Automatic Soil Moisture-Based Drip Irrigation for Horticultural Crops

Rafael Muñoz-Carpena[1], Michael D. Dukes[2], Yuncong Li[1] and Waldemar Klassen[1]

[1]Tropical Research and Education Center, University of Florida, Homestead; [2]Agricultural and Biological Engineering Dept., University of Florida, Gainesville

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Outline

- Introduction
- Objectives
- Experiment
- Results

Introduction

- Florida growers are at a competitive disadvantage due to off-shore competition where labor is considerably cheaper than in the United States, and stricter environmental regulations are in place.

- Improving irrigation efficiency can contribute greatly to reducing production costs making south Florida's horticultural industry more competitive and sustainable

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- Soils with low water holding capacities (sands, gravels) are common in south Florida. These soils present special water management challenges

- Traditional irrigation based on low frequency (a few times per week), large volume irrigation usually results in over-irrigation in south Florida soils. Excess water in the root zone from excess irrigation has been shown to reduce yields and can negatively affect ground water quality.

- As an alternative to traditional irrigation systems, a low volume of water can be applied frequently (several times a day) to maintain a desired moisture range in the root zone that is optimal for plant growth.

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- Efficient and modern irrigation systems today are based on THREE PRINCIPLES:
    1) high-frequency/low volume (several times per day)
    2) soil moisture sensor based scheduling
    3) automatic operation
- One added benefit of high frequency, soil moisture-based automated irrigation is <u>convenience</u>. Once the system is properly installed, normally only minimal supervision is required.

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Objectives

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Evaluate the performance of QIC, a newly designed real time irrigation controller based on soil moisture content, on tomato in the fall 2003 through the spring 2004

Experiment

- A research and demonstration project was conducted at UF/IFAS Tropical Research and Education Center, Homestead (Florida) on a Krome gravelly-loam soil.
- Tomatoes were cultured and protected according to local agronomic practices.
- A field (0.4 acre) in which sorghum sudangrass had been grown as a summer cover crop was used for this experiment.
- The tomato seedlings of the cultivar, ‘FL 47’, were transplanted on 11/20/03 into plastic mulched raised beds spaced 1.83 m apart in one row per bed, with plants spaced 0.46 m, and supplied with dual drip irrigation lines under the plastic mulch.

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- Pre-plant dry fertilizer (6-6-12) at1867 kg/ha was rototilled into the bed. Dissolved fertilizer (4-0-8) at 2.8 kg N/ha was applied manually to each individual plant only during each of the final 5 weeks prior to harvest.

- Tomatoes were harvested four times during the period March 1 -18, 2004. Harvested fruits were graded following Florida Tomato Committee standards.

- Irrigation treatments were established in a randomized complete block design with 3-4 replications. Irrigation scheduling methods consisted of soil moisture based (switching-tensiometer and QIC/dielectric probe), historical evapotranspiration (ET) weather based, and local grower practices.

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Table 1. Irrigation treatments, scheduling methods, and scheduling devices.

Treatment	Scheduling Method	Scheduling Device
C1	no_Kc-High (10 cbar)	Tensiometer
C2	no_Kc-Low (25 cbar)	Tensiometer
C3	no_Kc-Low - 400mV	QIC/ECH2O
C4	no_Kc-High- 450 mV	QIC/ECH2O
C5	kc-High (100% needs)	ET/historical weather
C6	no_Kc-High (100% needs)	ET/historical weather
C8	Kc-Low (75% needs)	ET/historical weather
C10	Typical grower schedule	Custom

Kc/ no_Kc: ET-based adjusted/not_adjusted with crop coefficient;
Low/High: low moisture (dry) and high moisture (wet) treatments;

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Irrigation design

1	*7	*3
*4	*1	*3
*8	2	*9

*2	*5	6
*10	*2	*9
*10	*10	*2

*1	*8	*7
4	*5	*1
*6	*6	*5

5	*6	*4
*7	*4	3
*3	*9	*8

PUMP --> *N*

Tape:T-TAPETSX 508-12-450 (double drip lines)
Internal diameter=0.625 in
Drip spacing=12 in
Nominal flow=0.450 gpm/100'
Nominal pressure=8 psi
Entry working pressure: 10 psi

Max needs=3800 g-ac-d
Each plot= 0.083 acre
Max needs/plot=233 gal/d
Time to irrigate ≈ 60 min/plot-day
Max no. of irrigations/day=4
Time/irrigation=15 min/plot

