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Principles of Micro Irrigation[1]

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The objective of this publication is to review the basic principles of micro irrigation, describe the major components of micro irrigation systems and discuss advantages and disadvantages of the irrigation method.

The terms "drip", "trickle" and "spray" irrigation, common in many quarters in the last 15 years, have been supplanted by the term "micro irrigation", recently adopted by the American Society of Agricultural Engineers. Micro irrigation includes all methods of frequent water application, in small flow rates, on or below the soil surface. Ideally, the volume of water is applied directly to the root zone in quantities that approach the consumptive use of the plants. Through good management of the micro irrigation systems the root zone moisture content can be maintained near field capacity throughout the season providing a level of water and air balance close to optimum for plant growth. In addition, nutrient levels which are applied with water through the system can be controlled precisely. During the dry season in humid areas, or in arid climates, micro irrigation can have a significant effect on quality and quantity of yield, pest control and harvest timing.

COMPONENTS OF A MICRO IRRIGATION SYSTEM

In micro irrigation systems, water is distributed using an extensive hydraulic pipe network (Figure 1) that conveys water from its source to the plant. Outflow from the irrigation system occurs through emitters placed along the water delivery (lateral) pipes in the form of droplets, tiny streams or miniature sprays. The emitters can be placed either on or below the soil surface. In general micro irrigation systems are classified by the type of emitter used in the system. These are drip, bubbler, spray jet, and subsurface (ASAE EP 405).

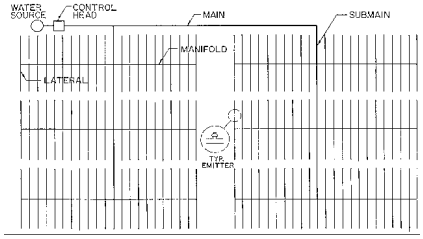

Figure 1.

Emitters can vary from sophisticated, constant-flow-rate at variable pressure types of devices (pressure compensating emitters) to very

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small, simple orifices. A large number of different types of emitters have been developed in attempts to find a perfect one. The main objective is to assure uniformity of water distribution. It is essential that the discharge from the emitter be uniform and that it not change significantly with small pressure variations in the system. At the same time the emitter should be constructed in such a way that it does not clog very easily. The cost and the size are also important. The emitters presently available on the market can be classified (Jensen, 1980) in five distinct categories: long path emitters, short orifice emitters, vortex emitters, pressure compensating emitters, and porous pipe or tube emitters. In addition, micro irrigation emitting devices include bubblers and jet sprays. Various types of emitters are presented in Figure 2 .

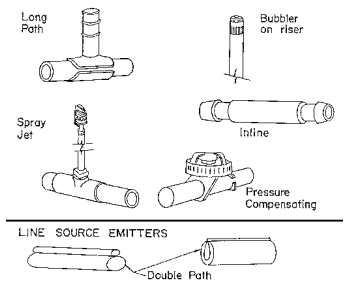

Figure 2.

Emitters are placed along laterals which are the final water delivery lines designed for uniform water distribution. The lateral line is generally constructed of flexible polyvinyl chloride (PVC) or polyethylene hose (PE). It is often placed above the ground but it can be buried. For row crops, in the line-source type of micro irrigation system, a lateral line combines the function of the line and the emitter. These include laterals constructed from porous pipe, twin bore pipe or pipe provided with evenly spaced, built in emitters. Each manufacturer supplies data giving allowable length of laterals and recommended pressure for particular line source systems. Recommendations are based on the hydraulic characteristics of the product. The emitters, which may be connected to the lateral using a variety of connectors during installation of the irrigation system, are usually placed at predetermined positions, for example at the base of the irrigated tree.

Lateral lines are attached to manifolds or submains. The manifolds and submains, which distribute the water to the specific parts of the field, are usually constructed from flexible smooth-walled, non-collapsible, black PE or flexible PVC pipe which can be left on the soil surface. They can be also constructed out of rigid PVC pipe which is buried beneath the soil surface for protection against sunlight damage and prevention of algae growth in the line. The controls for adjustment of flow rate and pressure are usually located in the submain or manifold line along with valves and timing devices for the separate parts of the field.

