MICROIRRIGATION OF MELONS UNDER PLASTIC MULCH IN THE LOWER RIO GRANDE VALLEY OF TEXAS

Guy Fipps and Enrique Perez[1]

ABSTRACT

The microirrigation system used for vegetable production in the Lower Rio Grande Valley of Texas is described. Components of this system include inexpensive drip strip-tubing (commonly referred to as "tape"), plastic mulch, layflat tubing, and portable pumping and filtration trailers. Typically, the drip tape and plastic mulch are used for only one growing season. For melon production, this system has several benefits over conventional furrow irrigation. These include higher production with reduced amounts of water and fertilizer, and earlier melon maturation. Techniques and types of devices for scheduling irrigation are also discussed, and comparative data is presented.
KEYWORDS: microirrigation, plastic mulch, irrigation scheduling, melons.

INTRODUCTION

The term "Lower Rio Grande Valley" (LRGV) refers to a four-county area along the Mexican border located at the southernmost tip of Texas (Fig.1). While usually referred to as the "Valley", the area is actually a delta of the Rio Grande River. The LRGV has a semi-tropical climate and receives about 406 mm (16 in) of rain each year. However, the amount of rain varies in direct relationship with the distance from the Gulf of Mexico, from a 660 mm (26 in) in Brownsville to 330 mm (13 in) in Rio Grande City.

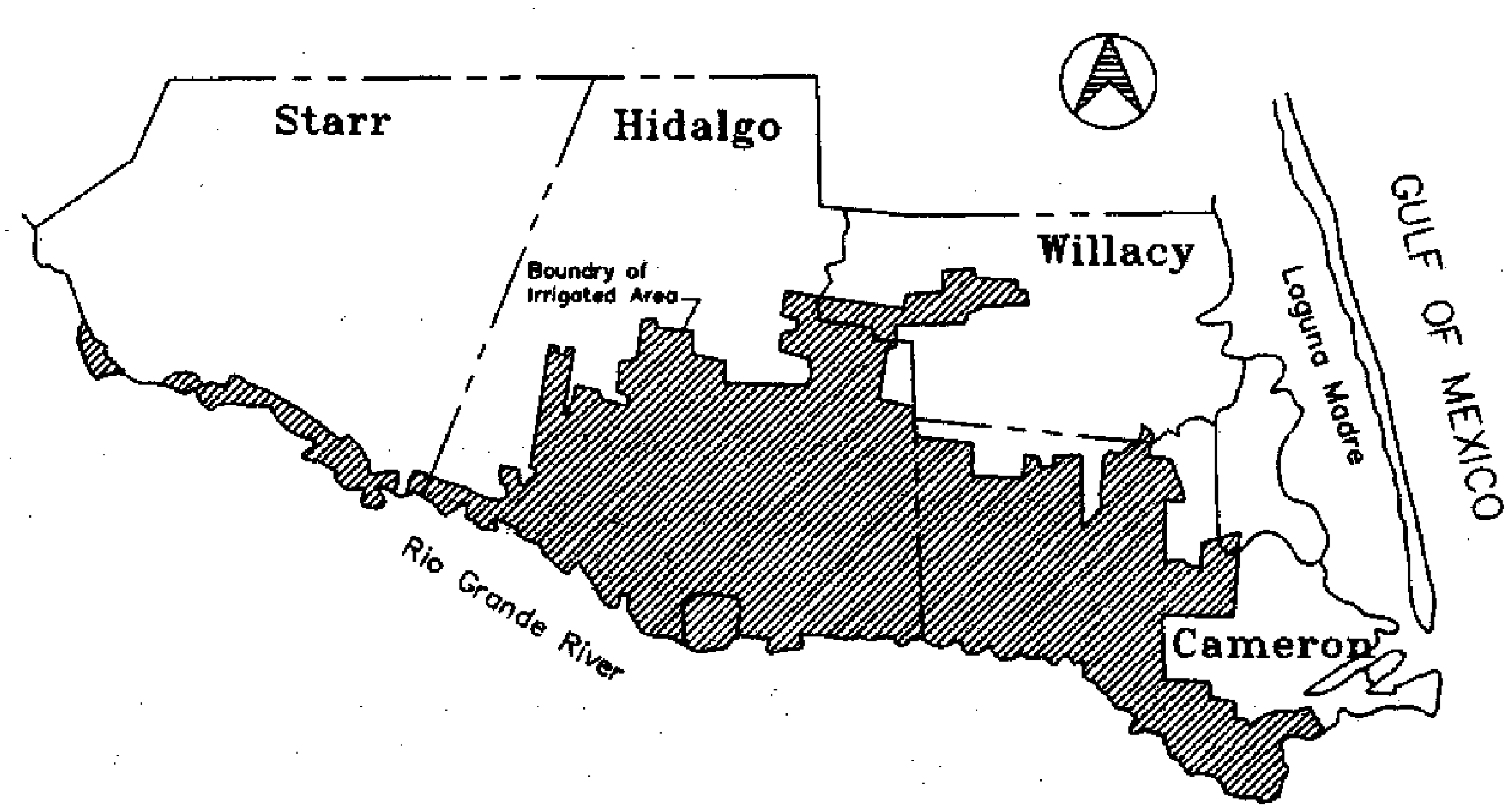

Figure 1. The Lower Rio Grande Valley of Texas. The shaded area shows the extent of the developed surface irrigated regions.

The LRGV is also one of Texas' most intensively irrigated regions, containing approximately 310,000 ha (765,000 acres) of surface irrigated land and a wide variety of crops, including cotton, sorghum, sugar cane, citrus, aloe vera, and vegetables. Annual irrigation water use varies from 1110 to 1480 million m^3 (0.9 million to 1.2 million ac-ft), depending on rainfall.