Pump: 1HP, well tank 35-50psi

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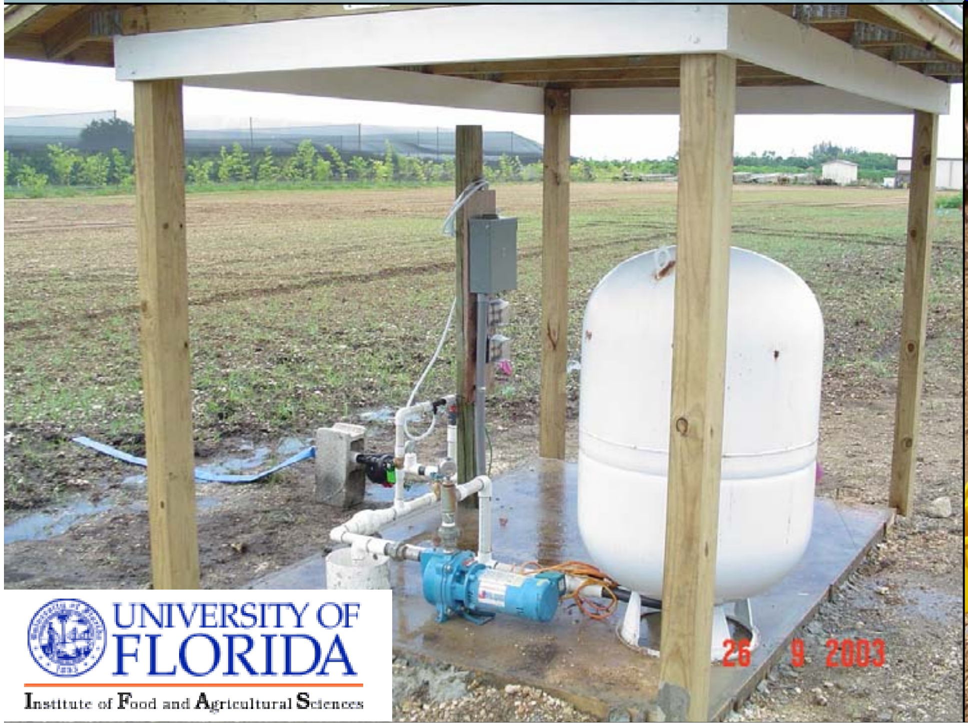
Irrigation system



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- The tensiometer, QIC, and ET/weather-based methods were set to irrigate a maximum of four times each day (high-frequency-low-volume). The grower schedule was set to irrigate one time (morning) per day (high volume/low frequency).
- Tensiometer and QIC methods allowed irrigation only if soil tension exceeded set points for tensiometer treatments, or if soil moisture was below set points for QIC treatments, respectively.
- The tensiometer-based methods were comprised of switching tensiometers set at two levels (High:10 cbar and Low:25 cbar).
- The QIC system was set at two thresholds of Low:400 mV and High:450 mV, corresponding to the soil moisture level at 25 cb and 10 cb, respectively, for the gravelly-loam soil of the area

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- The soil moisture sensors were wired in closed loop control with the irrigation timer. With this setup, if sufficient soil water is available (below 10 or 25 cbar), sensors can by-pass irrigation start-up signals sent to the electro-valve by the irrigation controller.

- The signals from the irrigation controller were sent on five times a day for each sensor-based replication. This way a significant volume of water can potentially be saved during periods of reduced plant-water needs, and the soil moisture kept at optimal levels in the root zone.

- The sensors were inserted 30 ft from the electro-valve, between plants, in the center of the bed

