FLOWAID

Farm Level Optimal Water Management Assistant for Irrigation Under Deficit

More Crop per Drop

FLOW AID

GOCE 036958

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More crop per drop

Technology supports growers to cope with water shortage challenges

MANAGING WATER AND FERTILIZERS

Water shortage forces growers to irrigate with less water or even with water of a lower quality. To avoid crop damage and income losses they need to manage their water and fertilizers more precisely. This may also reduce nutrient leaching, one of the major aims of the Water Framework Directive (WFD). New knowledge and technology to help growers to make the best possible operational decisions has been developed in the FLOW-AID project.

Agriculture is the largest user of water in the world. Irrigation water use efficiency must be increased drastically to secure food production for future generations, in other words: we need 'more crop per drop'. The general approach is to avoid water loss and to ensure that all irrigation water is being utilized by the crop. However, in many cases this is not enough.

Working under deficit conditions means that the grower needs to operate his water management more precisely to prevent income losses. In the FLOW-AID project scientists of universities and research stations have co-operated with engineering companies to develop new systems and technologies for irrigation and drainage. The program has now resulted in innovative sensor technologies, which are integrated into a grower decision support system. The system has been evaluated at sites located in Lebanon, Jordan, Turkey, Italy, the Netherlands and Spain and over the years it has been improved. The final system has been demonstrated to growers during the third year at the test sites.




The case studies have shown that the introduction of innovative technologies may raise water use efficiency by up to 60% while maintaining existing crop yields. The use of fertilizers may be reduced by up to 30%, which reduces costs and saves the environment. It has been shown that in fact yields often increase thanks to the new water management system. Growers might use this extra income for investments in new technologies.

This brochure presents all newly developed technologies in the FLOW-AID project and illustrates the promising case study results. We are convinced that FLOW-AID can help growers in meeting future water constraints and that our effort for "more crop per drop" will advance sustainable water use.

Jos Balendonck,
FLOW-AID Project Coordinator, Wageningen University and Research centre

WATER SCARCITY

Growers have to deal with new challenges. Climate change and water shortage forces them to adopt deficit irrigation practices. They also have to deal with new legislation, such as the Water Framework Directive (WFD). Having less water at their disposal makes it difficult for growers to avoid crop damage and income loss. It is therefore necessary to manage water and nutrients more precisely. This will contribute to the reduction of leaching, one of the major aims of the WFD.

New technology based on innovative tools can help growers to meet the challenges of the future. By making the best possible operational decisions, yields will increase and fertilizer costs will decrease. This will result in a better income, which enables growers to invest in the new technologies.




WATER FRAMEWORK DIRECTIVE

In the nearby future the use of water and the management of water resources in Europe will be governed by the Water Framework Directive (WFD). The WFD aims at achieving a 'good ecological status' of water bodies in Europe by 2015. This is the reason for promoting Integrated Water Resources Management, involving all stakeholders from policy-makers to water suppliers and end-users.

High-value, intensively grown horticultural crops need a lot of water and fertilizers. Nowadays, water shortage forces growers to apply less water than needed for optimum production. They are also required to irrigate with water of a lower quality. This practice leads to soil salinization due to the accumulation of nutrients and sodium chloride, not used by the crop. Growers then use over-irrigation to force leaching, either continuously or in multiple events to clean their soils.

POTENTIAL IMPACT

As good water is becoming scarce, the availability is of major concern to all. Growers sometimes negate their responsibility towards the environment as they make ample use of water. Fortunately less available water of lower quality forces them to improve water management to ensure a high quality crop. Although this will be primarily driven by economic arguments, controlled use of water and fertilizers is also the key approach to reduce the environmental load. Combining both targets into a single practical management approach opens perspectives for introducing a new type of irrigation practice.

In the FLOW-AID project new techniques and methodologies have been developed, enabling growers to make better decisions on how to mix water from different sources and of different qualities (dual water or treated water). FLOW-AID proved that the use of these new tools can substantially reduce the nitrate load of groundwater sources and save water, while maintaining good crop quality and sometimes even slightly higher yields.

IMPLEMENTATION

The results of this project will make new technologies affordable for third partner countries. However, growers are reluctant to change their way of irrigation due to lack of knowledge about the technology. Furthermore, many growers do not seem to be aware that legislation will force them to stop emitting nutrients in the near future. The FLOW-AID approach can help to increase economic efficiency of water application and decrease the pressure on water resources.

