Technology and science for efficient irrigation

Supporting tools for growers to cope with water shortages as well as legislation like the Water Framework and the Nitrate Directive

FLOW AID

Farm Level Optimal Water Management Assistant for Irrigation under Deficit

Wageningen (The Netherlands)
July, 22nd, 2010

EC project: 036958

Public Report
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**Consortium:** 11 partners from 8 countries

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<th>Partners</th>
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<td>Wageningen University &amp; Research Center, Plant Research International</td>
<td>NL</td>
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<td>Rothamsted Research</td>
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<td>University of Castilla La Mancha, Regional Center of Water Research</td>
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More Crop per Drop

Technology supports growers to cope with water shortage challenges as well as legislation like the Water Framework and the Nitrate Directive

Water shortage forces growers to adopt deficit irrigation practices. They tend to irrigate with less water at a lower quality. To avoid crop damages and income losses, they need to manage their water and nutrients more precisely. New technology based tools might help them by making the most optimal operational decisions. The extra income, due to slightly higher yields and use of less fertilizers, might help to invest in these new technologies.

The Problem

Agriculture is the largest user of water, making it a big competitor for domestic and industrial users. To secure our food production for future generations, the irrigation water use efficiency must be increased drastically, in other words: we need “more crop per drop”.

Generally the way to go is to avoid spilling of water, and to ensure that all the irrigation water is being used by the crop. Over-irrigation invokes leaching of water and fertilizers affecting the environment. This can be ensured by optimizing irrigation equipment and irrigation management.

However, in many cases this step is not enough, and currently growers need to adopt a deficit irrigation strategy in which they supply water under the advised FAO amount or even use non-fresh water resources. Crop yield is closely related to water and fertilizer use. Limiting water supply or using marginal water resources might result in yield and quality losses. Working under deficit conditions means that the grower needs to operate his water management more precisely to prevent income losses. He cannot longer rely on his common sense, but needs help from technology.

Container grown ornamental plants grown under high saline conditions show crop damages: brown leaves (Italian case study)
**Objectives**
FLOW-AID contributes to sustainable irrigated agriculture by developing a deficit irrigation management system for farm-level crop production in cases with limited water supply and marginal water quality. It integrates innovative sensor technologies into a decision support system, taking into consideration boundary conditions and constraints for a number of practical growing systems in the Mediterranean. It focuses on innovative, simple and affordable, hard- and software concepts; particularly a maintenance free tensiometer, a wireless and low-power sensor network; an expert system for farm zoning and crop planning in view of expected water availability and quality; and an irrigation scheduler for allocation of multiple water sources. The system is being evaluated at five sites located in Italy, Turkey, Lebanon, Jordan and the Netherlands, which differ in the type of local constraints, irrigation structures, crop types, local water supplies, availability of water and water sources in amount and quality, the local goals, and their complexity.

**Methodology**
The FLOW-AID system consists of irrigation controllers, distributed over the irrigated farm zones. They are connected via a wireless link to a local computer that regularly reads out sensor data and updates the scheduling programs running autonomously in the controllers. A Decision Support System containing an expert system with “best practice irrigation rules”, running either on the local or remote (connected via internet) computer helps growers to optimise their scheduler programs in view of the expected water availability and climatic conditions on a long-term as well as short-term basis. During three growing seasons, the system components are mainly being evaluated at Mediterranean test-sites. Over the years, the system is enhanced and the final system was shown to farmers during the 3rd year at the test-sites. The FLOW-AID system is being developed through a close partnership between research institutes, universities and SME’s.

*Intensified use of technology in the field (Lebanese case study)*
Results
Industry and SME’s may take up the following research results to build new hardware and software for deficit irrigation systems:
1. Low-cost sensor and controller technology: a solid-state tensiometer; a wireless, low-power sensor network for soil moisture and EC sensors; an irrigation controller for optimal irrigation scheduling.
2. A Decision Support (Expert) System to assist in farm zoning and crop planning, in view of expected water availability (amount and quality); a crop response model for deficit irrigation; and a deficit irrigation scheduling module that allocates available water(s) among several plots.

The SME partners involvement already ensures that the results will be implemented in a short time into adequate and appropriate products for the end-user irrigation market. The participation of the Mediterranean test-sites ensures that the final products will also be fine-tuned to the [economic and physical] conditions of non-European markets, where the largest growth for irrigation equipment is expected.

Case studies have shown that compared to current practices, by using innovative technologies, the water use efficiency can be raised up to 10% while maintaining the existing crop yields.

