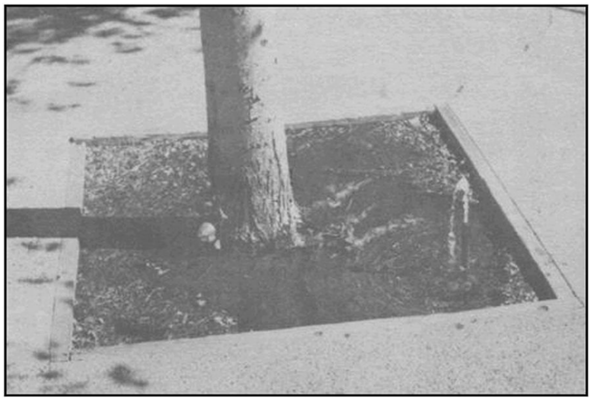

Figure 21. Bubblers have high flow rates and require some means of containing the water to prevent runoff.

Bubblers are relatively large flow rate microirrigation emitters (Fig. 21). Flow rates are typically 1-gpm or greater. Because of the high flow rates, relatively large orifice sizes are used, and clogging is typically not a problem, even without filtration. However, the high flow rates may result in runoff rather than infiltration into the soil. Thus, bubbler systems are typically only used in containers such as large ornamental planters or in individual tree basins, which retain the water and prevent runoff. Also, bubblers are typically operated only a few minutes per irrigation, because the required water volumes can be applied in a short period of time.

Line-source

Line-source microirrigation systems use laterals with very closely spaced emitters, or either perforated or porous tubing are used rather than discrete emitters. Water is emitted either continuously along the lateral lengths, or at close intervals so that the wetting patterns overlap and approximate that of a continuous line source.

Line-source tubing laterals are used in Florida vegetable, strawberry and ornamental (bedded flower) production systems (Fig. 22). These are typically thin-walled tubing of the disposable, lay-flat type that have perforations or emitters molded into the tubes at 6 to 24-inch intervals along their lengths.

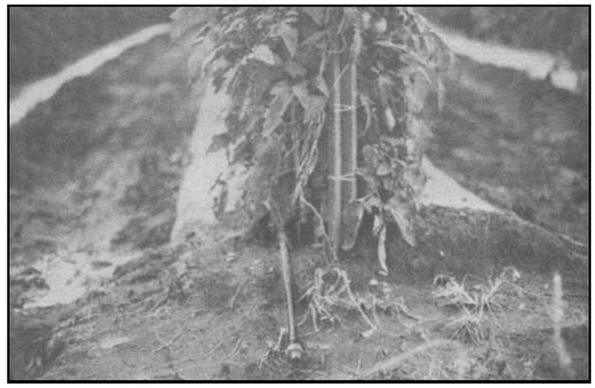

Figure 22. Line-source microirrigation systems require a lateral under the plastic mulch of each crop row for tomato production.

Because of the limited water movement for typical sandy soils, 8 to 12-inch spacings are commonly used.

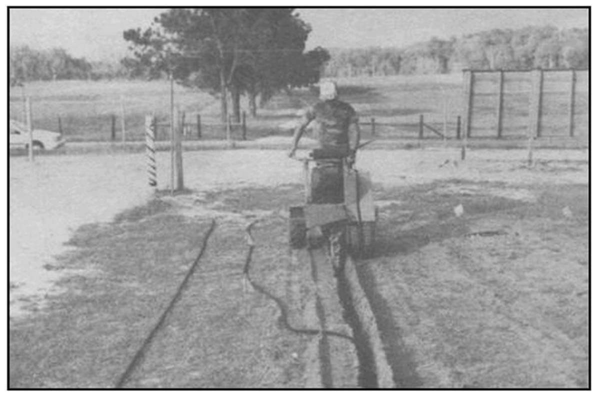

Figure 23. Installation of line-source porous pipe microirrigation laterals for subsurface irrigation of a small turf plot.

Another common application of line-source tubing is porous tubing which is buried or placed under mulch in turf and landscape irrigation systems (Fig. 23). Buried porous tubing can be used to avoid overspray of water from roadway medium strips and other turf areas where the sprayed water might cause an inconvenience or hazard.

Summary

Irrigation is extensively practiced in Florida because of Typical low water-holding capacity sandy soils, nonuniform rainfall distributions, and sensitivity to drought stress of the many high cash value crops grown. Irrigation systems can be classified as sprinkler, surface, subirrigation (seepage), and microirrigation. Irrigation system characteristics, applications, advantages and limitations were presented for systems in each of these classes, with emphasis on systems commonly used in Florida. The choice of an irrigation system for a specific application requires careful consideration of economics, yield potential, water supply quantity, and quality, soil, crop and cultural characteristics, design limitations and management, maintenance and labor requirements.