Policy-makers might stimulate the successful introduction of new technologies by supporting a number of actions. The presented methodology is a prototype which has shown its benefits in a limited number of case studies. First, more research should be supported. Then, engineering companies should be enabled to start transferring this prototype into new readily available cost-effective products. Finally, capacity building programs for training are needed to ensure a broad and wide implementation of the tools.

A robust dielectric tensiometer for very dry soils

Sensing when to start your irrigation

APPROACH

The output of water-filled tensiometers, particularly in drying soils, can result in serious measurement errors. Therefore partners in FLOW-AID worked together to develop an innovative prototype tensiometer, which measures soil hydraulic pressure using a novel dielectric measurement principle. The prototype dielectric tensiometer aims to be: low-cost, easy to install, low maintenance and independent of soil type.

RESULTS

A prototype dielectric tensiometer to measure the matric potential has successfully been developed. Evaluation during the FLOW-AID project demonstrated that under dry and very dry conditions the prototype dielectric tensiometer gives more accurate readings and is more reliable than standard hydraulic tensiometers. It has been shown that low-cost dielectric tensiometer technology has significant potential to help enable wider use of deficit irrigation practices.

TECHNOLOGY

IMPLEMENTATION

The results from the prototype dielectric tensiometer development and evaluation will help enable Delta-T Devices and Rothamsted Research to develop low-cost dielectric tensiometer products for the end-user irrigation market. The system aims initially to meet the economic and physical conditions of non-European markets, where the largest growth for irrigation equipment is expected.

USER BENEFITS

A dielectric tensiometer is easier to set-up and install than a hydraulic tensiometer. Furthermore, the dielectric tensiometer can cope with significant drying events that would normally result in the user having to remove and service a hydraulic tensiometer. Using a dielectric tensiometer to measure matric potential also simplifies the setting up of a deficit irrigation controller as soil-dependent soil-moisture calibrations are not required.

PARTNERS

Rothamsted Research – United Kingdom
Delta-T Devices – United Kingdom

A WIRELESS SENSOR SYSTEM FOR IRRIGATION MANAGEMENT

ALWAYS AND EVERYWHERE ACCESS TO SOIL WATER INFORMATION

APPROACH

Optimum and precision irrigation control requires a large number of sensors that are spread out on each plot of the farm. These sensors have to communicate with the irrigation system. A wireless sensor network has been developed based on commercially available components. These components have been intensively tested and adapted to the boundary conditions. Field experiments with different systems were carried out in ornamental container crops and field grown lettuce.

RESULTS

It is shown that with the wireless sensor network it is possible to monitor soil temperature, moisture and electrical conductivity (EC) in a robust manner. Distances up to 500 meter between base station and field and up to 200 meter between two sensor nodes can be achieved. The used system is solar powered and self recharging and practically maintenance-free. Data can be transferred automatically over internet and processed by a remote decision support system for irrigation.




TECHNOLOGY

IMPLEMENTATION

The costs of application in container crops were calculated. The assumption of a necessary high density sensor grid of 10 meter x 10 meter resulted in the conclusion that the costs per sensor node should be no more than 100 euro. Current costs are still too high for this and cheaper systems have to be developed. Nevertheless, the current system has demonstrated to have the potential to be used at a lower density in a number of other applications like for instance in soil grown horticultural crops.

USER BENEFITS

Users can at any time and location obtain information about the actual soil water status for their cropping fields, and thus optimize their irrigation management practices. Installation costs of sensors may be kept low due to the wireless concept.

PARTNERS

Wageningen University & Research centre – The Netherlands
University of Pisa – Italy
Centro Sperimentale Vivaismo, Pistoia – Italy

A crop planning and farm zoning tool

Optimizing gross margin with a decision support system

APPROACH

To reach an acceptable income, a grower has to make the correct decision on which crop he is going to grow. Many factors are determining profits, such as harvest prices, availability of water for irrigation, climate conditions, subsidy policies, results of previous years. A decision support system, based on an earlier developed model performing yield calculations for multiple irrigation strategies (MOPECO-model), has been developed.

RESULTS

Participating growers have received an easy to use tool to make an optimal decision on which crop to grow. An on-line version of the MOPECO model has been developed which was extended for deficit conditions in order to make the decision support system available to a great number of users. The software is available in English and Spanish and can be easily translated into any other language. It can be downloaded from http://mopeco.agr-ab.uclm.es or www.mopeco.uclm.es.