Associate Professor and Extension Specialist, Department of Agricultural Engineering, Texas A&M University, College Station, and Starr County Extension Agent, Texas Agricultural Extension Service, Rio Grande City, respectively.

Irrigation development began in the late 1800's. Now, most of the irrigated area is administered by 27 separate irrigation districts which pump water from the Rio Grande River and deliver it to individual fields through canals and underground pipelines. In most cases the irrigation district holds the water rights; however, some farms located near the river hold water rights and pump their own water. In the 1950's, the United States and Mexico established treaties which define the volume of water which can be withdrawn from the Rio Grande River. The International Boundary and Water Commission was created to manage the reservoirs and maintain the river bed. Water rights for Texas farmers are administrated by the Texas Natural Resources Conservation Commission.

MICROIRRIGATION SYSTEM

A typical microirrigation system used for melon production is shown in Fig. 2. In the LRGV, as in many other surface irrigated regions, underground pipelines have been installed to deliver water for low head, high volume flood/furrow irrigation. To reduce total equipment costs, Texas growers have adopted the use of portable pump and filtration trailers (commonly referred to as "*drip trailers*"). Most trailers have a centrifugal pump, a diesel engine to power the pump, sand media filters, a flow meter, a fertilizer injector, and associated pipes and valves, and connections for attaching to existing alfalfa valves. The water is pumped from the underground pipeline, pressurized, filtered and then discharged into flexible layflat tubing which serves as the manifold. Each lateral is connected to the layflat tubing with a spaghetti tube.

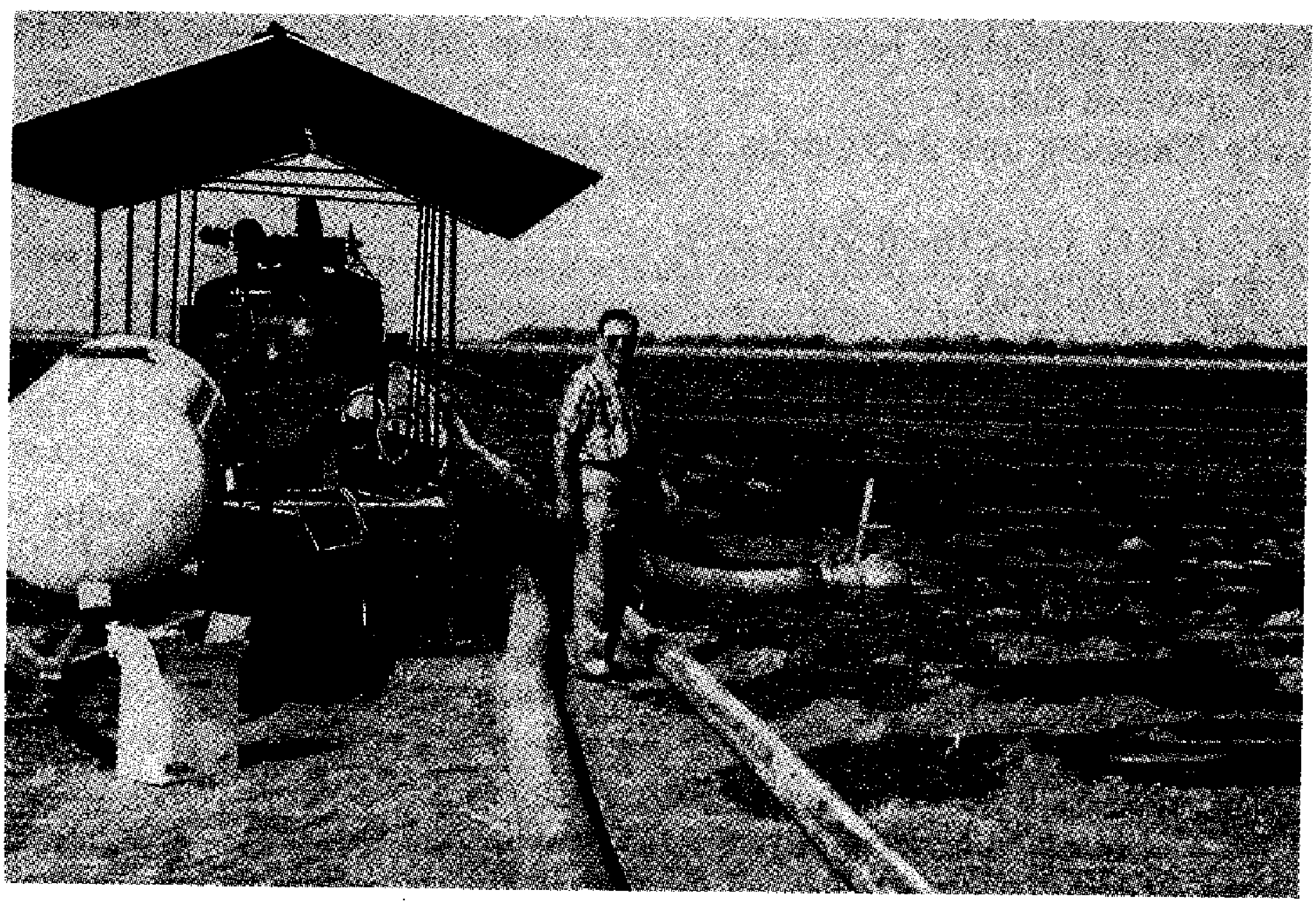

Figure 2. A typical microirrigation system for melon production.

