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**Drip Irrigation Management by TDR Monitoring
of Soil Water and Solute Distribution**

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DRIP IRRIGATION MANAGEMENT BY TDR MONITORING OF SOIL WATER
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ABSTRACT

Drip irrigation has the potential of high water use efficiency, but actual water measurement is difficult because of the limited wetted volume. Two long - term experiments in orchards in Israel and in California and several field crop studies supported by this project have demonstrated the feasibility of precise monitoring of soil water distribution for drip irrigation in spite of the limited soil wetting. Time Domain Reflectometry (TDR) enables in situ measurement of soil water content of well defined small volumes. Several approaches were tried in monitoring the soil water balance in the field during drip irrigation. These also facilitated the estimation of water uptake:

1. The use of a multilevel moisture probe TDR system. This approach proved to be of limited value because of the extremely small diameter of measurement.
2. The placement of 20 cm long TDR probes at predetermined distances from the drippers in citrus orchards.
3. Heavy instrumentation with neutron scattering access tubes and tensiometers of a single drip irrigated almond tree.
4. High resolution spatial and temporal measurements (0.1m x 0.1m grid) of water content by TDR in corn irrigated by surface and subsurface drip.

The latter approach was accompanied by parametric modelling of water uptake intensity patterns by corn roots and superimposed with analytical solutions for water flow from point and line sources. All this lead to general and physically based suggestions for the placement of soil water sensors for scheduling drip irrigation.

ORIGINAL OBJECTIVES

1. Define critical zones of measurement of water content and salinity in a drip irrigation situation, based on soil hydraulic properties, water quality, emitter discharge and placement (surface or subsurface) and crop characteristics.
2. Develop practical guidelines for proper management of drip irrigation with different water qualities based on joint use of TDR measurements and physical models.

DEVIATION FROM ORIGINAL OBJECTIVES

In the original objectives the effects of salinity and water quality were included. The task of defining critical zones of measurement of water content, the development of proper methodology and physical models for different configurations of drip irrigation proved to be a formidable one. Therefore, the effects of water quality were not investigated and additional research is needed on this topic.

3. INTRODUCTION

Drip irrigation offers a large degree of control on water application. High irrigation efficiency requires, in addition to this, precise scheduling and management, which depend on knowledge of the components of the soil water balance (root water uptake, evaporation and drainage). Monitoring changes in the soil water content of the wetted volume and their proper interpretation is a prerequisite to proper drip irrigation management.

In this report, a systematic approach to this problem is attempted. In the first part (section 4) the feasibility of drip irrigation in orchards as compared to other microirrigation methods is investigated by two long-term experiments.

The second part (section 5) shows different approaches to the monitoring of the soil water balance in orchards and field crops:

- by using single or multilevel TDR (time domain reflectometry) probes,
- by heavily instrumenting one tree with neutron scattering tubes and tensiometers,
- or by the use of a high resolution (10×10 cm) TDR grid with corn.

In the third part (section 6) several approaches to the modeling of root growth, soil water flow and plant water uptake are tried. In the first paper by Clausnitzer and Hopmans the growth of individual roots as a function of the changing soil environment is dynamically simulated in a general way. In the second paper by Coelho and Or, more relevant to drip irrigation, relatively simple analytical solutions are applied to steady and transient water flow from point sources. These solutions were combined with simple parametric models for two-dimensional water uptake by corn roots under drip irrigation. The third paper in this section by Or and Coelho shows good agreement between the water flow and plant uptake models and experimental results obtained for different plant-dripper configurations.

Finally, in the last section, this approach is applied to the problem of sensor placement based on physical principles, also in heterogeneous soils, which is the main objective of this study.

9. DESCRIPTION OF COOPERATION

The basis of cooperation on this project was laid during the winter of 1990-1991, when S. Dasberg and D. Or were at the department of Land, Air and Water resources at UC Davis. Frequent discussions and formal meetings between Hopmans, Dasberg, Or and Schwankl were held during this period and resulted in the proposal. The almond orchard at the Nichols tract was proposed by Schwankl as a possible field site and approved by the other members of the team.

In October, 1993, Jan Hopmans paid a short visit to Israel. The site of the citrus experiment in Nordiya was inspected and the initiation of the project in Davis and in Israel was discussed. There was frequent E-mail contact between Dasberg and Or in Logan, Utah. In July 1994 Hopmans and Dasberg met again at the International Soil Science Society Congress in Acapulco, Mexico.

Dasberg and Or met at the microirrigation congress in Orlando, Florida in April 1995. Or visited Israel for several weeks in July 1995, and again during the Agritech conference in May 1996. This conference was also attended by Schwankl. At that time we started to work on the final report of the project.

10. LIST OF PUBLICATIONS

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