TECHNOLOGY




IMPLEMENTATION

The model has been offered to growers in Eastern Mancha (Spain) and South Bekaa (Lebanon). They are now entering their own crop data. Researchers are working on validation of the decision support system with these data. The next objective is to increase the number of users by dissemination tasks and training courses for technicians and local growers in both areas.

USER BENEFITS

Growers will be able to optimize their crop planning and farm zoning by using the new tool. They can easily enter a great number of data related to their farms in the programme. The decision support system then automatically generates an advice that will improve the efficiency of their business.

PARTNERS

Regional Centre of Water Research (CREA),
University of Castilla La Mancha – Spain

A crop stress response model

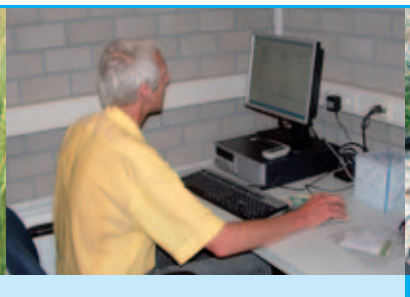
Understanding the effect of water-shortage and salinity

APPROACH

To optimize irrigation scheduling, growers need to understand plant-water relations and the related effects on the plant, such as reduced growth and wilting. World-wide a great effort has been undertaken to obtain the response of a large number of agricultural and horticultural crops. To disclose new knowledge about the effect of crop water stress, this information was collected from the literature and incorporated into a database.

RESULTS

A practical database was designed providing information about the response to water constraints of a selection of representative irrigated crop species. A mathematical model was developed to predict the gross effect of reduced water supply or increasing salinity on crop yield and economic profit.

TECHNOLOGY

IMPLEMENTATION

The database is designed in such a way that it allows users to modify the data provided for specific crops as well as to add new crops. The data can easily be exported, as the database generates two tables that are compatible with other software.

USER BENEFITS

The information in the database can help growers to improve crop selection in regions affected by water shortage and/or salinity. Optimization of crop selection will help growers to increase their yield with minimal use of water.

PARTNERS

University of Pisa – Italy
Regional Centre of Water Research (CREA),
University of Castilla La Mancha – Spain

A DECISION SUPPORT SYSTEM FOR IRRIGATION UNDER DEFICIT

Optimum irrigation and fertilizer management in dry regions

APPROACH

Scarce water should be applied with the highest possible efficiency and crop damage must be limited when using water of poor quality. A decision support system that combines information from various sources (visual observations, sensors, expert examinations and forecasts) has been developed. The tool has been evaluated at sites located in Lebanon, Jordan, Turkey, Italy, the Netherlands and Spain.

RESULTS

A decision support system for irrigation management has been evaluated. The system is based on soil-water-plant reactions and fertilizer balance encoded knowledge. It combines information of wireless soil water sensors and data from a database of crop response to drought and salinity. All other tools developed within the FLOWAID project can be easily interfaced with the decision support system. It is robust, safe and easy to use, and is interoperable with other affordable deficit irrigation equipment and management tools.

TECHNOLOGY




IMPLEMENTATION

At all locations, irrigation based on the new system has reduced water use without loss of yield or quality. The results will now be implemented 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 both the economic and the physical conditions of non-European markets.

USER BENEFITS

Growers will obtain affordable hard- and software, such as a maintenance-free tensiometer, a wireless and low-power sensor network and an expert system for farm zoning, crop planning and irrigation scheduling. These instruments will help them to increase the efficiency of their water use and fertilization management under soil water deficit conditions.

PARTNERS

Wageningen University & Research centre – The Netherlands
Geomations – Greece

Sensor-activated irrigation controllers

Minimizing wastage and environmental damage

APPROACH

Having a low-cost irrigation controller with soil condition feedback takes out the guesswork of deficit irrigation. The GP1 data logger has therefore been designed to control irrigation. Sensors are connected to the data logger to feedback information on soil condition, such as soil water content, and EC (obtained with WET-sensors) and matrix potential. This information is used in a decision support system, which now has been evaluated on five sites located in Italy, Turkey, Lebanon, Jordan and the Netherlands.

RESULTS

GP1 loggers have been successfully installed in a network with remote access and control capability. A local computer regularly reads out sensor data and updates autonomously the running scheduling program. The decision support system helps the grower to optimize irrigation. Up to ten GP1's can be networked on a single Ethernet adapter channel.