A fully-equipped drip trailer costs \$15,000 to \$30,000, depending on capacity needed. Since the same trailer can be used to irrigate several different fields or blocks, drip trailers are usually less expensive than installing a permanent pumping plant and distribution system for each field. Table 1 provides the specifications of a drip trailer with a capacity of about 2080 L/min (550 gpm); at a cost of approximately \$19,000.

Table 1. Specifications for a portable drip trailer with a capacity of 2080 l/min (550 gpm). Specifications are given as written for purchase in the United States.

Description

Diesel engine power plant - engine, with radiator, starter, battery, cables, air cleaner, muffler, throttle control panel, tachometer, hour meter, and engine cover. Engine should be rated at 26 hp @ 1800 rpm and 35 hp @2500 rpm.

Stainless steel media filter (dual tanks), shipping weight less than 700 lbs with auto flush 12-V DC, 400 gpm to 550 gpm capacity with 22 ft^2 of filtration area.

6" saddle flow-meter, propeller and cable type accurate to within $\pm 2\%$ with odometer in acre-ft and gauge in gallons per minute.

Centrifugal pump delivering 600 gallons per minute at 100 ft of head and 75% efficiency.

18-foot trailer with 2 axles (tandem, 7000lbs/axle), springs, 4 wheels, 4 tires, 2 screw jacks, 6" channel, 5" channel cross members, 2" x 8" Decking Fenders, with disc brakes

Injector pump 10-100 gallons per hour, 12-Volt, with ball valves, hose, tees, and fittings for fresh water flush, 10-100 gallons per hour with stainless steel cylinder and chemical resistant piston cups with specified fittings.

Injector pump 0-7.5 gallons per hour, 12-Volt, with ball Valves, hose, tees, and fittings for fresh water flush, 0-7.5 gallons per hour with stainless steel cylinder and chemical resistant piston cups with specified fittings.

Necessary Plumbing and Accessories, Including:

Twenty six (26) - 100 lb Sacks 16-30 Silica Sand
Twelve (12) - 75 lb gravel bags
0-60 psi liquid filled pressure gauge
4" flanged check valve
#7 Protex diaphragm primer
6" PVC suction hose w/6" end & 10" end
Steel pipe hook-up from pump to filter for meter assembly with .275" to .383" walls.
4" gate valve
4" layflat flexible discharge hose for flush assembly

Inexpensive, thin-walled drip tape is the type of microirrigation tubing used exclusively for melon production. Most growers use the thinnest wall tape available which has been found to perform adequately. The drip tape is buried just below the soil surface, often at about 10 mm, and near the center of the bed. The beds are covered with plastic mulch. Most growers install both the tape and mulch at the same time using a home-constructed roller and plow combination. Either transplants or seeds are planted as the last operation. Fertigation is also a common practice. This irrigation and plastic culture system is referred to as *drip under plastic*. Excluding pumps and layflat tubing, material costs for this system range from $500 to $750 per ha ($200 to $300 per ac).

Most growers remove and dispose of the plastic following harvest of spring melons in May. Using the drip tape for a single growing season minimizes maintenance problems associated with clogging and damage caused by rodents and field operations. In 1992, some growers began experimenting with growing two successive crops on the same plastic (spring and fall melons). In 1994, one such field was planted with an additional spring crop of melons. No major problems were experienced with this third crop on the same plastic. Currently, the used plastic is disposed of by burning or by hauling to landfills. However, the State of Texas has an open air burning band; thus, alternative disposal methods are needed.

The use of inexpensive drip tape for irrigating under plastic mulch in melon production has increased dramatically in the last 10 years. The first experiments with drip under plastic began in Starr County in 1984. A few rows of drip under plastic was incorporated into a small-plot variety trial conducted as part of the Starr County Extension demonstration program. In 1986, the program was expanded to include field-scale evaluations. These early experiments resolved design questions concerning the number and placement of laterals for irrigation water salinity management, and helped develop installation techniques for preventing wind disruption and damage of the plastic mulch.

BENEFITS

During the 1992 growing season, two identical fields were used to demonstrate the advantages of drip under plastic over conventional furrow irrigation. These results are summarized in Table 2. The drip under plastic field produced 60% more melons than the furrow-irrigated field, with a third of the water and half the fertilizer (the furrow-irrigated field did not have plastic mulch).

Currently about 95% of all melons in the LRGV are produced with this system. This system has also created much interest in the state and is being adopted throughout South Texas. While higher yields can be obtained with less water and fertilizer, these are not the reasons for its increasing popularity. Under the plastic, the soil warms up earlier in the spring, resulting in faster growth; and, in most years, the melons ripen 7 to 10 days earlier. The typical early season higher prices more than pay for the costs of this production system. While other vegetable crops also respond well to drip under plastic, melons (cantaloupes and honeydews) have proven the most profitable. However, fall watermelons are also showing promise.

IRRIGATION SCHEDULING

Tensiometers are the most common devices used for scheduling irrigations under the plastic mulch. Some growers try to maintain a reading of about 40 kPa, while others maintain 60 kPa at the 0.3 m (1 ft) depth for melons. The alluvial soil varies from a silt loam to a clay loam in the region. Measured soil moisture levels for the 1992 demonstration are shown in Fig. 3.

Four soil moisture sensing devices[2]: tensiometer, Delmhorst gypsum blocks, Watermark sensor and Aquaterr meter were compared in 1993. Sensor measurements and rainfall and irrigation amounts are shown in Fig. 4. The Delmhorst gypsum block responded more slowly than the other devices to changes in soil moisture.