Water is delivered to the field by the main line. The main line is usually constructed from white PVC pipe which is again buried beneath the soil surface for protection against harmful sunlight. The pipe should be properly rated for the particular application and able to withstand the design pressure in the system.

A main control station, often called the "control head", is usually located close to the water supply. A typical control station includes the pump, backflow prevention system, chemical injection system for fertilizers, chlorine or other chemicals, and a combination of different filters. A main line valve and flowmeter are also included in the control head. Micro irrigation systems can be controlled manually or automatically. Automatic control can be electro-mechanical (clock) or electronic (computer). The controller is often located next to other components of the control station. It can control the main valve, chemical injection, backflushing of filters, solenoid valves, and other controls located at remote locations in the irrigation system. Depending on the system, all or some of these components can be automated.

WETTING PATTERNS UNDER MICRO IRRIGATION

Due to the manner in which water is applied by a micro irrigation system, only a portion of the soil surface and root zone of the total field is wetted. Water flowing from the emitter is distributed in the soil by gravity and capillary forces creating the contour lines presented in Figure 3 , often referred to as "onion" patterns. The exact shape of the wetted

volume and moisture distribution will depend on the soil texture, initial soil moisture, and to some degree, on the rate of water application. Figure 4 presents some examples of how soil texture or an underlining hardpan (4c) can influence the water distribution pattern under a micro irrigation system. In the line-source type of micro irrigation tube, where the emitters are spaced very closely, individual "onion" patterns connect/creating a continuous moisture zone along the row.

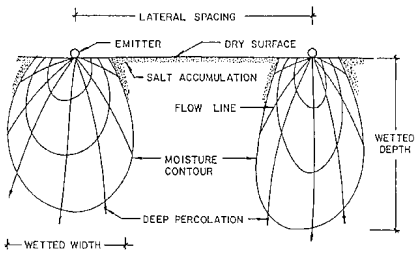

Figure 3.

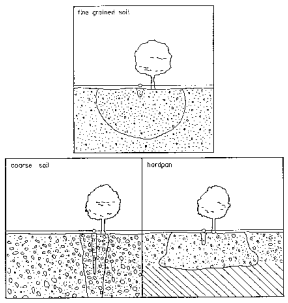

Figure 4.

ADVANTAGES OF MICRO IRRIGATION SYSTEMS

Micro irrigation systems have many potential advantages when compared with other irrigation methods. Most of them are related to the low rates of water application. It can be argued that some of these benefits are not unique to a micro irrigation system. However, certain combinations of these advantages are responsible for uniqueness of micro irrigation in contrast to other systems.

1. Water Savings

Irrigation water requirements can be smaller with micro irrigation when compared with other irrigation methods. This is due to irrigation of a smaller portion of the soil volume, decreased evaporation from the soil surface, and the reduction or elimination of the runoff. The losses due to the evaporation from the soil are significantly reduced compared with other irrigation systems since only a small surface area under the plant is wetted and it is usually well shaded by the foliage. Since the micro irrigation system allows for a high level of water control application, water can be applied only when needed and deep percolation can be minimized or avoided.

2. Smaller Flow Rates

Since the rate of water application in micro irrigation systems is significantly lower than in other systems, smaller sources of water can be used for irrigation of the same acreage. The delivery pipes, the pump, and other components of the system can be smaller and therefore more economical. The systems operate under low pressure (5-30 psi) and require less energy for pumping than high pressure systems.

3. Application of Chemicals

Micro irrigation systems allow for a high level of control of chemical applications. The plants can be supplied with the exact amount of fertilizer required at a given time. Since they are applied directly to the root zone a reduction in the total amount of fertilizer used is possible.

There is also an advantage to the frequent application of fertilizers through the system in Florida's humid climate. In case of rain, only a small portion of recently applied fertilizer will be washed out and it can be easily replaced through the irrigation system. This application method is more economical, provides better distribution of nutrients throughout the season, and decreases ground water pollution due to the high concentration of chemicals that could ordinarily move with deep percolated water.

Other chemicals, such as herbicides, insecticides, fungicides, nematicides, growth regulators and carbon dioxide can be efficiently applied through micro irrigation systems to improve crop production.