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Results

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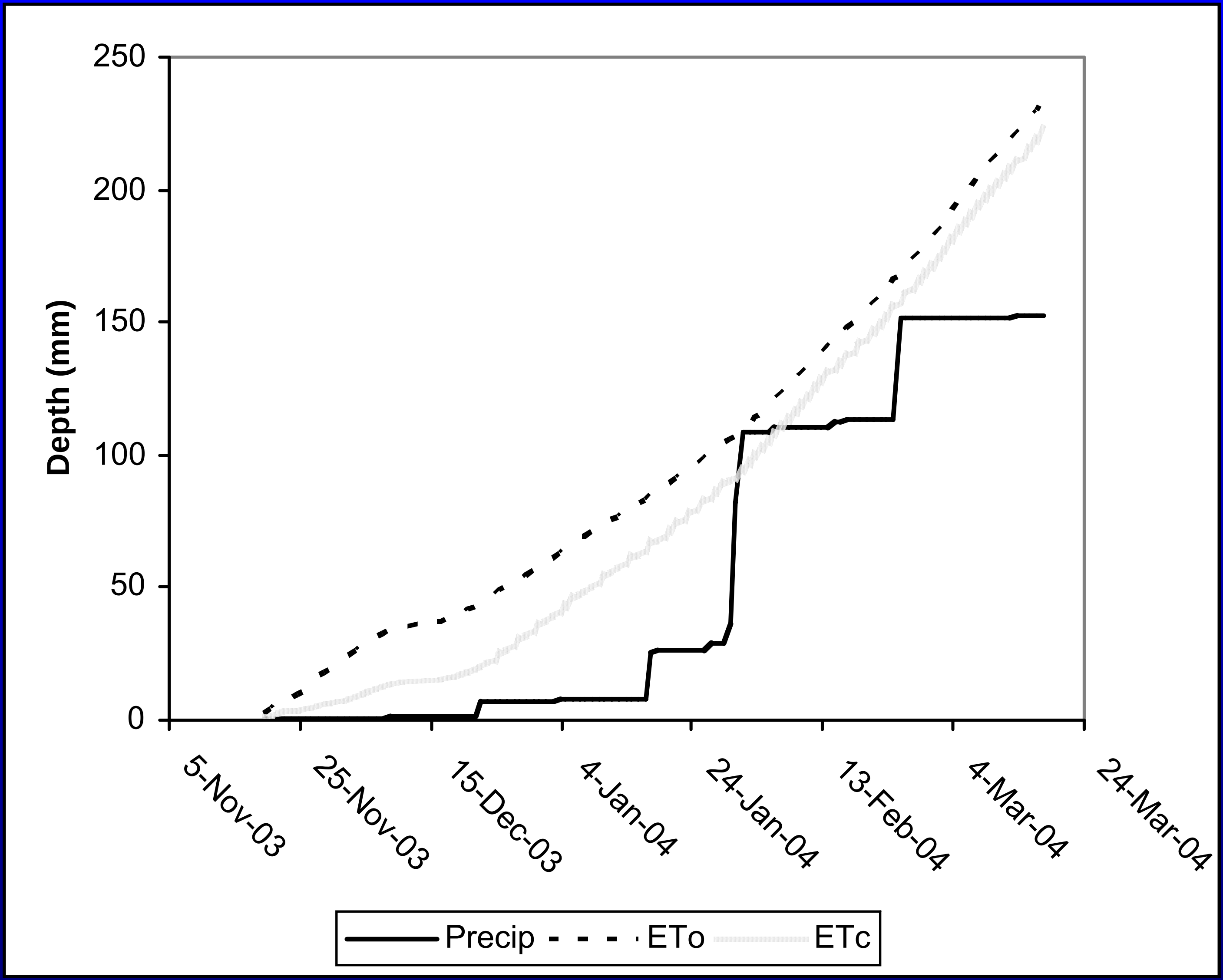
ET/Rainfall measurements:

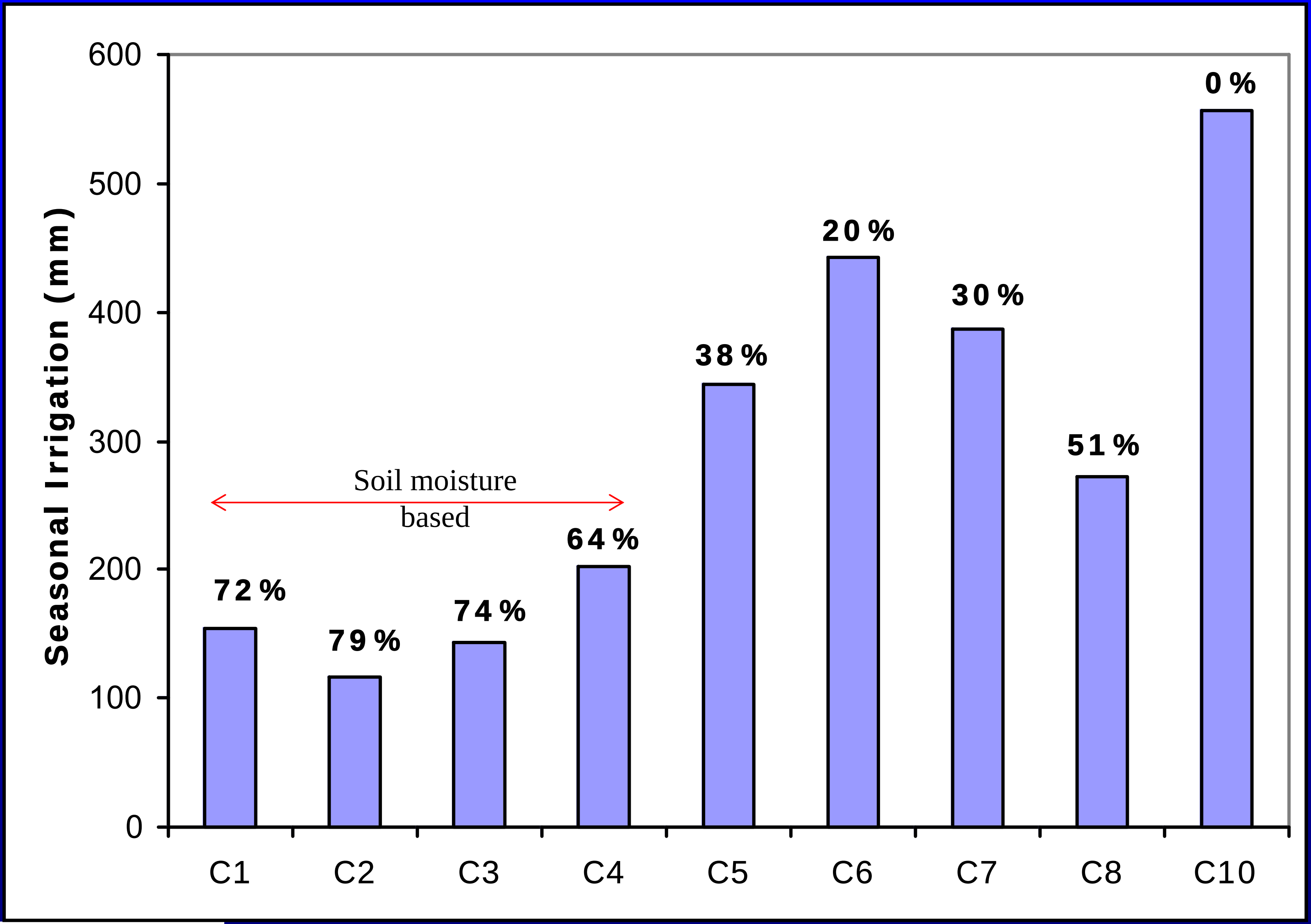


Water use and yields and efficiency:

Treatment Number	Seasonal Irrigation (mm)	CV	Marketable Yield (kg/ha)	CV	Irrigation WUE (kg/m^3)	CV
C1	154 d	0.51	36,852 ab	0.23	27.4 ab	0.34
C2	117 d	0.90	40,835 a	0.03	58.7 a	0.71
C3	144 d	0.52	37,538 ab	0.29	31.9 ab	0.49
C4	202 cd	0.49	37,790 ab	0.21	23.2 ab	0.66
C5	345 bc	0.05	36,728 ab	0.08	10.3 b	0.09
C6	442 ab	0.07	27,834 b	0.19	5.6 b	0.12
C8	272 bcd	0.17	37,306 ab	0.11	14.9 b	0.18
C10	556 a	0.23	28,300 ab	0.08	5.1 b	0.31

Numbers followed by the same letter are not significantly different based on Duncan's Multiple Range Test at the 95% confidence level. Coefficient of variation for each treatment indicated by CV columns

Water savings:



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Tomato yields were not affected (at 5% signif. level)

Sensor performance:

- Switching-tensiometers, when subject to weekly maintenance, performed well and consistently across repetitions for each treatment
- However, if left unattended for more than a week, air entered the tensiometer breaking the water column. The problem increases the with the driest treatment (25 cbar).
- From a practical point of view it is essential in South Florida field conditions to include routine maintenance of tensiometers (minimum of once a week is recommended).

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- The QIC prototype performed consistently well without requiring any maintenance (2 boxes were substituted earlier on in the trial).
- This system is now being evaluated for peppers in sandy soils of central Florida and
- The reduction of deep percolation and potential benefit to water quality will be evaluated in the Fall 2004 at TREC

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THANK YOU!

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