Farm Level Optimal Water Management Assistant for Irrigation under Deficit

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Int. Symp. on Strategies Towards Sustainability of Protected Cultivation in Mild Winter Climate

Antalya (TURKEY), April 6-11, 2008
Contributing countries and target areas

Co-ordinator: Wageningen-UR (NL)
Start: Oct. 2006
Duration: 3 years
Partners: 10
Water management trends

- Over irrigation in cases of high (fresh) water availability
  - Irrigation amounts depend on availability
  - Leaching or run-off of water and nutrients

- Deficit irrigation if water availability and irrigation water quality is low
  - Use of marginal water resources
  - Yield losses and crop damages
Objectives

- **Sustainable irrigated agriculture**
  - Efficient use of available water
  - Rational use of nutrients and marginal water resources
  - Economically and socially accepted farming

- **Improve irrigation practices by introducing new tools**
  - Decision Support System for optimal irrigation
  - Sensitive, simple and affordable tools to determine optimal amount and source of water
  - Generally applicable in Mediterranean countries for protected and non-protected cultivation
System Components

- Decision Support System
  - Farm Zoning and Crop Planning
  - Irrigation Scheduling
    - Allocate water and schedule irrigation
    - Individual farm zones
    - In view of expected water availability (amount and quality)
  - Economic Optimizer for Water Allocation
  - Crop Response Model for Deficit Regimes

- Irrigation System
  - Remote Irrigation Controller
  - Wireless Sensor Network
System Layout

Plot 1

Valves

Irrigation Controller

Sensors

Wireless Network

Local Computer

Grower Input

Remote Computer

Plot 2

Sensor Node (MOTE)

Decision Support System

Irrigation scheduler

Farm Zoning Module

Crop Response Model

Crop Database

Remote Computer

Basin Management
Weather/Water Forecasting
DSS-Irrigation Scheduler

- Farm-level tool
- Day to day planning
- Short-term Water Availability
- Weather Forecasts
- Plant Status (Crop model)
- Set Irrigation Controllers

DECISION SUPPORT FOR OPTIMISED IRRIGATION SCHEDULING

Sigrimis, N., Anastasiou A. et al.
Economic Optimizer for Water Allocation

- Web-based Advising Tool
  - Used every season for Farm Zoning and Crop Planning
  - Regularly used for Optimal Economic Water Use Efficiency
  - Multiple crops/plots
  - MOPECO (Ortega)
  - Crop response model for deficit

- Inputs of farm related data
  - Long-term water availability
  - Local constraints:
    - Economics, crops, sizes, machines, water constraints …

- Outputs
  - Maximum Gross Margin
  - Optimum Distribution of Crops
  - Scheduling tasks, water allocation and sources

Diagram:
- Crops restrictions
  - Maximum irrigated area
  - Maximum gross irrigation depth
  - Max. and Min. set-aside area

- Farm restrictions
  - Maximum irrigated area
  - Available volume for irrigation

- Optimizer

- Maximum Gross Margin

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Crop Response Model for Deficit

- Yield response to
  - Water Quantity (ET-based)
  - Water Quality (Salinity model)

\[ Y = 100 - B \cdot (EC - A) \]
Crop Response Database

Salinity response of vegetable crops

Threshold Salinity (ds/cm)

Yield Decline (% per dS/cm)

Tolerant
- Asparagus
- Cherry Tomato
- Purslane
- Zucchini
- Artichoke
- Garden beet
- Rocket salad
- Turnip
- Broccoli
- Tomato
- Cucumber
- Carnation
- Melon
- Cabbage
- Celery
- Spinach
- Rose
- Eggplant
- Chrysanthemum
- Pepper
- Lettuce
- Onion
- Fennel
- Radish
- Carrot

Sensitive
**Wireless Network**

- High spatial and temporal density
  - Multiple nodes
  - Multiple sensors

- **Wireless Advantages**
  - No cabling
  - Easy installation and handling

- **Robustness in field**
  - Weather
  - Data Reliability
  - Long Range
  - Solar powered or long battery life time
Improve Sensor Performance

- **Volumetric Water Content**
  - Soil/substrate calibrations

- **EC**
  - WET-sensor, ECHO-probe
  - Pore Water EC calibration

- **Porous Matric Sensors**
  - New Tensiometer
  - Large range (no air entry at dry end)