4. Water Sources with High Salt Content

A significant advantage of micro irrigation is that water with relatively high salt content can be used by the system. For optimum plant growth a certain range of total water potential in the root zone

must be maintained. The potential defines how difficult it is for a plant to extract water from the soil. Large negative numbers are characteristic of very dry soils with low total water potentials while potentials near zero reflect soils near saturation. The total water potential in the root zone is a sum of the matric potential and osmotic potential. Since matric potential is close to zero under micro irrigation (high moisture content) the osmotic potential component can be a relatively large negative value, indicating high salt content, without harmful effect on plant growth. This is not true for other irrigation systems.

5. Improved Quality of the Crop

Micro irrigated plants are supplied very frequently with small amounts of water and the stress due to the moisture fluctuation in the root zone is reduced to the minimum, often resulting in larger and better quality yield. In arid climates, or during dry seasons, the harvest timing can be controlled by proper water management.

6. Adaptation to any Topography

Micro irrigation systems can operate efficiently on hilly terrain if appropriately designed and managed. Well managed micro irrigation system will not create runoff even on hilly terrain.

7. Additional Advantages of Micro-Irrigation Systems

During dry seasons or in arid climates disease and insect damage can be reduced under micro irrigation system since the foliage of the plant is not wetted. With a small portion of soil surface being watered, field operations can be continued during irrigation. The water distribution is not affected by the wind for drip irrigation. However, wind can have some effect on jet spray patterns.

Since only the portion of the soil surface is wetted/water uptake by the weeds between the rows can also be significantly reduced. Micro irrigation systems can also be extensively automated/ decreasing labor and operating costs.

POTENTIAL PROBLEMS IN MICRO IRRIGATION

To operate satisfactorily, a micro irrigation system have to be correctly designed and managed to account for the physical properties of soil, quality of irrigation water, and water requirement of the grown plants. This type of system definitely requires a higher management level than other irrigation systems. With all the advantages listed above, a micro irrigation system is not a system without problems.

1. Clogging

One of the biggest problems encountered under micro irrigation is clogging of the emitters. The small openings can be easily clogged by soil particles, organic matter, bacterial slime, algae or chemical precipitates. The micro irrigation system requires very good filtration (most often recommended is 200 mesh screen) even with a good quality water supply.

More information on filtration requirements for micro irrigation systems is included in extension publications AE-57, AE-61 and AE-65.

2. Moisture Distribution

Moisture distribution depends largely on the soil type being irrigated by the micro system. In some soils, for example deep sands, very little lateral water movement (low capillary forces) can create many problems. The wetted volume has a shape approaching a cylinder rather than a hemisphere (Figure 4) since gravity forces dominate. Under these conditions it is difficult to wet a significant portion of the root zone. It is also more difficult to manage the irrigation without deep percolation since only a small amount of water can be stored in the wetted volume desired. Increasing the number of emitters per plant may improve water distribution in the soil. As a result, coarse sands will require much closer spacing of emitters than fine soils. In general, for any soil, the number of emitters and their spacing must be based on the geometry of wetted soil volume.

It is important to realize that the micro irrigation system wets only a limited portion of the potential soil-root volume. Most of the plants can perform very

well under these conditions. However, there is a minimum volume of roots which has to be wetted or a reduction in yield will be observed.

3. Salt Buildup

Micro irrigation systems can use saline water. However, a problem may occur from salts accumulating at the edges of the wetted zone during prolonged dry periods. Light rain can wash these salts into the root zone and cause injury to the plants. In arid climates, where the rainfall is less than 10 inches per year, an additional irrigation system (sprinkler or surface) may be necessary to leach accumulated salts from the soil between growing seasons. In areas with heavy rainfall the salts will be washed out of the root zone before significant accumulation occurs.

4. Initial Cost

The initial investment and maintenance cost for a micro-irrigation system may be higher than for some other irrigation methods. Filters, chemical injectors and possible automation components add to the cost of a micro irrigation system. Actual costs will vary considerably depending on the selection of a particular micro system, required filtration equipment, water quality, water treatment and selection of automation equipment.

5. Additional Drawbacks

Rodents and insects can create additional maintenance problems by chewing holes in the plastic. In addition, some components of the system can be easily damaged by persons unaware of their locations.

A micro irrigation system does not provide significant frost protection; therefore it is not suitable for that purpose.

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