Application of new technologies cost money. Some case studies have shown that by using technology and adapting strategies one could even raise the productivity up to 10%, while the amounts of water and nutrients being used where less than current practices. By using treated waste water resources farmers could benefit from the already available nutrients in these water sources. Farmers might use this extra income for investing in new technologies.

Result of the Jordan case study (left) in which conventional and innovative irrigation practices are compared under standard and deficit regimes. It was shown that when using fresh water sources the water use efficiency can easily be raised with 10%. When using marginal water resources (treated waste water), irrigation management is more complex, but one can make use of the extra nutrients in the water source. Result of the Turkey case study (right) show that innovative irrigation practices, whether with full irrigation or under deficit, give a better (10-40%) water use efficiency compared to farmer practice.
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Practice, Brussels Belgium 28-29 May 2009, p 64/69.
DEFICIT IRRIGATION MANAGEMENT SYSTEM USING SENSOR ACTIVATED CONTROL:
RESULTS OF FIVE CASE STUDIES. Third International Symposium on Soil Water
Measurement Using Capacitance, Impedance and TDT, Murcia, Spain, April 7–9, 2010.

The following briefs are available through www.flow-aid.eu

Technology Briefs
A New sensor to measure matric potential: The dielectric tensiometer
Wireless sensor systems for irrigation management High density measurement of soil
moisture, EC and temperature
A Crop Planning and Farm Zoning Tool
Crop stress response model: Assessment of crop yield response to water and salinity
stress
Optimal management of irrigation under scarcity: A decision support system,
derivation and working of the system
Sensor activated Irrigation Controllers: Precise management of irrigation water to
minimise environmental damage & wastage
Sensor Activated Fertigation Controllers: Managing fertigation and dual water
irrigation in container crops

Case Study Results
LEBANON: Optimizing Farm Water management Using Smart Irrigation Controller:
Field grown eggplants under different irrigation regimes
JORDAN: Irrigation strategy with dual quality water: Irrigation with Fresh and Treated
Wastewater under full and deficit soil moisture conditions for Tomato Crop
TURKEY: More Yield, less water and less leaching: Minimization of leaching for
cucumber grown in greenhouses under mild winter conditions.
ITALY: Dual Water Irrigation of Pot Ornaments: Saving water resources in
ornamental nursery industry
THE NETHERLANDS: More yield, more quality and less emission of nitrate: Soil grown
Iceberg lettuce under rain-fed conditions
Coordination, wireless sensor network and irrigation scheduler
Water management, agronomy, ICT systems, software/hardware, optimal control engineering, soil sensors, crop response to irrigation with saline water, optimal use of low-quality water.

Dielectric tensiometer
Sensor development, especially for hydraulic pressure. Whole plant responses to root stress. Modelling climate change, crop growth, physical stresses, root environment, soil water.

Farm Zoning based on long term water availability
Crop planning and modelling irrigation management. Irrigation technology and scheduling, sprinklers, micro-irrigation, agricultural water management and conservation, GIS-based methods for agro-environmental management and irrigation advisory services.

Crop response model for drought and salinity
Test-site (Italy)
Horticultural science, crop biology and modelling. Crop response to environmental stress, such as cold temperature, drought and salinity, crop model versus soil water status and weather.

Test-site (Turkey)
Yield and quality response to water management, water use efficiency, modern irrigation techniques, reclamation of saline and alkaline soils, hydrological modelling, reuse of new techniques on land consolidation and development of farm structures for regional conditions.

Test-site (Jordan)
Fertigation, wastewater reuse for irrigation, training and capacity building programs. Coordination and consultancy for international Potash Institute and International Atomic Energy Agency in the field of fertilizer use and fertigation.

Test-site (Lebanon)
Evapo-transpiration and crop water requirements, optimizing use and performance analysis of modern irrigation techniques, water use efficiency of cultivated crops.

Hardware and sensors for water management
Worldwide supplier for the irrigation market and research, sensor technology, instruments for environmental science, agronomy, plant physiology, eco-physiology, data logging, meteorology, soil moisture, solar energy studies and environmental monitoring.

Software for irrigation management
Turnkey software development for automation and irrigation management, database management and data collection systems, internet, client/server, web based, multimedia, mobile and wireless.

Irrigation management systems
Software development for irrigation management, supplier to endusers. Specialty in fertigation, sensors for horticulture, irrigation systems, supervision and management systems for horticulture.