Table 2. Demonstration results for microirrigation with drip tape under plastic mulch and conventional furrow irrigation of melons in Starr County, Texas in 1992.

	drip under plastic	furrow
precipitation	66 mm (2.6 in)	66 mm (2.6 in)
irrigation water	112 mm (4.4 in)	333 mm (13.1)
number of irrigations	8	7
nitrogen (as N)	68 kg/ha (61 lb/ac)	177 kg/ha (158 lb/ac)
yield, boxes*	1235/ha (500/ac)	741/ha (300/ac)
water use efficiency (boxes/total water)	6.9/mm (71.8/in)	1.8/mm (19.1/in)
nitrogen use efficiency (boxes/application rate)	18.1/kg/ha (8.2/lb/ac)	4.2/kg/ha (1.9/lb/ac)

* 1 box = 0.14 m^3

[2]Trade names are provided for informational purposes only and do not imply endorsement by the authors or the Texas A&M University System.

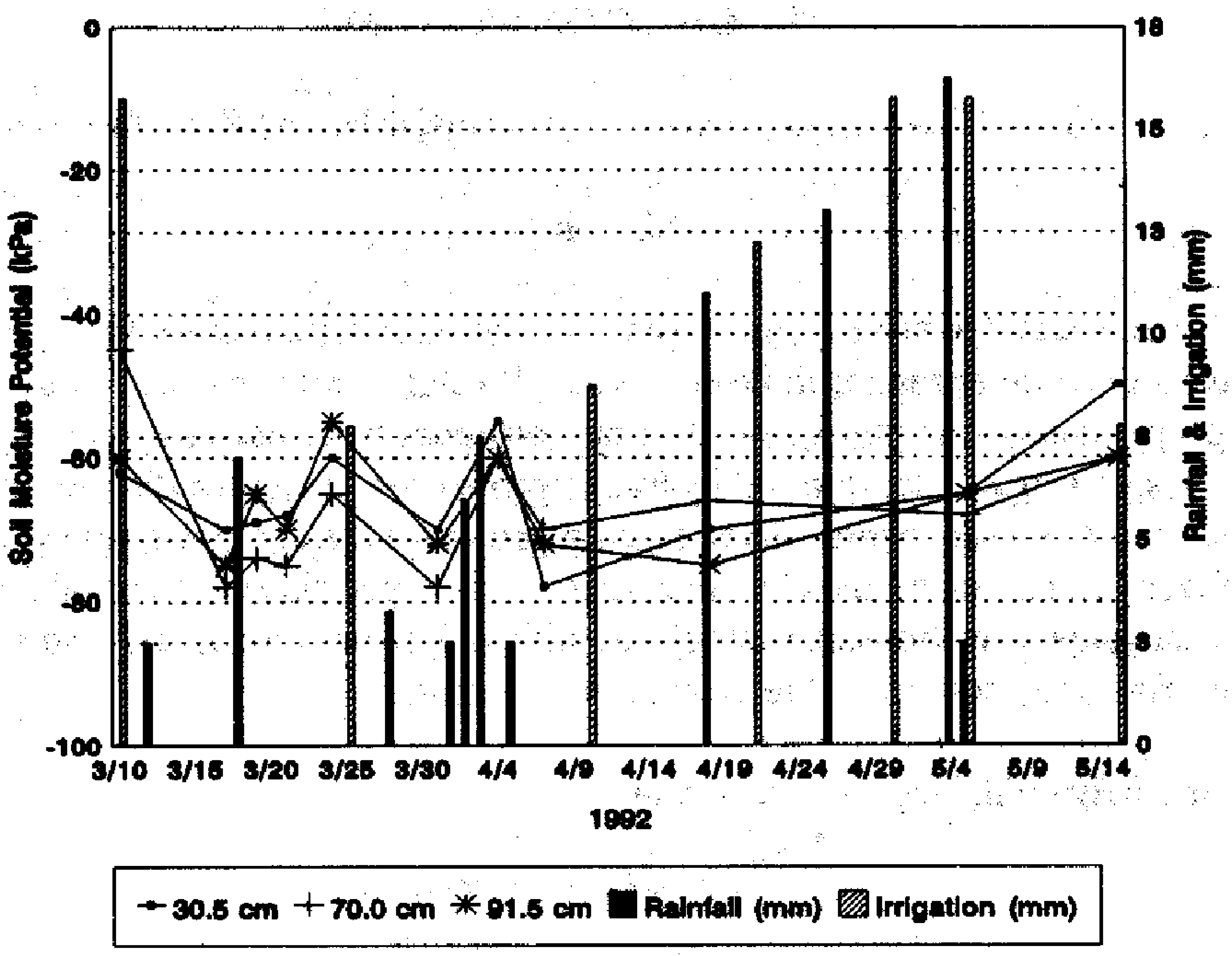

Figure 3. Soil moisture potential, rainfall, and irrigation amounts for the drip under plastic demonstration of melon production at Starr County, TX.