Calibration of WET-sensor for water content and pore water EC in different horticultural substrates;
[Incrocci, A. & Incrocci L. et al.](#)
Controller and Sensors

- Irrigation – Fertigation
  - Stand-alone operation
  - Parameterized
  - Wired or via GSM-link
- Activation On/Off
  - Timed
  - Sensor controlled
    - Water content, EC,
    - Tensiometer
    - Temperature, Rain gauge
    - Radiation …
  - Model based (f.i. ET)
  - Multiple valves
  - Multiple water sources
Field tests

- **Targets**
  - use deficit irrigation or prevent leaching
  - evaluate water use efficiency and yield
  - compare with common irrigation practise

- **Constraints**
  - crop production systems
  - system complexity
  - crop types
  - irrigation structures
  - availability of water
    - local/external water sources
    - amount and quality
  - goals and regulations
Italy

- Nursery stock production
- Experimental Station CeSpeVi, Pistoia, Tuscany
- Container plants (drip/sprinkler)
- Farm sizes: 10 - 100 ha
- Irrigation unit size: approx. 1200 m2
- Deficit (zero-drain)
- Dual water irrigation: Cleaned Waste Water and Fresh Water
Turkey

- Region Izmir (Tahtalı Dam)
  - Preservation area
  - Greenhouses permitted
  - Water from wells, but no leaching allowed

- Test-site targets
  - Test-site at local farmer (Cucumber)
  - Irrigation: zero drainage
  - Sensor activated control
  - Monitoring crop yield and quality

Response of Cucumber to Deficit Irrigation

Tuzel H. et al.
EC Project no. 036958 (FP6)

Thanks for your attention
### Tomato Developmental Stage

<table>
<thead>
<tr>
<th>Crop (Short name)</th>
<th>Developmental stage (description)</th>
<th>$K_C$</th>
<th>$RD$</th>
<th>$P$ (RAW/TAW)</th>
<th>$K_Y$</th>
<th>$EC_{th}$</th>
<th>$b$</th>
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<tbody>
<tr>
<td>I</td>
<td>Initial</td>
<td>0.6</td>
<td>0.25</td>
<td>0.30</td>
<td>0.4</td>
<td>2.0</td>
<td>9.0</td>
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<tr>
<td>II</td>
<td>Crop development</td>
<td>0.6</td>
<td>0.25</td>
<td>0.30</td>
<td>1.1</td>
<td>2.0</td>
<td>9.0</td>
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<tr>
<td>III</td>
<td>Mid-season</td>
<td>1.15</td>
<td>1.0</td>
<td>0.40</td>
<td>0.8</td>
<td>2.0</td>
<td>9.0</td>
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<tr>
<td>IV</td>
<td>Late season</td>
<td>0.7</td>
<td>1.0</td>
<td>0.50</td>
<td>0.4</td>
<td>2.0</td>
<td>9.0</td>
</tr>
<tr>
<td>V</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2.0</td>
<td>9.0</td>
</tr>
<tr>
<td>Total growing cycle</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.30</td>
<td>1.05</td>
<td>2.0</td>
<td>9.0</td>
</tr>
</tbody>
</table>
Jordan

- **Irbid, Jordan Valley**
  - Fruit trees, oriental trees, vegetables
  - Very limited water resources
  - Low water use efficiency
  - Poor water management at farm level

- **Pilot Project Site**
  - Treated Waste Water (2 types)
    - Extended Aeration (1000m³/day)
    - Rotating biological contactors (600m³/day)

- **Objectives**
  - Experiment with soil grown tomatoes
  - Dual water quality irrigation
  - Efficient irrigation scheduling
  - Use of soil moisture sensors (a.o. EC)
  - Technology transfer to farmers
**Lebanon**

- Litany River, South Bekaa Valley
  - Fruit trees and vegetables
  - Water sources
    - 2000 ha, pressurized pipelines (sprinklers and tricklers)
    - 4700 ha, furrow irrigation and other traditional surface irrigation

- Evaluation of Technology
  - Pilot irrigation farms
  - Deficit irrigation performance (potato)
  - Pressurized versus surface irrigation
  - Water use efficiency, yield and growth
  - Socio-economic impact
  - Evaluation Farm Zoning and Crop Planning
DSS implementation

Remote Client (basin management weather service ...)

Local Server at farm

Controller 1

Controller 2

Controller 3

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