TECHNOLOGY

IMPLEMENTATION

The improved decision support software and the GP1 based irrigation controller have resulted in a tool that is suited for scientific studies and to assist the further development of practical irrigation control strategies. The software capabilities of the GP1 logger/controller have been enhanced to include safety features such as: sensor misreporting, overdue irrigation, metered irrigation quantity, cut sensor cables or irrigation delivery failure to improve crop security and irrigation overshoot.

USER BENEFITS

The flexible GP1 based irrigation controller makes more precise water management possible. Environmental damages will be limited, water will be saved and crop yields are maximized.

PARTNERS

Delta-T Devices – United Kingdom

Sensor-activated fertigation control

Managing fertigation in container crops

APPROACH

In Tuscany (Italy) the production of landscaping ornamentals is hindered by over-irrigation. To develop a device that is able to control fertigation in container cultivation, the application of a substrate moisture sensor has been investigated. Sensor-activated irrigation scheduling has been compared with irrigation based on a timer and on a weather-based model of crop evapo-transpiration. Experiments have been running for three years.

RESULTS

Compared to the timer, the sensor-activated scheduling reduced seasonal water consumption and the drainage fraction of multi-crop plots. This was the result of a lower irrigation frequency and did not have a significant effect on plant growth. Application of the evapo-transporation model resulted in a water saving comparable to the sensor treatment.

TECHNOLOGY




IMPLEMENTATION

A new fertigator prototype has been developed by collaboration of Spagnol Greenhouse Technologies, University of Pisa and Wageningen University: the prototype was connected to sensors for moisture content and salinity (WET-sensor) and special algorithms were implemented in order to activate irrigation when a pre-set threshold for substrate moisture or cumulated evapo-transpiration was reached. Work is in progress to integrate the signals from substrate moisture sensor and evapo-transporation model.

USER BENEFITS

Growers obtain a device that is able to control fertigation based on the measurements of both moisture and salinity (EC) of the substrate. This will result in water savings and fertigation that matches plant needs.

PARTNERS

University of Pisa – Italy
Spagnol Greenhouse Technologies – Italy
Centro Sperimentale Vivaismo, Pistoia – Italy

Case study Lebanon

Optimizing eggplant production by using smart irrigation controllers

CHALLENGES

Limited water availability has placed immediate restraints on agricultural growth in the Bekaa Valley in Lebanon. Traditional irrigation techniques are not economical and only eight percent of the irrigated lands receive water with more efficient drip irrigation. The costs of irrigation are increasing and lack of operation and maintenance work has led to serious shortages. Modern techniques have to be incorporated in daily practice in Lebanon to ensure enough water for a profitable agriculture.

APPROACH

The GP1-loggers and sensors in combination with smart sensor-activated irrigation control offer perspectives for more efficient irrigation methods. Field installations were made at Tal Amara Research Station in the 2008 and 2009 summer periods. Eggplants were transplanted in an experimental field using drip irrigation. Traditional irrigation regimes were compared with deficit irrigation based on sensor-activated irrigation control.

Case study

RESULTS

The sensors were used to make an irrigation schedule based on soil water levels. This allowed good timing and management of the applied water volumes and resulted in nearly twenty per cent water saving, when calculated over the whole growing season. At production level, data showed that grower's production levels in the trials were high (15-20 t/ha). The GP1 proves to be a smart irrigation controller that offers a reliable irrigation system.

USER BENEFITS

The new approach makes it is possible to monitor the soil water content under good and deficit irrigation conditions. Water requirements of eggplants can be determined by various irrigation regimes. The effects of deficit irrigation on growth and production can be evaluated. A water saving strategy that enables the Lebanese growers to produce more eggplants with minimal water use can be developed.

PARTNERS

Lebanese Agricultural Research Institute – Lebanon
Delta-T Devices – United Kingdom

Case study Jordan

Growing tomatoes with treated wastewater

CHALLENGES

Jordan has very limited fresh water resources. The demand on water is ever increasing and is now estimated at about 1.2 billion cubic meters per year. Rainfall is not enough to meet growers' needs. And growers do not know the water requirements of their crops. It is necessary to increase water use efficiency and to improve wastewater for reuse to bridge the gap between available water and needed water.

APPROACH

A field test with tomatoes was carried out in the form of two experiments in the period 2007 to 2009. In the experiments, fresh water and treated wastewater were compared. Both water content sensors and tensiometers were used to schedule irrigation in the plots. Two irrigation schedules were simulated, one with adequate water and one with deficit conditions. The performance of the soil sensors was evaluated and the different irrigation strategies were compared.