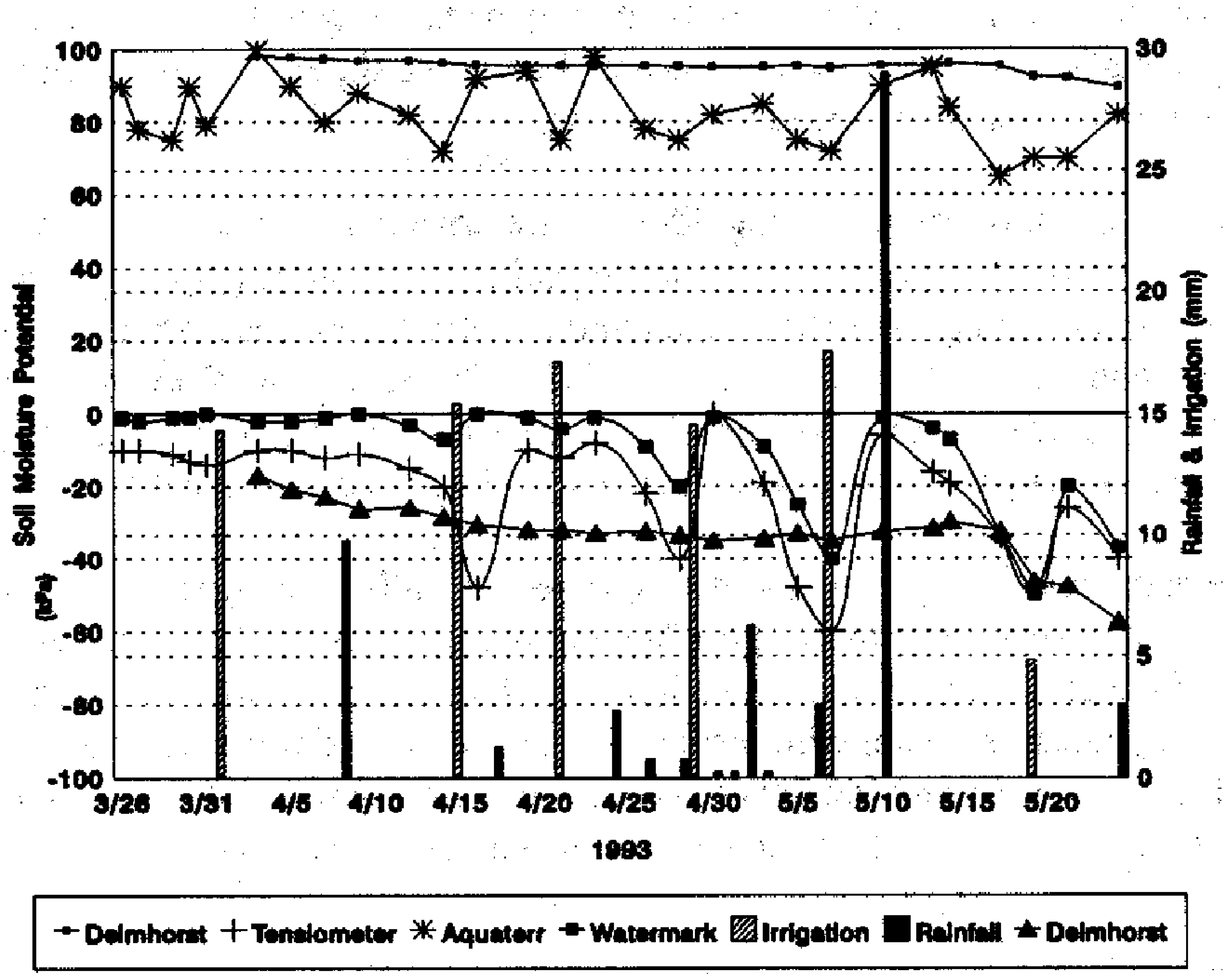

Figure 4. Comparison of 4 soil moisture sensors for drip under plastic of melons. Upper half of figure presents data for two sensors that have a unitless scale (0-100) as well as upper portions of rainfall and irrigation scale (mm).

MICROIRRIGATION DESIGN CONSIDERATIONS FOR SANDY SOIL VEGETABLE PRODUCTION SYSTEMS

G. A. Clark, C. D. Stanley, A. G. Smajstrla, and F. S. Zazueta[1]

ABSTRACT

Sandy soil vegetable production systems are sensitive with respect to water and crop nutrient inputs. Because excess or deficient levels of water or nutrients can result in yield reductions, proper design and management of microirrigation systems is essential for successful production. Systems must integrate soil hydraulic properties, crop root distribution characteristics, water requirements related to crop growth stage and environmental demand, and irrigation delivery system hydraulic characteristics. This paper discusses considerations for the design and management relationships associated with soil, plant, water, and drip emitter characteristics for sandy soil vegetable production systems.

Keywords. Drip irrigation, Irrigation scheduling.

INTRODUCTION

Since the early 1970's several research activities have evaluated vegetable crop production on sandy soils under microirrigation and in comparison with other methods (Myers and Locascio, 1972; Locascio et al., 1989; Clark et al., 1991; and Pitts and Clark, 1991). Potential water savings associated with microirrigation systems initiated regulatory agency efforts to encourage growers into adopting these conservative irrigation systems.

Advantages of microirrigation systems such as multiple cropping options (Stanley et al., 1991) and reduced bed widths to minimize plastic and soil fumigation costs (Clark and Maynard, 1992) have helped with the economics of these systems in vegetable production. However, the typically high irrigation system conversion costs (Prevatt et al., 1992) have generally retarded large scale adoption of microirrigation.

Proper design and management guidelines are essential to minimize potential problems with microirrigation systems under precise water and fertilizer management programs. Sandy soils with low water-holding capacities have limited wetting patterns from point-source drip emitters (Victor and Clark, 1991, Clark et al., 1993). Proper tubing placement (Pitts et al., 1989, Clark et al., 1994) and fertilizer scheduling (Locascio et al., 1989) are among the various design parameters requiring careful consideration for vegetable crop microirrigation systems.

While many microirrigation systems have been installed and are in use, designs are not always hydraulically balanced, low field application uniformities exist, and scheduling does not consider crop development or evaporative demand. Therefore, in efforts to compensate for these conditions, management is liberal with respect to applications of water and fertilizer. The objective of this paper is to provide general design and management considerations for microirrigation of shallow rooted vegetable crop production systems on sandy soils.

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[1] The authors are **G. A. Clark**, Assoc. Prof. of Agric. Engineering, Kansas State University, Manhattan, KS; **C. D. Stanley**, Assoc. Prof. of Soil Science, Univ. of FL, Gulf Coast R.E.C., Bradenton, FL; **A. G. Smajstrla** and **F. S. Zazueta**, Professors of Agric. Engineering, Univ. of FL, Gainesville, FL.
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Wetted soil volumes on sandy soils are similar to that shown in Fig. 1 with peak wetted radii ranging from 15 to 30 cm (Victor and Clark, 1991; and Clark et al., 1993). As a result of the soil wetting characteristics, discrete row systems used in vegetable production, and the drip tubing discharge characteristics, it is generally easier to discuss irrigation requirements and schedules in volumetric units rather than depth units. For example, Table 1 provides estimates of the available water (AW) to a crop in liters per 100 m of row length as a function of wetted radius and available water capacity (%). Available water (the difference between field capacity, FC, and wilting point, WP) ranges from 3 to 10 % for most sandy soils, but is typically in the 3 to 5 % range for many pure sands. From Table 1, a soil with a 4 % available water holding capacity, and a 30-cm wetted radius has 583 L of available water per 100 m of bed length.

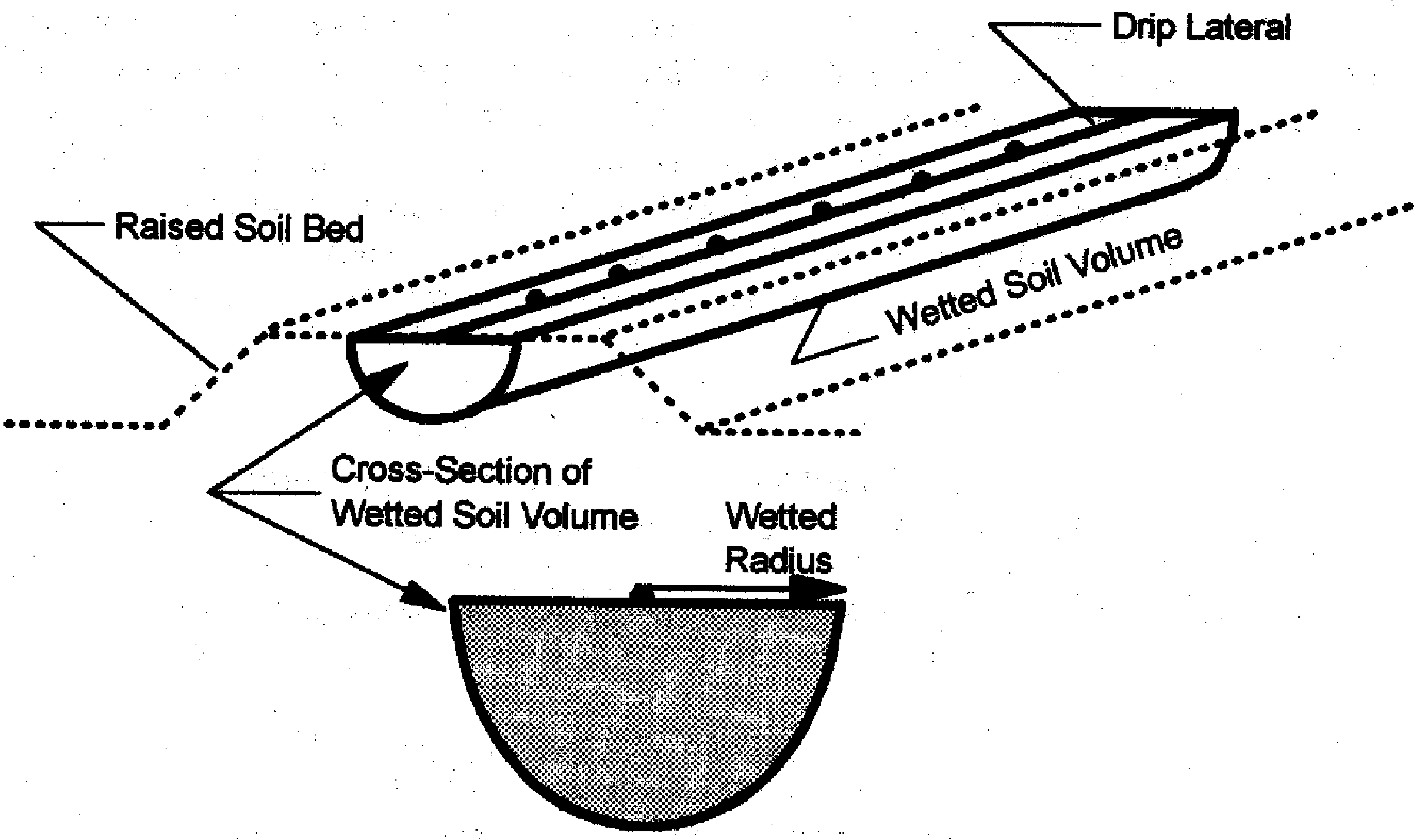

Figure 1. Wetting Patterns and Soil Volume Approximation for Line-Source Type Drip Laterals on Sandy Soils.

Table 1. Volume Of Available Water Stored In A Half Cylinder Distribution Pattern In Liters (L) Per 100 Meters (m) Of Length.