Case study




RESULTS

Water use efficiency in the innovative irrigation schedules is higher in all treatments except for the treatment with only treated wastewater. Lowest yields were obtained with deficit irrigation with treated wastewater. Highest yields were obtained when the tomatoes received sufficient treated dual water. The sensor technology has proven its value and is ready to be put into practice.

USER BENEFITS

Sensor technology contributes to a more efficient water use. Dual water can be used to produce tomatoes. Yields can be increased by introducing innovative irrigation schedules in Jordan.

PARTNERS

Jordan University of Science and Technology – Jordan
Wageningen University & Research centre – The Netherlands
Delta-T Devices – United Kingdom

Case study Turkey

Minimal percolation losses in cucumber production in greenhouses

CHALLENGES

The Tahtali Dam is the most important drinking water source of Izmir, the third largest city of Turkey. In this area greenhouse production is an important agricultural activity. In order to prevent pollution of drinking water by nutrients or pesticides, irrigation is restricted. Nevertheless, the growers are still using excessive amounts of water. This causes environmental impact in the region. A method for deficit irrigation should be developed to reduce the impact of greenhouse production.

APPROACH

An on-farm project was started to evaluate whether deficit irrigation could reduce leaching and at the same time increase water use efficiency. A three-year study has been carried out with greenhouse cucumber production under growers' conditions. The commonly used irrigation strategy was compared with sensor-activated irrigation scheduling. In the sensor-based culture the water content in the root zone was kept at a constant level as much as possible for full irrigation and two deficit levels.




Case study

RESULTS

The averaged three-year results show that higher crop yields (14%) can be obtained with automated irrigation and soil moisture control in the full irrigation treatment in comparison with growers' practices. This result was obtained without any notable percolation losses, while traditional grower practice showed significant percolation losses and over-irrigation. A slightly deficit irrigation program prevented leaching with acceptable crop yield.

USER BENEFITS

The new technology can be easily adapted to several specific growing conditions. However, it seems that the implementation of this technology will take some time since the cost of the equipment is still rather high for small farms.

PARTNERS

Ege University Faculty of Agriculture – Turkey
Rothamsted Research – United Kingdom
Wageningen University & Research centre – The Netherlands
Delta-T Devices – United Kingdom
Spagnol Agricultural Automation Systems – Italy
Geomations – Greece

Case study Italy

Irrigation of pot ornamentals with lower quality water

CHALLENGES

The production of ornamental nursery stock in Tuscany provides a substantial contribution to the Italian gross income. However, the environmental impact is significant due to the waste of water and the pollution of rivers and groundwater. Competition for water between agriculture and other users is affecting the future development of the nursery industry. Efficient water management systems and techniques to exploit reclaimed urban wastewater are therefore needed.

APPROACH

Most ornamental species are sensitive to salt stress and toxicity. This makes it necessary to develop an appropriate irrigation and fertigation strategy to avoid salinization of the growing medium when dual water is used. A fertigation device and software were tested in an experiment with pot ornamental plants simulating the use of a dual water source. Two fertigation regimes were compared, one based on a timer and the other based on a WET-sensor.




RESULTS

The device successfully modulated the EC of the nutrient solution. In both years, compared to the timer, the WET-based scheduling did not affect plant growth and significantly reduced (-35%) seasonal water use of a multi-crop plot and the drain fraction due to a lower irrigation frequency. In the WET-dual water treatment the use of groundwater was reduced by 68% (2008) or 62% (2009) compared to the timer.

USER BENEFITS

Producers of ornamental crops will be able to replace groundwater by dual water without production losses. The environmental impact of the nurseries in Tuscany will be reduced substantially.

PARTNERS

University of Pisa – Italy
Spagnol Agricultural Automation Systems – Italy
Centro Sperimentale Vivaismo, Pistoia – Italy

Case study the Netherlands

Reducing nitrate emission in rain-fed and soil-grown iceberg lettuce

CHALLENGES

Due to environmental legislation like the Water Framework Directive (WFD), there is a strong focus on controlling water and nutrient flows in the Netherlands. Growers need new techniques to optimize fertigation, especially for crops grown in soil. When grown on sandy soils, crops may soon suffer from drought. In addition, during heavy rainfall, valuable nutrients might leach into the groundwater and damage the environment.