Available Water Capacity	Wetted Radius (cm) 7.5	15	22.5	30	37.5	45
(%)	(Available Water L Per 100 m of Length)					
3	25	112	248	435	683	981
4	37	149	323	583	919	1316
5	43	186	410	732	1142	1639
6	56	223	497	881	1366	1974
7	62	261	571	1018	1602	2297
8	74	298	658	1167	1825	2632
9	81	323	745	1316	2048	2955
10	87	360	819	1465	2284	3290

Average daily reference evapotranspiration (ETo) levels in Florida and the southeast U.S. typically range from 2.5 to 5.0 mm with peaks that may reach 6.5 mm (Jones et al., 1984). Many vegetable production areas are in peak production during the high evaporative demand months. Tomatoes, watermelons, green peppers, and other crops have peak crop coefficients at or near 1.0. Table 2 can be used to convert from crop water use or desired application depth in inches to volumetric units of L per 100 m of bed length. A daily crop need of 5 mm on a field with a bed spacing of 1.5 m converts to 750 L of water per 100 m of bed. Because crop ET follows the diurnal flux of solar radiation (Zur and Jones, 1981), 30 to 40 percent of the daily ET can occur during the two hour period encompassing solar noon. This can convert to peak midday ET rates of 110 to 150 L per hour per 100 m of bed.

Many vegetable crops are sensitive to even short-term water deficits, and these deficits occur rapidly with shallow root systems on sandy soils. Usable water (UW) is often taken as 40 to 50 % of AW for water sensitive, high cash value vegetable crops. Therefore, 500 L of AW per 100-m may provide only 200 to 250 L of usable water prior to the next irrigation, possibly only a 1.5 to 2 hour reserve during peak ET periods. Thus, a daily crop need of 750 L per 100-m, may require two or three irrigation cycles per day. Over-irrigation during any one cycle can potentially leach soluble plant nutrients from the root zone. Therefore, because many of these crops have shallow root systems and the soils have low water-holding capacities, frequent, short duration irrigations are generally necessary with sufficient time between cycles for plants to utilize previously applied water.

Table 2. Conversion From Depth Of Crop Water Use Or Application To Volume In Liters (L) Per 100 Meters (m) Of Bed Length.

Bed Spacing	Crop Water Use or Application Depth (mm)					
	1	2	3	4	5	6
(m)	(L per 100 m of Bed Length)					
1.0	100	200	300	400	500	600
1.5	150	300	450	600	750	900
2.0	200	400	600	800	1000	1200

Soil physical and hydraulic characteristics must be considered regarding placement of emitters and maximum run time per cycle. Drippers should be within 10 to 15 cm of plants and plant rows and no more than 2 to 5 cm deep. In addition, daily system run times of 20 to 40 minutes per cycle may be necessary during plant establishment to ensure movement of applied water into immature root systems. Maximum run times per cycle should be based on dripper discharge, soil properties including water movement, and plant rooting characteristics. Water movement can be detected using a digital volt-ohm meter and heavy electrical wire or brazing rods used as paired electrodes (Fig. 2). A measure of soil resistance is recorded prior to irrigation followed by successive measurements during the irrigation process. Soil resistance will measurably drop when the wetting front approaches the electrodes. Thus, the time required for the water to move to certain lateral and vertical positions is determined for the specific field conditions. Typical maximum run times may range from 40 minutes for coarse textured sands to 80 minutes for fine textured sands for wetted radii and depths of 25 to 30 cm. Run times per cycle in excess of these typically do not increase lateral wetting distances and may move water and soluble nutrients out of the plant root zone.

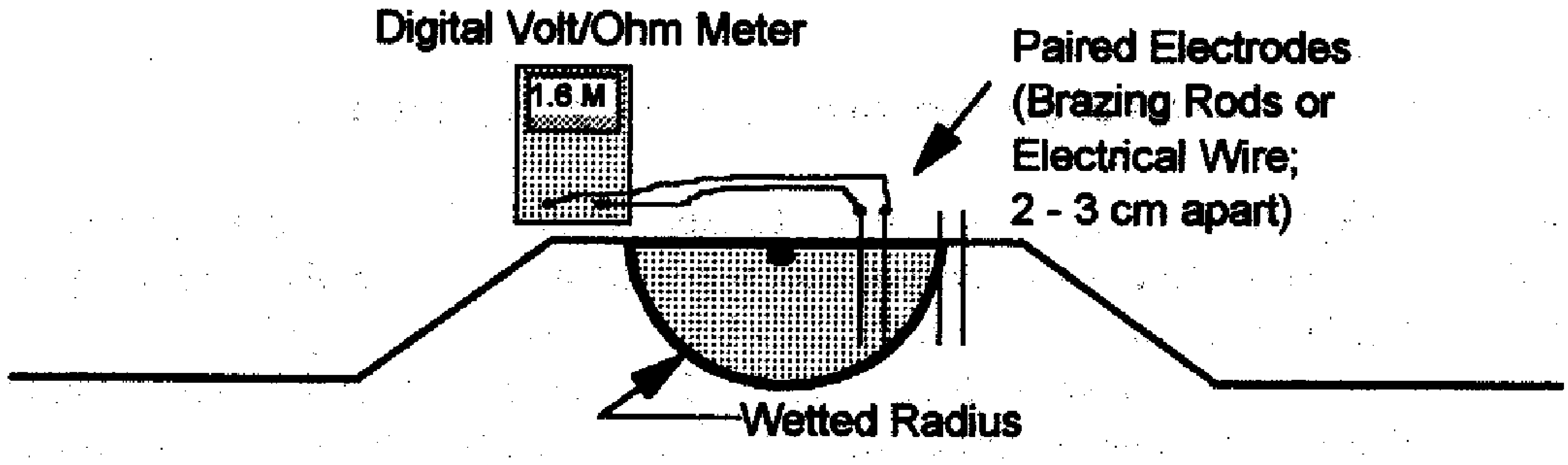

Figure 2. Soil Wetting Pattern Measurements Using a Digital Volt/Ohm Meter and Electrodes Made of Brazing Rods or Stripped Electrical Wire.

DRIP TUBING CONSIDERATIONS

Drip irrigation tubing is available in various wall thicknesses, emitter spacings, and discharge capacities. Products may be classed as tubes which typically have inserted or attached emitters and tapes which typically have emitters formed from the tubing material during the manufacturing process. Drip tube products are typically made from polyethylene tubing that is flexible, but does not collapse when depressurized. Most drip tape products collapse when not pressurized and have wall thicknesses from 4 mil for light-weight products to 20 or 25 mil for the very heavy-weight products. Vegetable crop production systems generally use drip tapes that are medium weight with wall thicknesses of 8 to 12 mil.

Emitter spacings will affect the cost of the product for tubes or tapes that use emitters that are physically attached to the tubing as opposed to the emitters molded into the tubing. Close emitter spacings of 20 to 30 cm are preferred for closely spaced vegetable crops on sandy soils. Spacings of 45 to 60 cm may be acceptable on crops that have greater plant spacings and on heavier soils. However, larger spacings are rarely used because of increased plant sensitivity to variability in emitter discharge uniformity regarding placement and availability of water and injected nutrients.

Drip emitter discharge rates typically range from 0.6 L per hour (Lph) for low flow drippers to over 4 Lph for higher flow drippers. A common tape arrangement for vegetable crops uses 1 Lph drippers on a 30-cm spacing providing 333 L per hour per 100 m of length. Higher flow rate drippers for vegetables produced on sandy soils may restrict run times to only 10 to 15 minutes per cycle due to the low water-holding capacity of the soil and shallow root zones. These times would not be acceptable for most chemical injection systems to fully purge injected chemicals from the pipe network.

Lower flow drippers may be better for use on very sandy soils. In addition, reduced lateral discharge permits greater lengths of tubing run. However, these drippers are more susceptible to clogging and require greater system maintenance. Some lower flow products discharge 150 to 200 L per hour per 100 m of length which closely matches peak ET rates of some vegetable crops. Some growers using these systems operate with single, daily irrigation cycles during crop peak growth and development periods from 1000 hr to 1400 or 1500 hr, thus continuously providing water and injected nutrients to the crop.

SUMMARY OF DESIGN GUIDELINES

Emitter Spacing: 30 to 45 cm (closer spacings for soils containing more sand and closer plant spacings).

Tube Placement: 10 to 15 inches off of the plant row and no more than 2 to 5 cm deep.

Emitter Discharge: Use low flow products (0.6 to 0.8 Lph per emitter; 2.5 to 5 Lpm per 100 m) for longer lateral run lengths; when connection manifolds are desired at field ends rather than the middle of the field; under limited water supply rates; or when longer irrigation cycle run times are desired or necessary. Use standard flow products (1 to 1.5 Lph per emitter; 6 or greater Lpm per 100 m) for water supplies (or maintenance programs) with higher clogging potentials; irrigation cycle length limitations; and on finer textured soils.

Irrigation Schedules: Initial schedules may require 20 to 30 minutes per cycle to move applied water and chemicals into the root zone. Schedules during crop growth and development may be limited to 40 to 80 minutes (maximum) per cycle for standard flow products (use reduced times on the more coarsely textured sands). Apply up to three cycles per day during peak growth and demand periods (morning, noon, and early afternoon). Longer cycle run times may be used with low flow products.

REFERENCES

1. Clark, G. A., C. D. Stanley, D. N. Maynard, G. J. Hochmuth, E. A. Hanlon, and D. Z. Haman. 1991. Water and fertilizer management of microirrigated fresh market tomatoes. Trans. of the ASAE 34(2):429-435.

2. Clark, G. A. and D. N. Maynard. 1992. Vegetable production on various bed widths using drip irrigation. Appl. Eng. in Agr. 8(1):29-32.

3. Clark, G. A., C. D. Stanley and F. S. Zazueta. 1993. Qualitative sensing of water movement from a point-source emitter on a sandy soil. Appl. Eng. in Agr. 9(3)299-303.

4. Jones, J. W., L. H. Allen, S. F. Shih, J. S. Rogers, L. C. Hammond, A. G. Smajstrla, and J. D. Martsolf. 1984. Estimated and measured evapotranspiration for Florida climate, crops, and soils. Fla. Coop. Ext. Ser. Bul. 840., Gainesville. 65p.

5. Locascio, S. J., S. M. Olson and F. M. Rhoads. 1989. Water quantity and time of N and K application for trickle-irrigated tomatoes. J. Amer. Soc. Hort. Sci. 114(2):265-268.

6. Myers, J. M. and S. J. Locascio. 1972. Efficiency of irrigation methods for strawberries. Proc. Fla. State Hort. Soc. 85:114-117.

7. Pitts, D. J., C. E. Arnold and J. M. Grimm. 1989. Influence of lateral tubing location and number on growth and yield of tomatoes with micro irrigation. Proc. Fla. State Hort. Soc. 102:304-307.

8. Prevatt, J. W., G. A. Clark and C. D. Stanley. 1992. A comparative cost analysis of vegetable irrigation systems. HortTechnology 2(1):91-94.

9. Stanley C. D., A. A. Csizinszky, G. A. Clark, and J. W. Prevatt. 1991. Sequential cropping for vegetable production using microirrigation on sandy soils in southwestern Florida. HortTechnology 1(1):72-76.

10. Victor, P. R. and G. A. Clark. 1991. Uniformity of soil moisture in microirrigated plastic mulched beds. Soil and Crop Sci. Soc. of Fla. Proc. 50:9-12.

11. Zur, B. and J. W. Jones. 1981. A Model for the water relations, photosynthesis, and expansive growth of crops. Water Res. Res. 17(2):311-320.