APPROACH

The use of drip irrigation and covering of soil with foil, in combination with controlled fertigation, was evaluated in an experiment. Iceberg lettuce was grown in a standard cropping system with minor adaptations. The aim was to reduce the emission of nitrate to the environment and at the same time increase crop yield while keeping the quality. An automatic sensor-activated irrigation control in combination with a decision support system was tested.




CASE STUDY

RESULTS

A slightly higher (10%) crop yield was obtained in the fertigated and sensor-activated situations, while maintaining crop quality compared to grower-controlled irrigation management. Under the foil, the automated system assured a less wet environment keeping soil moisture more constant and homogeneous. This prevented leaching of water and valuable nutrients. The technical systems, including the wireless links, worked well.

USER BENEFITS

The decision support system has to be adapted in such a way that it relieves the grower from checking and fine-tuning irrigation. The price of the automatic sensor-activated irrigation system is still a bottleneck for introduction in daily practice. However, growers are advised to apply water and nutrients at lower dose levels, with a closer match with crop demand. This will reduce emissions, increase yields and quality, and will save a lot of work.

PARTNERS

Wageningen University & Research centre – The Netherlands
Delta-T Devices – United Kingdom
Geomations – Greece

Case study Spain-Lebanon

Optimizing crop patterns under water scarcity and saline conditions

CHALLENGES

Reaching a maximum gross margin is a great challenge on irrigated farms. During the project the MOPECO-model has been highly improved through new calculation modules such as the saline water effect on yield and crop development. The overall aim was to develop and validate a methodology to optimize the application of irrigation water to crops by taking into account the soluble salt content of irrigation water. Gross margin must be optimized under restricted water conditions.

APPROACH

The model was developed using real data of an onion test carried out in Albacete (Spain) and validated in the Bekaa Valley (Lebanon) for a potato crop. The EC of the irrigation water in both areas was high enough to potentially affect crop growth, but despite this fact no leaching fraction was applied in the irrigation strategy. We used the model to determine whether progressive salinization of soils may occur and whether the irrigation strategy is appropriate in terms of water use efficiency.

Case study




RESULTS

Saline effects must be taken into account when modeling crop behavior under water stress even if the electrical conductivity of irrigation water is moderate. This is especially relevant in arid and semi-arid areas where regulated deficit irrigation shows a higher potential. It has also been demonstrated that a leaching fraction may be avoided if natural weather conditions between irrigation seasons is able to wash the soluble salts added by irrigation. The amount of saved water may be considerable.

USER BENEFITS

First on-line and desktop versions of this model are available on the internet (http://crea.uclm.es/) including a user manual in English and Spanish. This means that not only growers of Eastern Mancha can use the model but any grower and manager all around the world. The use of this tool is promoted through training courses as given in Albacete and Zaragoza (Spain).

PARTNERS

Regional Centre of Water Research (CREA), University of Castilla La Mancha – Spain
Lebanese Agricultural Research Institute – Lebanon

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Colophon

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Consortium:	10 partners from 8 countries (see partners)
Website:	www.flow-aid.eu
Total Costs:	1.53 M€ with an EC-contribution of 1.02 M€
Duration:	1/10/2006 – 31/12/2009
Financing:	The FLOW-AID project was supported as a Specific Targeted Research Project within the European Community's Sixth Framework Programme (FP6-2005-Global4, Priority II.3.5) within the theme: "New Systems and Technologies for Irrigation and Drainage" under the contract 036958.
Co-financing:	The FLOW-AID project was co-financed by: the Dutch Product Board for Horticulture (PT, NL); the Dutch Ministry of Agriculture, Nature and Food Quality (LNV, NL) and the Greek Ministry of Development.
Contributions from:	Centro Sperimentale Vivaismo, Pistoia – Italy, www.cespevi.it (sub-contractor case Italy); Wageningen-UR, Applied Plant Research, Arable Farming, Multifunctional Agriculture and Field Production of Vegetables, PPO Vredepeel – The Netherlands, www.ppo.wur.nl/UK (case The Netherlands); Agricultural University of Athens.
Disclaimer:	This publication is the sole responsibility of the authors and does not represent the opinion of the European Commission, nor is the European Commission responsible for any use that might be made of the information appearing herein.
Editors:	Wageningen-UR, The Netherlands, www.glastuinbouw.wur.nl Hortinfo, The Netherlands, www.hortinfo.nl
Layout and printing:	Thieme MediaCenter Rotterdam, The Netherlands